MORINGA OLEIFERA LEAVES
AS ANIMAL FEEDSTUFF
To Increase Libido and Sperm Quality

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Nursyam Andi Syarifuddin
Muhammad Rizal
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Diterbitkan Oleh
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PREFACE

Praise and gratitude for the writer to pray to Allah SWT, because of the abundance of His health, strength, and guidance grace so that this book can be completed. This book is compiled as a form of the author's contribution to the development of science, especially in providing information about the use of Moringa leaves as animal feed.

Moringa has been known by the community for a long time, especially in rural areas as a wild plant and there has been no cultivation. People do not know much about the benefits and nutritional value of moringa. However, for the last ten years, the world has seen moringa as a miracle tree, because all parts of the plant can be beneficial and have a high and complete nutritional content. Various research results have confirmed moringa as a miracle plant so that the information stored for thousands of years about the benefits and properties of moringa has been well explained by modern science. The World Health Organization (WHO) has also supported and promoted the moringa plant as a miracle plant, as it has been proven to overcome malnutrition (malnutrition) in poor African countries. Millions of lives have been saved by consuming moringa. Various research results have explained that parts of the Moringa tree can be utilized and have economic value. Moringa can be used as food, medicine, dye, animal feed, wastewater purifier, natural fertilizers and pesticides, renewable energy sources, nature and environmental conservation, and conservation.

This book explains the potential and use of *Moringa leaves* as animal feed. The results of the literature search conducted by the author indicate that when cultivated, moringa can produce high biomass so that it does not compete with humans when it is used as animal feedstuff. Various research results that have used *Moringa leaves* as animal feed, both in ruminants and non-ruminants are also described in this book. Likewise, the results of the author's research on the use of *Moringa leaves* to increase libido and sperm quality for Bali bulls and etawah crossbreed bucks.

In writing this book, the author would like to express his gratitude and highest appreciation to the Dean of the Faculty of Agriculture, University of Lambung Mangkurat, Banjarbaru who could motivate and encourage writers to produce the best works in the future about *Moringa*. The author does not forget to also express his gratitude to Ir. A. Dudi Krisnadi with his website http://kelorina.com/ which has inspired many writers about *Moringa*.

This book still has many deficiencies, therefore criticism and suggestions are expected for the perfection of this book. The author is still determined to improve and perfect the writings in this book in the future. Hopefully, this book can still provide great benefits regarding the use of *Moringa leaves*, especially as animal feed, both among students, lecturers, practitioners, breeders, and the wider community.

Banjarbaru, May 2021

Authors

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CHAPTER 1. INTRODUCTION

Historical records show that Moringa was used by humans around 5,000 years ago (2,000 years BC) in North India. Moringa has been used as medicinal ingredients. Moringa in the book of Ayurveda is explained to be able to prevent or treat 300 kinds of diseases. Everyone who is sick is always given an herb from this Moringa leaf. Moringa leaf extract is also believed to provide extra stamina and energy. Soldier Iskandar Zulkarnen (King of the Macedonian Empire) defeated the Mauritian army when he conquered India after learning the secrets of the physical strength of the Mauritian army which was resistant to illness, staying up late, hungry, far from being attacked by disease in long travel camps, because it always consumed Moringa leaf extract while fighting. At the celebration of his victory in India, he also invited all his warriors to drink moringa leaf concoction

Besides in India, historical stories in Ancient Egypt also often use Moringa leaves as skin protection during the summer which stings damages the skin. The Egyptians often squeezed Moringa leaves and rubbed them on his body, and some used it for bathing. The Greeks often consumed Moringa leaves for daily meals. One of the foods of heavy workers and soldiers is Moringa leaves. The great benefits of Moringa leaf by the Greeks were transmitted to the Romans and its development also extended to China a few centuries later, continue to the Philippines, and other Asian regions including Indonesia.

Moringa plants for centuries have been brought to various regions, ranging from semi-tropical to tropical regions. Moringa is now cultivated throughout the Middle East and almost all the tropics. Moringa is well known in Asian, African, South and Central American, Caribbean, and Oceania countries. Therefore, Moringa is known for 400 different names according to their origin and language. There is also a term that is based on its amazing benefits, for example, ***mother's best friend*** **(Best friend's mother)** because benefits increase milk production, ***miracle vegetable (vegetable magic)***, and ***the miracle tree (magic tree)***. However, almost all of them agreed with the last name of ***Miracle Tree,*** aka ***Magic Tree*** because of its enormous benefits. Moringa in English is commonly known as the *Horseradish tree, Drumstick tree, Never Die tree, West Indian Ben tree,* and *Radish tree*. Moringa is popularly called **'*drumstick*'** because of its pods that resemble drumsticks.

Moringa in Indonesia is spread throughout the archipelago. Moringa is known by various regional names such as *murong* (Aceh), *munggai, kalor, kerore* (Sumatera), *kilor* (Lampung), *kelor* (Jawa Barat dan Jawa Tengah), *marongghi* (Madura), kelor, tjelor (Bali), *kiloro* (Sulawesi), *parongge* (Bima), *kawona, wona* (Sumba), *kelo, oege kelo* (Ternate), *maroenga*, *motong* (Alor), *moltong* (Flores), *kafok*, *kai fok* (Roti), *kelo* (Tidore), and *baoe fo*, *maroenga* (Timor).

Studies of Moringa until the 1980s have not been promising about the importance of moving Moringa cultivation as an important food for humanity. Medical publications have not been widespread. In the era of the 1980s until the 1990s began experiencing developments in the discourse of the benefits of Moringa as a result of experience. One of the most instrumental in the development of Moringa plants is Lowell Fuglie, a French citizen who lives and works in Sinegal. He first examined the nutritional content of Moringa leaves in the late 1990s. He examined Moringa leaves and found the fact that pregnant women who experience poor nutrition can still have healthy babies by consuming Moringa leaves. Lowell's research results are now used by many countries to combat malnutrition, especially developing countries on the African peninsula.

For the past ten years, the world has looked at Moringa as the most useful tropical tree because of the content and benefits of all parts of its plants. Researchers in various countries are racing to report the results of their research which strengthens the moringa as a miracle plant. Moringa has been successfully used to combat malnutrition in children and efforts to improve the immune system in developing countries. Moringa is also often used to supplement modern medicines in people with chronic pain including AIDS and HIV-related diseases.

Moringa can now be used as an agribusiness commodity as a source of livelihood. Various parts of the Moringa tree can be utilized and economically valuable. Leaves, fruit, flowers, and roots are very well used as food, medicine, coloring, animal feed, and purifying wastewater and renewable energy sources as raw material for ethanol. Moringa can function as a source of nutritious food, live pharmacies, herbs, natural cosmetics, nature, and environmental preservation, conservation, carbon sequestration, vegetable oil sources, renewable energy, water quality improvement, animal feed needs, and sources of fertilizers and natural pesticides.

Indonesian society needs an adequate explanation of the benefits of Moringa. The results of research on the benefits of Moringa has been widely published both on a national and international scale. Indonesians are more familiar with Moringa through the phrase "The world is not as wide as Moringa Leaves". Whereas in every village we can find Moringa trees, but not every village knows the true benefits of Moringa. Moringa trees only grow in small portions and rarely used leaves and fruit, especially flowers and roots. One of the means of information about Moringa in Indonesia that can currently be utilized is the Indonesian Moringa Plant Information and Development Centre in Kunduran, Blora Regency, Central Java, which was pioneered by A. Dudi Krisnadi with his website http://kelorina.com/.

Because Moringa is known to have many benefits, this book will specifically review the benefits of Moringa leaves as animal feed. Moringa is a gift plant that can be used by farmers in rural areas in addition to being a source of highly nutritious food, it can also be used as feed ingredients to increase the productivity of their livestock for their welfare.

CHAPTER 2. MORINGA TAXONOMY

Figure 1. Moringa (*Moringa oleifera* Lam)

Source: http://www.plantamor.com/katalog/tanam-sayur/kelor_i90.

a. Taxonomy

According to Plantamor (2012), Classification Moringa as follows:

Kingdom: Plantae (plants)

Subkingdom: Tracheobionta (vascular plants)

Super Division: Spermatophyta (producing seeds)

Division: Magnoliophyta (flowering plants)

Class: Magnoliopsida (dicotyle)

Sub-Class: Dilleniidae

Order: Capparales

Family: Moringaceae

Genus: *Moringa*

Species: *Moringa oleifera* Lam

b. Synonym

Moringa moringa (L.) Millsp.

Moringa pterygosperma Gaertn

c. Common Names

English	: Moringa, ben-oil tree, clarifier tree, drumstick tree
Indonesia	: Moringa, limaran (Javanese)
Malay	: Kalor, merunggai, sajina
Vietnamese	: Chùm ngây
Thailand	: Ma-rum
Philippine	: Malunggay

d. General Description

Moringa *(Moringa oleifera)* grows in tree shape, long-lived (*perennial*) with a height of 7 - 12 m. Stems of wood (*lignosus*), upright, dirty white, thin skin, rough surface. Stem diameter of 20-40 cm. Sympodial branching, the direction of upright or oblique branches, tends to grow straight and elongated. Umbrella-shaped canopy with many branches. Overall leaf length of 20 - 70 cm. Compound leaves, long-stemmed, arranged alternately (*alternate*), leafless leafy (*imparipinnate*), leaf blade when young is light green - after the adult is dark green, the shape of ovoid leaves, length 1-2 cm, length 1-2 cm, limp thin, blunt tip and base (*obtusus*), flat edge, the arrangement of reinforcing pinnate (*pinnate*), smooth upper and lower surfaces. Flowers appear in the axillary (*axillary*), long-stemmed, rather creamy white petals, spread a distinctive aroma. Pollination of plants is usually carried out by bees and other insects, as well as birds. Moringa fruit in the form of a long triangular, 20 - 60 cm long, young fruit is green - after old turns brown, round seed shape - blackish brown, bearing fruit after the age of 12-18 months. This tree can produce 600 to 1,600

fruits every year. The immature fruit is green and some varieties have a reddish color. Mature fruit turns brown and on average contains 10-12 seeds. Large seeds with three wings like paper. The seed coat is generally brown to black but can be white if the kernel has low viability. This tree has a taproot, white, enlarged like a turnip, so it can survive drought. Propagation of *M.oleifera* can be done by seeds (generative) or stem cuttings (vegetative). Plants that are raised from seed, are reported to be slower flowering with low fruit quality. *Moringa* grows in the lowlands and highlands to an altitude of ± 1,000 m above sea level, many planted as a boundary or fence in the yard or fields.

Mark E. Olson botanist from Washington University explained that Moringa was found in the world today there are 13 different species, with scientific names and in English or synonyms:

1. *M.oleifera* Lam = *Guilandina moringa* L., *Hyperanthera arborea* JFGmel., *Hyperanthera decandra* Willd, *Hyperanthera moringa* (L.) Vahl, *Moringa erecta* Salisb, *Moringa moringa* (L.) Small, *Moringa octogona* Stokes, *Moringa parvifolia* Noronha, *Moringa polygona* DC, *Moringa pterygosperma* Gaertn, nom. illeg., *Moringa zeylanica* Pers = Ben tree, Behn tree, Behen tree, Benzolive tree (USA), Drumstick, Drumstick tree, Horseradish tree, West Indian ben.
2. *M.arborea* Verdcourt = Kenyan moringa
3. *M.borziana* Mattei = Kenyan moringa, Somalian moringa
4. *M.concanensis* Nimmo = Indian moringa, Wild Indian horseradish tree
5. *M. drouhardii* Jumelle = Madagascar moringa
6. *M.hildebrandtii* Engler = Madagascar moringa
7. *M.longituba* Engler = Ethiopian moringa, Kenyan moringa, Somalian moringa
8. *M.ovalifolia* Dinter ex Berger = Namibian moringa

9. *M.peregrine* (Forssk.) Fiori = *Gymnocladus arabicus* Lam.,
10. *Hyperanthera peregrina* Forssk, *Moringa aptera* Gaertn, *Moringa arabica* (Lam.) Press.
11. *M.pygmaea* Verdcourt = Somalian moringa
12. *M.rivae* Chiovenda = Ethiopian moringa, Kenyan moringa. *(Moringa rivae* Chiovenda subsp. *Rivae* = Short-fruited Ethiopian moringa; *Moringa rivae* Chiovenda subsp. *Longisiliqua* **=** Long-fruited Ethiopian moringa).
13. *M.ruspoliana* Engler = Ethiopian moringa, Kenyan moringa
14. *M.stenopetala* (Baker f.) Cufodontis = Ethiopian moringa, Kenyan moringa.

1. *Moringa oleifera* Lam

This species is one of the most useful plants in the world. The original plant is from the southern foot of the Himalayan Mountain. *M.oleifera is* cultivated in all countries in the tropics. *M.oleifera is* cultivated to take leaves, fruit, and roots for food and medicinal purposes. Young fruit (sometimes called "drumsticks") can be cooked in various ways. Good oil comes from seeds, can be used for cooking and engine lubricating. The leaves are widely used as a vegetable in various parts of the world, and their roots can be used as a spice similar to turnips (true radish, *Armoracia rusticana*, is a member of the family *Mustard, Brassicaceae*). *M.oleifera is* also in demand because of the production of compounds with antibiotic activity such as *glucosinolate 4 alpha-L-rhamnosyloxy benzyl isothiocyanate*. Other research has also focused on the use of seeds *M.oleifera* in water purification. Generally also known as *M.aptera* and *M.pterygosperma*.

Figure 2. Leaves of *M.oleifera*
Source: http://www.mobot.org/gradstudents/olson/oleifera.html

2. *Moringa arborea* Verdcourt

This species was discovered by Allan Radcliffe-Smith and Peter Bally in 1972. They found a tree that grows in a rocky canyon in northeast Kenya near the Ethiopian border. The tree is flowering and fruiting but not leafy, so the leaves are a mystery because no one has returned to the area for more than 26 years.

In 1998, Mark E. Olson reviewed the location and looked for *M.arborea*. In the same canyon, he found the species and residents told him that the tree grew widely spread. But the trees were not leafy when he saw them.

M.arborea is a very beautiful tree, especially when covered with a large pale pink flower and red wine. Young fruit resembles long beans. Residents use the tree, like species *Moringa* other, for medicines, especially thick, fleshy roots and strong odor.

Figure 3. Leaves *M.arborea* **Verdcourt**
Source: http://www.mobot.org/gradstudents/olson/marborea.html.

3. *Moringa borziana* Mattei

This little *Moringa* came from southern Kenya to the Kisimayu region in southern Somalia, growing within 100 miles of the coast. Usually only produces one or two stems, which usually reach around the waist. These shoots seem to die back to the bulbs every few years, but sometimes plants can grow into small trees. The tuber is often very large and can reach more than one and a half meters below the ground surface.

The flowers of *M.borziana* are green to beige to yellow with brown stains on the tips of the petals and have an almost nauseating odor. If it does not flower or bear fruit, this species is often confused with *M.rivae*, but the latter species has never been found so close to the coast.

A B C

Figure 4. (A) Leaves, (B) Flowers, and (C) Fruit *M.borziana* Mattei

Source: http://www.mobot.org/gradstudents/olson/mborziana.html.

4. Moringa concanensis Nimmo

M.concanensis looks like *M.oleifera* but the leaves are bipinnate. The tree is very striking among other Moringa species. *M.concanensis* has a very strong central stem which is covered in a layer of very sharp wrinkled skin, which can be more than 15cm thick. The flowers also have distinctive green patches on the tips of the petals and leaf petals.

M.concanensis grows in tropical dry forests from southeast Pakistan to the southern tip of India. Recently found in western Bangladesh. Nonetheless, the habitat of *M.concanensis* is under heavy pressure from agricultural activities and urbanization.

A B C

Figure 5. (A) Leaves, (B) flowers, and (C)Tree *M.concanensis* Nimmo

Source: http://www.mobot.org/gradstudents/olson/slenderspecies.html

5. *Moringa drouhardii* Jumelle

The stem is white swelling is very striking in the dry forests of southern Malagasy. Growing spreads can reach hundreds of individuals, usually on limestone. When cultivated, *M. drouhardii* grows very fast to exceed three meters in its first year. This rapid growth rate makes it possible to exploit crevices in the forest.

M. drouhardii is used medically like *Moringa* other. The local people gouged and removed the scalp bark of this tree which was very flavorful to treat colds and coughs.

A B C D

Figure 6. (A) Stems, (B) Leaves, (C) Flowers, and (D) The Rootstock bark removed from M. *drouhardii* **barks Jumelle**

Source: http://www.mobot.org/gradstudents/olson/bottlespecies .html.

6. *Moringa hildebrandtii* Engler

M.hildebrandtii is a beautiful tree with a large water storage trunk that can grow as high as 20 meters. The leaves *pinnately* can be up to one meter in diameter, rachis leaves and the tips of young plant stems are often dark red. Leucorrhoea small flowers depend on large stems.

The tree was planted as an ornamental plant, medicine, and used for special occasions.

A B

Figure 7. (A) Leaves and (B)Tree *M. Hildebrandtii* **Engler**
Source: http://www.mobot.org/gradstudents/olson/bottlespecies.html.

7. *Moringa longituba* Engler

Moringa longituba Engler is different from species *Moringa* other. No other species has bright red flowers or base of petals and leaf petals which fuse to form a *tubular hypanthium* long. Usually has a large tuber under the ground with a small bud that reaches knee-high above the ground. If a shoot under a tree grows properly, it can form branches more than three meters. At the beginning of this century, botanist Engler placed this species in his subgenus *Dysmoringa*.

M.longituba grows in northeast Kenya, southeast Ethiopia, and much of Somalia. Like other moringa species, *M. longituba is* used medically mainly to treat intestinal disorders of camels and goats, whose roots are given internally.

A B C

Figure 8. (A) Flowers, (B) Tuber, and (C)Plants *M.longituba*
Source: http://www.mobot.org/gradstudents/olson/mlongituba.html.

8. *Moringa ovalifolia* Dinter ex Berger

After *M.oleifera*, species is perhaps *Moringa* this the most well known, growing in Namibia's crowded parks such as Etosha and Namib-Naukluft. The swollen white tree stands on a bare hillside so it is given the name "ghost tree".

This species is found from central Namibia to southwest Angola, usually on very rocky soil. In the Sproukieswoud area ("Fairy Forest") in Etosha Park. *M.ovalifolia is* rarely found growing in the soil.

A B C D

Figure 9. (A) *M.oleifera* **in Namib - Naukluft Park, Namibia**
(B) *M.oleifera* **in Sproukieswoud, Etosha National Park, Namibia**
(C) *M.oleifera* **in Halali, Etosha National Park, Namibia**
(D)Fruits and seeds *M. Oleifera*
Source: http: //www.mobot.org/gradstudents/olson/bottlespecies.html.

9. *Moringa peregrina* Forssk. ex Fiori

Plants native to the Red Sea region, are members of the most peculiar Moringa group. When the seeds of seedlings *M. peregrina* start coming out, they have large leaflets and large tubers. Through many dry seasons, shoots die and grow back on underground tubers. The older the plant, the longer the leaves, but the smaller the sheet and the wider the distance. Mature trees produce complete leaves, small sheets, and abort when they mature. The leaf axis remains but is bare so that the tree looks thin similar to the Tamarix tree (*Tamarind tree*) or *Cercidium microphyllum*. Pink zygomorphic flowers are sweet-smelling, different from blue flowers. It is estimated that oil *M. Peregrina* one of the most important oils in ancient Egypt. The tiller tubers are roasted and eaten in the southern Arabian Peninsula.

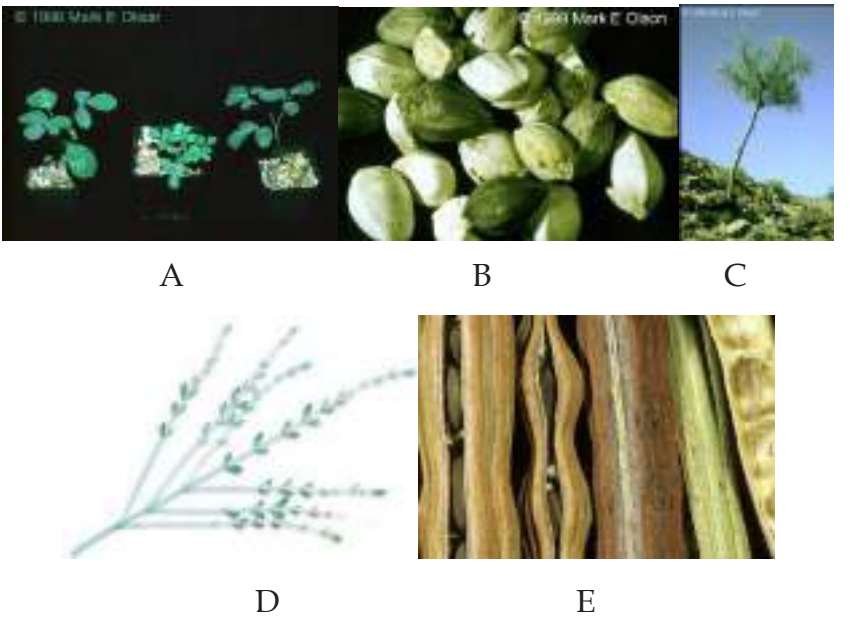


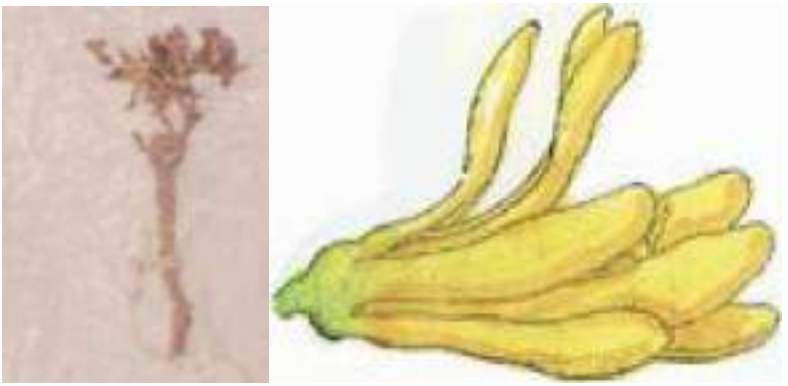
Figure 10. (A) Seedlings, (B) Bulbs, (C) Trees, (D) Leaves, and (E) Fruits *M. Peregrina.*

Source: http://www.mobot.org/gradstudents/olson/slenderspecies.html.

10. Moringa pygmaea Verdcourt

M.pygmaea is only known from 2 specimens from northern Somalia. Specimens were collected near Qardho, Somalia, in 1980.

Having fine tubers in the bush, this plant has small, leafy leaves. The flowers are reportedly yellow. Recent searches on location failed to find this type.



A B

Figure 11. (A) Photograph of the specimen and (B) Flowers *M.pygmaea*

Source: http://www.mobot.org/gradstudents/olson/mpygmaea.html.

11. *Moringa rivae* Chiovenda

There are two subspecies of *Moringa rivae* Chiovenda subsp. *Rivae* and *Moringa rivae* Chiovenda subsp. *Longisiliqua*. This plant originates from Lake Turkana south to the Mandera District in Kenya and throughout southeast Ethiopia, not far from Somalia subspecies *rivae are* known to have cream-colored petals with brownish tips and short fruit. The subspecies *longisiliqua* has yellow flowers and very long fruit.

The shrub can reach 3 meters in height with very swollen roots. *M.rivae is* very similar to *M. arborea* and *M. borziana*.

The Samburu, Turkana, and Rendille people in Kenya give the same name as "*lorsanjo*" for the *M. stenopetala* large and *M. rivae* the much smaller. Likewise, the northeastern Somalis of Kenya call these five species in this area "*wamo*".

A B C

Figure 12. (A) Leaves, (B) Trees, and (C) Fruits *M.rivae*
Source: **http://www.mobot.org/gradstudents/olson/mrivae.html.**

12. *Moringa ruspoliana* Engler

One of the most morphologically different species in the family *Moringaceae*. *M.ruspoliana* originates from northern Somalia to southeast Ethiopia, which almost reaches northeastern Kenya.

This is easily distinguished from all other species in the family *Moringaceae*. The only species that have pinnate leaves. The largest leaf sheet in the family *Moringaceae*, 15 cm in diameter, and is the thickest, hardest and roughest sheet.

M.ruspoliana also stands out because it has the largest flower in the family *Moringaceae*, reaching 3 cm in length. The flowers are pink with a green base and when flowering, the tree looks very similar to *Erythrina*.

M.ruspoliana at a young age forms a thick single root. As the plant ages, its roots swell and become more rounded. Thick roots start coming out on the sides, usually four. Mature plants are 6meter tall trees with an octopus-like system with long, fleshy roots.

A **B** **C**

Figure 13. (A) Trees, (B) Stems and leaves, and (C) Leaves of *M. Ruspoliana*

Source: http://www.mobot.org/gradstudents/olson/mruspoliana.html.

13. Moringa stenopetala (Baker f.) Cufodontis

Most research on the use of *Moringa* besides *M.oleifera,* focuses on this species. This is an important food crop in southwest Ethiopia, where it is cultivated as a food crop.

All moringas have nectar at the base of their leaves and sheets. *M. stenopetala* when cultivated, quickly produces large production, gray stems, and leaves covered with glittering nectar.

Figure 14.Tree *M.stenopetala*

Source: **http://www.mobot.org/gradstudents/olson/bottlespecies.html.**

https://www.ecured.cu/Moringa_stenopetala

e. Tree Species *Moringa*

Mark E. Olson divides into three categories of tree shapes from the 13 species *Moringa* and their distribution area.

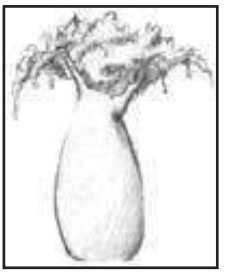
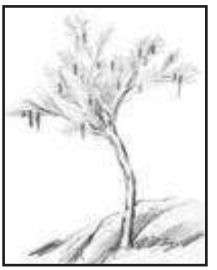
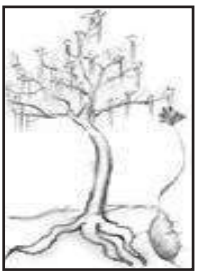
Bottle trees	**Slender trees**	**Trees, shrubs, and plant forms of northeast Africa**
		
• *M. drouhardii*, Madagascar • *M. hildebrandtii*, Madagascar • *M. ovalifolia,* Namibia and Angola • *M. stenopetala*; Kenya and Ethiopia	• *M. Concanensis*, mostly Indian • *M. Oleifera*, Indian • *M. Peregrina*, Red Sea, Arabic, and Africa (Horn section)	• *M. arborea*, Kenya • *M. borziana*, Kenya and Somalia • *M. longituba*, Kenya, Ethiopia and Somalia • *M. pygmaea*, Somalia *northern* • *M. rivae*, Kenya and Ethiopia • *M. ruspoliana,* Kenya, Ethiopia and Somalia

Figure 15. The shape of the tree *M.oleifera* and its distribution area

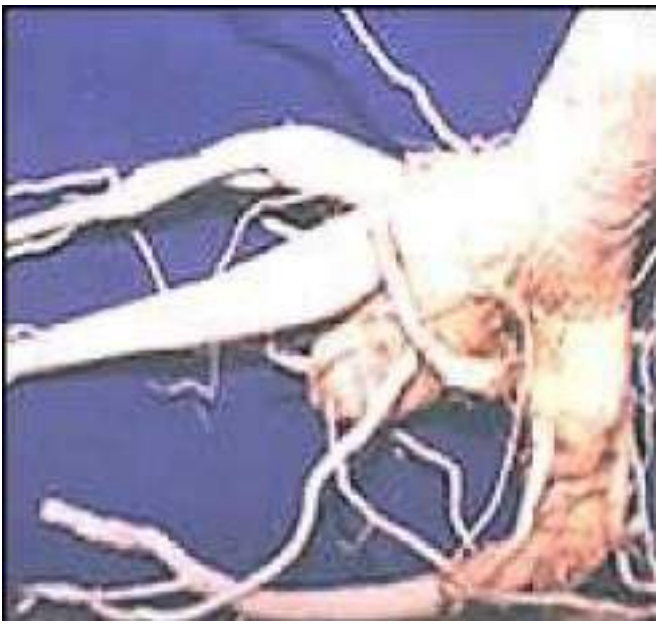
f. Habitat Spread of *Moringa oleifera*

Muhl's study (2009) shows that, although *M.oleifera is currently* found in tropical regions throughout Africa, Southeast Asia, and South America, its origin is located in the sub-Himalayan region in northwest India. Moringa trees do not have a preference for certain habitats but like hot and humid environments. As such it is found in all eco-zone areas from dry savanna to rainforest. Moringa trees generally prefer altitudes below 600 m above sea level. However, in the tropical zone, they have been found growing at altitudes up to 2000m. *Moringa oleifera* thrives in humid tropics or hot dry land, survive in infertile soils, and can tolerate drought. Because of the roots of the tuber tree, the Moringa tree can survive between tropical rain from 250mm to 1,500mm. The susceptibility of trees to frost regulates their natural distribution. They can tolerate mild frost but suffer severe injuries when temperatures drop below -5 ° C, even if only for a moment. Severe frost usually kills mature trees to the root, new shoots usually emerge from the base of the stem the following spring. *Moringa* can grow on most types of soil with a wide pH tolerance from 4.5 to 9 but prefers sandy and alluvial soils. Their vulnerability to waterlogging requires adequate drainage, especially for clay soils.

g. Morphology *Moringa oleifera*

Krisnadi (2015) explains the morphology of *Moringa oleifera* as follows:

1. Root (*radix*)



The root bark is pungent and has a sharp odor, from the inside pale yellow, smoothly striped but bright and transverse. Not hard, irregular shape, the outer surface of the skin is rather slippery, the inner surface is somewhat stringy, the wood part is light brown, or beige fibrous mostly separated. The taproot is white, enlarged like a turnip.

Roots derived from seeds, will expand into tubers, swell, the taproot is white and has a characteristic sharp odor. Trees growing from seed will have deep roots, forming wide taproots and thick fibers. Taproot is not formed on trees that are propagated by cuttings.

2. Rod *(caulis)*

Moringa is a type of shrub that can have stems of 7 - 12 meters. It is a plant that has stems and belongs to a type of woody stems, so the stems are hard and strong. The shape itself is round and the surface is rough. The direction of growth is straight up or commonly called perpendicular *(Erectus)*. Branching on the stem is a branching method *sympodial* where the main stem is difficult to determine because, in subsequent developments, the main stem stops its growth or may lose out and grow faster than its branches. The direction of the branching is upright *(fastigiatus)* because the angle between the trunk and branches is very small so that the direction of growth of the branch is only slightly more upward, but then almost parallel to the main stem.

3. Leaves *(folium)*

Compound leaves, long-stemmed, arranged alternately (*alternate*), leafless leafy (*imparipinnate*), leaf blades when young light green - after adults dark green, the shape of the leaves are ovoid, length 1-2 cm, width 1 - 2 cm, thin weak, obtuse tip and base *(obtusus),* flat edge, pinnate arrangement *(pinnate),* smooth top and bottom surfaces.

A type of leaf stem because it only consists of stems and strands. The petiole is cylindrical with a slightly flattened upper side, thickened at the base, and smooth surface. Wake up round or circular leaves *(orbicularis)*, the base of the leaves is not carved and included in the shape of an ovoid shape. The tip and base of the leaf are rounded *(rotundatus)* where the tip is blunt and does not form an angle at all until the leaf tip is a kind of arc.

The composition of the leaf bone is pinnate *(penninervis)*, where the leaves of Moringa have a mothering bone that runs from the base to the tip, and is a canal of leaf stalks. Besides, from the mother's bone toward the side out the branch bones, so that the structure is like a fin-fin on fish.

Moringa has a flat leaf edge *(integer)* and the leaf blade is thin and soft. Dark green or brownish green, slippery surface *(laevis)*, and waxy membranes *(pruinosus)*. Is an odd-pinnate compound pinnate leaf that is not perfect.

Besides, from the mother's bones to the side out the branch bones, so that the composition is like fins in fish. Moringa has a flat leaf edge *(integer)* and the leaf blade is thin and soft. Dark green or brownish green, slippery surface *(laevis)*, and waxy membranes *(pruinosus)*. The leaves are compound a pinnate odd number of the triple not perfect.

4. Flowers

Flowers appear on the axillary (*axillary*), long-stemmed, rather creamy white petals, spread a distinctive aroma. The flowers are yellowish-white collected in the tops of the institution in the armpit and the stem of the flower stem is green. Panicles droop 10-15 cm, have 5 petals surrounding 5 stamens and 5 *staminodes*. Moringa flowers come out all year with a fragrant scent.

5. Fruit or pods

Moringa fruit bear fruit after the age of 12-18 months. Moringa triangular fruit or pods called *klentang* (Java) with a length of 20 - 60 cm when young is green - after darkness becomes brown, seeds in the pods are round, when young are bright green and turns blackish brown when the pods are ripe and dry. When dry the pods open into 3 parts. In each pod contains an average of between 12 and 35 seeds.

6. Seeds

Round seeds with a brownish semipermeable stomach. The hull itself has three white wings that spread from top to bottom. Each tree can produce between 15,000 and 25,000 seeds/year. The average weight per seed is 0.3 g.

CHAPTER 3. BIOMASS PRODUCTION AND NUTRITION

A. BIOMASS PRODUCTION

Moringa oleifera is the only family species *Moringaceae* that is cultivated as a plant and is now widely planted in parts of the world. *M. oleifera is* cultivated for various purposes such as food, medicines and cosmetics, animal feed, biogas, green manure, biopesticides, bioenergy sources, and others. *M.oleifera* can be used as animal feed because the ability of growth and regrowth is high as a multi-cut forage.

M.oleifera at the beginning of cultivation in Nicaragua, biomass production can reach 120 tons of dry matter/ha/ year with eight cuts after planting one million seeds per hectare (Makkar and Becker, 1999). Furthermore Sánchez *et al.,* (2006[a]) also in Managua, Nicaragua tried to

plant *M.oleifera* at densities of 250,000, 500,000 and 750,000 plants/ha with a cutting frequency of 45, 60, and 75 days. The highest biomass production was obtained at the age of 75 days with the production of fresh materials at each density at the first and second harvests were 100.7 and 57.4 tons/ha/year, and dry matter production 24.7 and 10.4 tons/ha/year. In the first year, with a density of 750,000 plants/ha, the highest biomass production was obtained with the production of fresh ingredients 88.0 tons/ha and dry matter 18.9 tons/ha. In the second year, with the density of 500,000 plants/ha, the highest biomass production was obtained with the production of fresh material 46.2 tons/ha and dry matter 8.1 tons/ha.

Manh *et al.,* (2005) in the Mekong Delta, Vietnam tried to plant *M. oleifera* at a spacing of 40 × 20, 40 × 30, and 40 × 40 cm with a harvest age of 70, 115, and 157 days. The highest biomass production was obtained at a spacing of 40 × 30 with a harvest age of 70 days with the production of fresh material 11.1 tons/ha/harvest and dry matter 2.1 tons/ha/harvest (Table 1).

Table 1. Production of biomass *M.oleifera* based on spacing and age of harvest.

Harvest Age (days)	Spacing (cm)	Fresh Material Production (tons/ha/ harvest)	Dry Material Production (tons/ha/ harvest)
70	40 × 20	8.63	1. 63
	40 × 30	**11.1**	**2.10**
	40 × 40	7.63	1.44
115	40 × 20	7.60	1.34
	40 × 30	7.91	1.40
	40 × 40	6.25	1.10
157	40 × 20	6.28	1.05
	40 × 30	6, 34	1.06
	40 × 40	4.88	1.06

Nouman *et al.,* (2013) in Faisalabad, Pakistan tried to plant seeds *M.oleifera* in a polybag to determine biomass production per plant. Plants are *M.oleifera* maintained for three months then cut to make uniform growth, then cut every month at a cutting height of 30, 90, and 150 cm. The highest biomass production of 472 g/plant was obtained in August (hot rainy season) at a cutting height of 30 cm. The lowest biomass production of 113.54 g/plant was obtained when the plants were harvested at the age of three months after planting at a cutting height of 150 cm.

Basra *et al.,* (2015) have examined the effect of spacing and cutting intervals on biomass production and nutritional quality of *M.oleifera* in Faisalabad, Pakistan *M.oleifera* seeds are planted on plantation soils with a spacing of 15 × 30 cm (narrow) and 15 × 60 cm (broad) with cutting intervals of 15, 20, and 30 days. The highest fresh yields in the first and second years were recorded at 6.40 and 7.57 tons/ha, at narrow plant spacing and 30-day cutting intervals. However, the highest growth rate when plants are harvested at 15-day cutting intervals. The highest nutrient content with nitrogen content (6.11%), potassium (9.14%), and ascorbic acid (89.73 µg/g) were obtained when the plants were harvested at 30-day cutting intervals with large plant spacing. The highest phosphorus content (3.40%) at 20-day cutting intervals, while the highest calcium (2.53%) content is obtained when harvested at 30-day cutting intervals at narrow plant spacing. In conclusion, to obtain maximum biomass production with better nutritional composition, *M.oleifera* as animal feed should be planted at a narrow distance (15x30 cm) with an optimum cutting interval of 30 days.

González-González and Crespo-López (2016) tried to see the effect of organic-mineral fertilization on the productive performance of *M.oleifera*, on Red Ferralitic reduction soils in San José de las Lajas Province, Mayabeque Cuba. *M.oleifera was* given fertilizer T1 = 0.6

tons/ha with the formula 9: 9: 12 (54 kg N, 54 kg P_2O_5, and 72 kg K_2O) at planting and 130 kg/ha and urea (61 kg N) at each cutting of forage; T2 = 0.3 tons/ha with the formula 9: 9: 12 (27 kg N, 27 kg P_2O_5 and 36 kg K_2O) with 4 tons/ha manure on planting and a mixture of 65 kg urea (30 kg N) with 2 tons/ha of manure at each cut; and T3 = 8 tons/ha of manure during planting and 4 tons/ha of cow manure at each cut. The organic-mineral (T2) combination produces the highest dry matter production of 20.11 tons/ha, compared to controls producing only 10.57 tons/ha. Annual dry matter production is also highest at T2 of 11.34 tons/ha. It was concluded that organic-mineral fertilizer could be used to increase the production of *M.oleifera*.

Fadiymu *et al.,* (2011) planted *M.oleifera* in the dry and dry season in the Nigerian rainforest zone. *M.oleifera was* cut at 4, 5, 6, and 12-week intervals with the cutting height were 50, 100, and 150 cm. In the rainy season, harvests with a cutting interval of 4 to 6 weeks at a cutting height of 150 cm give the highest yield. Whereas the cutting interval of 12 weeks with a cutting height of 150 cm produces the lowest harvest. In the dry season, the treatment response is very different, with a 12-week harvest interval with a cutting height of 100 cm giving the highest yield. It was concluded that harvest management must vary according to season. In the rainy season, *M.oleifera* 4-6 weeks should be harvested at intervals with a cutting height of 100 to 150 cm. Conversely, in the dry season, the cutting interval should be extended to 12 weeks with a cutting height of 100 cm.

Prisdiminggo *et al.* (2011) have also evaluated the production and quality of Moringa forage in BPTP-NTB Gardens from January to April 2011. Moringa has planted in 2 × (1.7 × 7.5 m) beds with a spacing of 10 × 10 cm. Seeds are sowed after soaking for one night. Urea is given as much as 250 kg/ha 30 days after planting (HST). Power grows at the age of 10 days reaching 43% and growth power reaches 86% at 20 days after planting. At the age of 90 days, the plant

mortality rate was 14%, plant height reached 168.3 cm, production of fresh biomass planted 210 g, dry matter production of fresh biomass per plant 26 g with the crude protein content of 14.6%, and organic matter content of 95.0 % and total biomass production of 8.7 tons/ ha. Based on this, Moringa has the potential to be developed as a new source of animal feed to increase the availability of animal feed in West Nusa Tenggara.

Based on the results of the aforementioned studies, it can be concluded that Moringa is a multi-cutting plant potentially developed as a new animal feed source that does not compete with humans. The production of biomass produced can support the availability of animal feed, especially as a source of forage. To get maximum production, it is necessary to manage (management) with good regard to plant density, cutting intervals, cutting age, cutting height, type and dose of fertilization, season, and ecological zone.

B. NUTRITIONAL CONTENT

Moringa oleifera is a plant in the tropics and subtropics (Anwar *et al*., 2007), tolerant of drought and grows during the dry season (Duke, 1983). Moringa leaves show low water content, lower phenol percentage (3-4%), high protein content (13-14%), and minerals (11-13%). Moringa leaves also contain: calcium (2.9 - 3%), potassium (1%) and iron (50 - 80mg / 100g dried leaves) (Juliani *et al*., 2008).

Moyo *et al*., (2011) have evaluated the nutritional characteristics of leaves *Moringa oleifera* Lam, especially as animal feed. Dry leaves contain 30.30% crude protein (Table 2) with 19 amino acids (Table 3). The highest amino acid content is alanine (3.03%) and the lowest cysteine (0.01%). The dried leaves contain macro and micro minerals (Table 4), the highest respectively Ca (3.65%) and Fe (490 mg/kg). Dry leaves contain 17 fatty acids with the highest content of α-linolenic acid (44.57%) (Table 5). The low antinutrient content is tannin 0.32%

and total polyphenol 2.02% (Table 2). While the results of the analysis of the vitamin content of *Moringa* leaves based on the United States Department of Agriculture (2015) are presented in Table 6.

Table 2. Chemical composition of dried *Moringa oleifera* leaves.

Nutrition Content	Dried Leaf	Standard Error
Water content (%)	9,533	0,194
Crude protein (%)	30,29	1,480
Fat (%)	6,50	1,042
Ash (%)	7,64	0,433
Neutral detergent fiber (%)	11,40	0,425
Acid detergent fiber (%)	8,49	0,348
Acid detergent lignin (%)	1,8	2,204
Acid detergent cellulose (%)	4,01	0,101
Tannin (mg /g)	3,12	0,104
Total polyphenols	2,02	0,390

Source: Moyo *et al.,* (2011).

Table 3. The composition of amino acids dried *Moringa oleifera* leaves.

Amino Acid	Total (average%)	Standard Error
Arginine	1,78	0,010
Serine	1,087	0,035
Aspartic Acid	1,43	0,045
Glutamic Acid	2,53	0,062
Glycine	1,533	0,060
Threonine *	1,35	0,124
Alanine	3,033	0,006
Tyrosine *	2,650	0,015
Proline	1,203	0,006
HO-Proline	0,093	0,006
Methionine *	0,297	0,006
Valine *	1,413	0,021
Phenylalanine*	1,64	0,006
Isoleucine *	1,77	0,006
Leucin *	1,96	0,010
Histidine *	0,716	0,006
Lysine *	1,637	0,006
Cysteine	0,01	0,000
Tryptophan *	0,486	0,001

Description: * = Essential amino acids

Source: Moyo *et al.,* (2011).

Table 4. The mineral content of dried *Moringa oleifera* leaves.

Nutrition Content	Dried Leaf	Error
Macro mineral (%):		
• Calcium (Ca)	3,65	0.036
• Phosphorus (P)	0,30	0.004
• Magnesium (Mg)	0,50	0.005
• Potassium (K)	1,50	0.019
• Sodium (Na)	0,164	0.017
• Sulfur (S)	0,63	0.146
Micro minerals (mg/kg):		
• Zinc (Zn)	31,03	3.410
• Copper (Cu)	8,25	0.143
• Manganese (Mn)	86,8	3.940
• Iron (Fe)	490	49.645
• Selenium (Se)	363,00	0.413
• Boron (Bo)	49,93	2.302

Source: Moyo *et al.,* (2011).

Table 5. Composition fatty acids of dried *Moringa oleifera* leaves.

Fatty acid	Total (%)	SE
Ether extract	6,50	0,041
Capric (C10:0)	0,07	0,064
Lauric (C12:0)	0,58	0,402
Myristic (C14:0)	3,66	1,633
Palmitic (C16:0)	11,79	0,625
Palmitoleic (C16:1c9)	0,17	0,056
Margaric (C17:0)	3,19	0,155
Stearic acid (C18:0)	2,13	0,406
Oleic (C18:1c9)	3,96	2,000
Vaccenic (C18:1c7)	0,36	0,038
Linoleic (C18;2c9,12(n-6)	7,44	0,014
α-Linolenic (C18:3c9,12,15(n-3)	44,57	2,803
g-Linolenic (C18:3c6,9,12 (n-6)	0,20	0,013
Arachidic (C20:0)	1,61	0,105
Heneicosanoic (C21:0)	14,41	0,194
Behenic (C22:0)	1,24	0,383
Tricosanoic (C23:0)	0,66	0,025
Lignoceric (24:0)	2,91	0,000
Total saturated fatty acids (SFA)	43,31	0,815
Total mono unsaturated fatty acids (MUFA)	4,48	1,984
Total poly unsaturated fatty acids (PUFA)	52,21	2,792
Total Omega-6 fatty acids (n-6)	7,64	0,012
Total Omega-3 fatty acids (n-3)	44,57	2,805
PUFA: SFA (PUFA: SFA)	1,21	0,096
n-6/n-3	0,17	0,016
PUFA: MUFA (PUFA: MUFA)	14,80	7,168

Source: Moyo *et al.,* (2011).

Table 6. Vitamin of *Moringa oleifera* leaves.

Vitamin	Unit	Content per 100 g
Vitamin C, total ascorbic acid	Mg	51,700
Thiamine - Vitamin B1	Mg	0,257
Riboflavin - Vitamin B2	Mg	0,6600
Niacin - Vitamin B3	Mg	2,220
Pantothenic acid - Vitamin B5	Mg	0,125
Pyridoxine - Vitamin B-6	Mg	1,200
Folate, total	µg	40
Folic Acid	µg	0
Folate, food	µg	40
Folate, DFE	µg	40
Vitamin B-12	µg	0
Vitamin A, RAE	µg	378
Retinol	µg	0
Vitamin A, IU	IU	7564
Vitamin D (D2 + D3)	µg	0
Vitamin D	IU	0

Source: USDA (2015). http://ndb.nal.usda.gov

Ferreira *et al.,* (2008) has reviewed the nutritional properties of leaves *M. oleifera* for humans and animals. *Moringa oleifera (Moringaceae)* is a cosmopolitan tree that grows in many tropical countries and has been used by countless people because of its diverse nutritional and pharmacological applications. Young leaves, flowers, and pods are common vegetables in Asian foods. All parts of this plant are renewable sources of tocopherol (γ and α), phenolic compounds, ß-carotene, vitamin C, and total protein, including essential amino acid sulfur, methionine, and cysteine. The protein and fat content of the seeds is higher than those reported in grains and soybeans. Unsaturated fatty acids, especially oleic acid, carbohydrates, and

minerals present in the seeds in reasonable quantities. In general, plants have anti-nutrient substances even in low concentrations. The seeds have glucosinolate (65.5 µmol/g dry matter), phytates (41g/kg). The leaves have a considerable amount of saponins (80g/kg), but the number of phytates and tannins is low (21g/kg and 12g/kg). Taking into account the excellent nutritional properties, low toxicity of seeds, and the excellent ability of plants to adapt to poor soil and dry climate, *M.oleifera* can be an alternative legume seed source of high-quality protein, oils, and antioxidant compounds, and treatments water (*water treatment*) in rural areas where water sources are not available.

The use of moringa as animal feed ingredients is different from the use of moringa for human consumption. Livestock can consume Moringa directly in the form of leaves, along with flowers, petioles, twigs, and soft small stems, as well as the fruit. Utilizing Moringa for human consumption, the leaves must be cleaned from the petioles, twigs, and small stems, as well as the fruit. Parts of the moringa have different nutritional content. The results of the review of Nouman *et al.,* (2014) showing the nutritional content of the different parts of Moringa are presented in Table 7.

Table 7. Nutrient content of *M.oleifera* by its parts.

Parts of Moringa	DM	PK	L	SK	Ash	NDF	ADF
Leaves (*fodder*)	7,8	21,87	6,5	4,5	12	8	6
Stems (*fodder*)	8,0	8,75	2	20	12,5	28	21
Leaves and stems (*fodder*)	7,6	15,31	3	14,5	12	16	12
Leaves (*tree*)	8,6	23,51	3	7,5	13,5	11	6
Stems (*tree*)	8,6	10,93	1	26,5	10,5	36	26
Leaves and stems (*tree*)	9,2	16,41	2,5	17,5	11	21	15

Source: Nouman *et al.,* (2014)

Table 2 shows that the nutrient content in the form of a *tree* is better compared to *fodder* (a term for plants used as animal feed). The content of dry matter, crude protein, ADF, and NDF of *the tree* is higher compared to *fodder*. The fat content of the *tree is* also lower compared to *fodder*, but the crude fiber content of the *tree* is higher compared to the *fodder*. Ash content depends on the parts.

Utilization of Moringa leaves as food for humans, Krisnadi (2015) quoted Dr. Gary Bracey, a writer, entrepreneur, motivator, and health expert in Africa, published in *moringadirect.com*, that Moringa leaf powder contains:

- Vitamin A, 10 times more than carrots.
- Vitamin B1, 4 times more than pork.
- Vitamin B2, 50 times more than sardines,
- Vitamin B3, 50 times more than nuts,
- Vitamin E, 4 times more than Corn oil,
- Beta Carotene, 4 times more than carrots,
- Iron, 25 times more than spinach,
- Zinc, 6 times more than almonds,

- Potassium, 15 times more than bananas,
- Calcium, 17 times more than Milk,
- Protein, 9 times more than Yogurt,
- Amino Acid, 6 times more than garlic,
- *PolyPhenol,* 2 times more than red wine.
- Fiber (*Dietary Fiber*), 5 times more than vegetables in general.
- GABA (*gamma-aminobutyric acid*), 100 times more than brown rice and is a good source of protein, vitamins, β-carotene, amino acid *phenolics,* and various other essential amino acids. *Moringa* provides a rich and rare combination of *zeatin, quercetin, β-sitosterol,* acid *caffeoylquinic,* and *kaempferol*.

CHAPTER 4. THE UTILIZATION OF MORINGA LEAVES AS ANIMAL FEEDS

Moringa oleifera has become an important crop in the world such as in India, Ethiopia, the Philippines, and Sudan. *M.oleifera is* now planted in the west, east, and South Africa, tropical Asia, Latin America, the Caribbean, Florida, and the Pacific Islands. Almost all parts of the tree *M.oleifera* can be eaten and used as medicine. *M.oleifera* has long been consumed by humans since ancient Roman and Greek times. Uses of *M.oleifera* as food and non-food ingredients are presented in Table 8.

Table 8. Various uses of *M.oleifera* as food and non-food.

Uses as Food, Nutrition, and Medicine	Non-Food, Industrial and Environmental
1. Uses Antimicrobial/biocidal (all parts of the plant), against bacteria, viruses, fungi, parasites.	1. Cleaning Household (crushed leaves)
2. Honey (flower nectar)	2. Agent coloring for wood
3. Oil (seeds, produce 30-40% oil), sweet without stickiness, not drying	3. Fences (living trees)
4. Vegetable oil	4. Biogas (leaves)
5. Green vegetables, roast, flour/ powder (for tea and curry)	5. Animal feed (processed leaves and seeds)
6. Nutrition: antioxidants, highly digestible proteins, carotenoids, energy, vitamins, and minerals	6. Fertilizer
7. Blood circulation/endocrine disorders	7. Leaf nutrition (taken from leaves)
8. Disorders digestion	8. Honey and sugar clarification (seed flour)
9. Inflammation/swelling	9. Green fertilizer (leaves)
10. Immunity/immune	10. Machine Lubricants (oils from seed)
11. Nerve disorders	11. Perfume and hair care products
12. Reproductive health Reproductive	12. Flocculation and water purification (seed flour)
13. Skin health	
14. Therapy /cancer	

M.oleifera has been cultivated and can be used as animal feed. Some parts of Moringa which have been used by humans can also be used as animal feed. Foidl *et al.,* (2011) have explained the parts of *M.oleifera* that can be utilized as animal feed ingredients are presented in Figure 16.

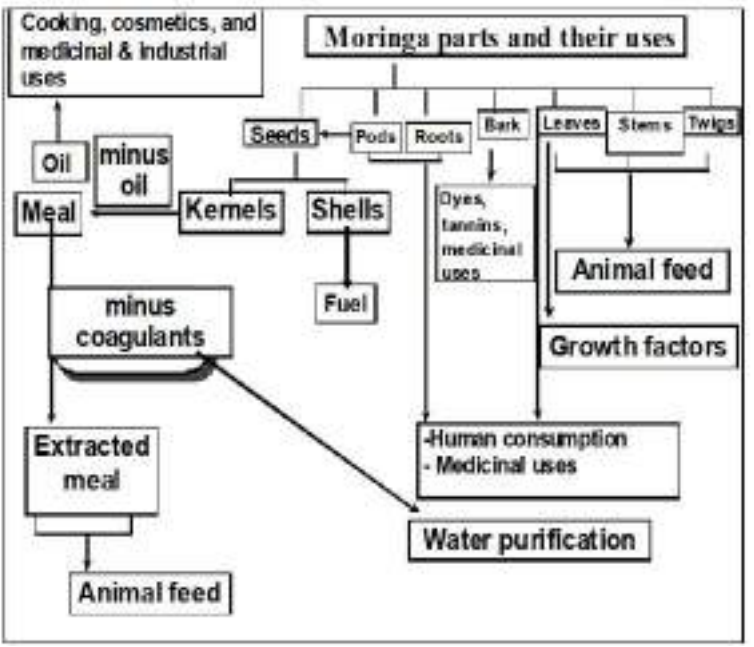


Figure 16. Parts of *M.oleifera* and their use (Foidl *et al.*, 2001).

A. THE UTILIZATION OF MORINGA LEAVES AS A FEEDS FOR RUMINANT

1. Goat and Sheep

Moringa oleifera has been used by Aregheore (2002) to increase live-weight gains goat Anglo-Nubian crossbreed × Local Fiji. The goat aged 7-9 months with a bodyweight of 9.45 ± 0.09 kg were given batiki grass. The goats were then supplemented with 20, 50, and 80% M.*oleifera* from the total forage needs. The goats supplemented with *M.oleifera* produce a live-weight gain of 57, 78, and 86 g/kg0.75 per day, while those that are not supplemented are only 55 g/ kg0.75 per day. The use of *M.oleifera* at a rate of 20 to 50% of the total daily forage needs, can be used as a cheap protein supplement in goat fed with batiki grass-based.

The feed supplementation technology molasses block *Moringa leaf*-based has been applied by Soetanto *et al.,* (2011) on the people's goat farm in Pasrujambe Village, Pasrujambe District, Lumajang Regency, East Java. The formulation of molasses blocks used were molasses (38%), moringa leaves (25%), pollard (6%), bran (7%), urea (6%), salt (5%), minerals (3%), and cement (10%). The goat supplemented with molasses blocks gained a weight gain of 100 g/head/day which can be converted as an additional profit for four months of Rp. 125,000 per tail.

The feed supplement technology molasses multi-nutrient block Leguminosae-tree-based has also been developed (Adegun *et al.,* 2011) and tested on West African Dwarf sheep in Nigeria. Supplements Molasses multi-nutrient block used each contain 30% *Moringa oleifera* (MMNB), *Gliricidia sepium* (GMNB), and *Leucaena leucocephala* (LMNB) (Table 9). MMNB-based supplementation can improve performance better and not cause health problems in sheep. Feed conversion obtained respectively are 11.6, 12.6, 12.4. and 18.3 (control).

Table 9. Composition of *molasses multi-nutrient block.*

The content	**MMNB**	**GMNB**	**LUMNB**
Molasses	40	40	40
M.oleifera leaf flour	30	-	-
Gliricidia leaf flour	-	30	-
Leucaena leaf flour	-	-	30
Urea	10	10	10
Salt	5	5	5
Cement	15	15	15
TOTAL	**100**	**100**	**100**

MMNB = Moringa Multi Nutrient Block, GMNB = Gliricidia Multi Nutrient Block, and LMNB = Leucaena Multi Nutrient Block

Asaolu *et al.,* (2012) also used dried leaves *Moringa oleifera* (MOR), *Leucaena leucocephala* (LEU), and *Gliricidia sepium* (GLI) as feed supplement on West African Dwarf rams which were fed cassava peel rations. The supplementation control (MC) in the form of concentrate the mixture of peanut with wheat bran (50:50). The MOR supplementation increased the average body weight of 20.83 g/head/day, proportional to the value of MC supplemented by an average of 21.43 g/head/day. Feed and protein are more efficiently used by MOR supplemented animals, with a value of feed conversion ratio (FCR) and protein efficiency ratio (PER) of 14.94 and 1.87, significantly lower than those of animals supplemented with MC with values of 16.54 and 2, 74. The MOR has high potential as a substitute for expensive concentrate feed as a feed supplement for various fibrous plant wastes, such as cassava peel.

Asaolu (2012) then tried to determine the optimum protocol and conditions for making *Moringa Multi-Nutrient Block* (MMNB) which was considered suitable for adoption by ruminant farmers in Nigeria. He tried to make MMNB formulas that were suitable in terms of violence, cohesiveness, and cost while aiming for nutritional complementarity between various ingredients. Eight formulas that were tested contained leaf flour *M.oleifera*, wheat bran, urea, salt, and cement as a binder. The blocks were considered violence and cohesiveness for 7, 14, and 21 days. The cost implication of the block formulation uses market prices of raw materials that apply in Nigeria, namely *Naira* (N). The most suitable MMNB formulas in terms of hardness, compactness, and cost are leaf flour *M.oleifera* 35.0%, wheat bran 37.0%, cement 15.0%, and lime powder, urea, and salt respectively 5.0 %. The formulation process involves five different blends. Leaf flour

M.oleifera, wheat bran, and lime powder are measured and mixed to form Mix 1. Urea is measured and dissolved in water to form Mix 2, while salt and cement are measured and mixed with water in a ratio of 1: 2 to form Mix 3. Mix 2 was added to Mix 1 to form a paste (Mix 4), and Mix 3 was then added to Mix 4. Adequate water was added to form a homogeneous semi-solid mixture forming Mix 5 which was ready to be printed. The optimum amount of water for the most homogeneous mixture is 6.5 liters. Mixing cement and salt with water with a ratio of 1: 2 (weight/volume), to produce a mixture of more homogeneous materials, have a positive effect on the hardness and compactness of the block. The urea is more soluble in water than mixed with salt and requires little water. More complete urea dissolution before being incorporated into MMNB is an effort to control urea to reduce the risk of urea toxicity to livestock. During the dry season in the Nigerian savanna zone, air drying for 21 days produces MMNB with dry matter content which is considered quite good. MMNB is formulated to contain enough energy, protein, and minerals to meet the needs of ruminants. The potential and prospects of MMNB which are formulated as ruminant animal feed supplements in the dry season are quite promising and are likely to be adopted by farmers because of the simplicity in their production technology.

Asaolu and Okewoye (2013) then used *M.oleifera* in the form of *Moringa Multi-Nutrient Block* (MMNB) as a feed supplement on West African Dwarf goats fed cassava peel basal rations. The goats supplemented 47 g/head/day MMNB significantly increased the intake of cassava peel dry matter by about 29% (191.66 vs 148.66 g/head/day) and crude protein intake 16.66 vs 4.87 g/head/day. The digestive coefficient of dry matter and crude proteins was 74.58% and 69.10%, respectively, significantly higher than those without supplementation.

M.oleifera has also been used to supplement young Red Sokoto male goats (Raji and Njidda, 2014). The Red Sokoto goats that are used are aged 5-10 months with a bodyweight of 7.0 - 9.0 kg given forage *Cynodon dactylon* as a basal ration. The feed supplement used contains *M.oleifera* at 12.5, 25, 37.5, and 50%. The use of *M.oleifera* to a level of 50% in feed supplement feed can increase gonadal and extragonadal sperm reserves, sperm motility, and semen pH of Red Sokoto male goats

M.oleifera leaves have been tried to replace elephant grass (*Pennisetum purpureum*) as a forage feed in growing Bengal male goats (6.98 ± 0.86 kg BW) (Sultana *et al.,* 2015). The proportion of *moringa* leaves used to replace elephant grass is: T1 = (100% *M.oleifera*), T2 = (75% *M.oleifera* + 25% elephant grass), T3 = (50% *M.oleifera* + 50% elephant grass) , T4 = (25% *M.oleifera* + 75% elephant grass), and T5 = (100% elephant grass) as a control. The trial results showed that dry matter, crude protein, and an ash content of rations increased with the increasing proportion of *M.oleifera*, but the opposite occurred in the content of organic matter and ADF. The intake of dry matter was significantly higher in the ration in the form of *M.oleifera* alone (T1) than a mixture of *M.oleifera*-elephant grass and elephant grass singly. Crude protein intake increases according to the higher inclusion level of *moringa* leaves in the ration. Digestibility of dry matter and organic matter was significantly higher in the ration *M.oleifera* singly than in other experimental rations. The digestibility of crude protein increases linearly with the increase of *M.oleifera* in the ration. Nitrogen retention was significantly higher in the ration *M.oleifera* single and the mixture of *M.oleifera* leaves-elephant grass and elephant grass singly. The increase in average weight-life follows the same trend with the retention of nitrogen shows that nitrogen retention in all treatment groups was above the level of the maintenance requirement animals. It was concluded

that, and *M.oleifera* could replace elephant grass up to 75% in an elephant grass-based goat rations.

2. Cattle and Buffaloes

M.oleifera have leaves been used to substitute cottonseeds made in the form of cottonseed cakes as feed supplements for dairy cows (Zebu × Friesian) on community farms in Tanzania (Sarwatt *et al*., 2004). Dairy cows are fed basal fresh elephant grass and concentrate. Moringa leaves can be used up to 1.65 kgDM can replace 1.23% cottonseed in a dairy ration without affecting milk production. Replacement of cotton seeds with Moringa leaves does not affect the total solids, fat, milk protein, and ash content of milk produced. Moringa leaves have a higher dry matter digestibility (820 g/kgDM) than cotton seeds (697 g/kgDM). Degradation Dry matter of Moringa leaves is higher than cotton seeds. Thus, the use of Moringa leaves can substitute more expensive cotton seeds which can increase the total solids, fat, milk protein, and ash content of milk.

M.oleifera has been used to supplement the Creole Reyna dual-purpose dairy cows fed *Brachiaria brizantha* in the dry season in Nicaragua (Sánchez *et al*, 2005). *M.oleifera* used 2 kg of DM/day and 3 kg of DM/day. Giving Moringa leaves 2 kgDM/day and 3 kgDM/day significantly increases intake of dry matter, digestibility of nutrients and milk production without affecting milk composition (fat, protein, and total solids) or organoleptic characteristics of milk (odor, taste, and color). Thus, Moringa leaves can be used as a protein supplement in low-quality rations, especially in dual-purpose dairy cows during the dry season.

M.oleifera has been used as an alternative to commercial concentrate feed in crossbred cattle in West Africa (Nouala *et al*., 2009). N'Dama pure cattle and N'Dama × Jersey are given two kinds of basal rations, namely *stover baby corn* and peanut

hay. The ration was then supplemented with concentrate feed and *M.oleifera* with levels 0, 10, 20, 30, and 40% respectively. The results showed that *M.oleifera could* potentially be used as a supplementary feed instead of concentrated feed.

M.oleifera leaves have also been used as feed ingredients to improve the efficiency of beef cattle reproduction on people's farms (Rahardja *et al*., 2010). The administration of Moringa leaves gives a significantly higher body weight compared to those without Moringa leaves (0.48 kg vs. 0.39 kg). The birth weights of calves in the treatment group were also significantly higher compared to controls (16.2 kg vs. 13.4 kg), but the child mortality rate was not significantly different between the two treatments. This data shows that the use of Moringa leaves has a positive impact on body weight gain for pregnant cows and birth weights of calves. Latief *et al.,* (2010) have also used Moringa leaves as feed on Bali's cows to speed up lust postpartum. The results showed that oestrus for postpartum Bali cows given Moringa leaves was faster than those without Moringa leaves (128.3 ± 10.3 days vs. 148.7 ± 10.0 days).

Mendieta-Araica *et al.,* (2009) have tried to make silage combinations mix of Moringa leaves *(Moringaoleifera),* elephant grass *(Pennisetum purpureum* cv Taiwan), and sugarcane *(Saccharum officinarum).* It was concluded that *M.oleifera* can be used as a high-quality silage component also containing high crude protein. Mendieta-Araica *et al*., (2011[a]) then tried to compare the leaves of *M.oleifera* in fresh form and silage in dairy cows in the dry season in Managua, Nicaragua. Dairy cows are given the main feed of elephant grass supplemented with leaves *M.oleifera* in fresh and silage form. Production of milk did not differ between the provision of fresh silage form. Milk production averages 13.7 kg/head/day. This shows that the use of fresh Moringa leaves and in the form of silage can be used as a source of forage during the lean

season. The composition, color, and appearance of milk are also the same, although in the provision of fresh Moringa leaves have a taste and aroma of grass, but it does not differ organoleptically. Mendieta-Araica *et al*., (2011[b]) then also tried to use *M.oleifera* leaves to replace 20% of soybean meal in the concentrate of dairy cows in Masaya, Nicaragua. Consumption of dry matter, organic matter, neutral detergent fiber, and acid detergent fiber did not differ significantly between treatments. Average daily milk production was significantly higher in cattle fed soybean meal compared with leaf flour *M.oleifera* and iso protein and energy concentrate with moringa leaves. Locally produced moringa leaves can, with the same protein and energy content, can replace commercial ingredients in dairy cow concentrates.

Roy *et al.,* (2016) have also evaluated the intake, digestibility, and growth performance of local BLRI-1 (BCB-1) bulls in Bangladesh fed with plants *M.oleifera,* Indian Sweet Jumbo (*Sorghum bicolor* As *Jumbo*), and silage corn. The daily dry matter intake of bulls given the *M.oleifera* leaves was significantly higher compared to those given Jumbo or corn silage or AS. Similar trends in crude protein intake and dry material intake. Feeding *M.oleifera* leaves had an average daily increase of 376g significantly higher than that of corn silage and jumbo (289g and 218g) with an average feed conversion efficiency of 8.85, 11.52, and 13.08. *Moringa oleifera* has a higher nutritional value and lower production costs compared to jumbo corn and corn silage.

Moringa oleifera is a promising source of antioxidants and animal feed, because of the significant amount of protein, vitamins, carotenoids, and polyphenols, and the number of anti-nutritional factors that can be ignored. Cohen-Zinder *et al.,* (2017) have tested whether the ensilage process will maintain the antioxidant capacity of plants *M.oleifera*, and assessed whether silage *M.oleifera*

can be used as a substitute for corn silage, will provide health-enhancing properties that affect milk production in cattle cash. *M.oleifera* silage shows a higher antioxidant capacity compared to fresh and dried plants. Giving *M.oleifera* silage in dairy cattle rations can replace 263 g of corn silage/kg in ration. Cows given *M.oleifera* silage had higher milk production and antioxidant capacity and a lower number of milk somatic cells compared to controls during the lactation stage. These findings indicate that the ensilage process *M.oleifera* is the right practice to improve the health and production of dairy cows.

Utilization of leaves *M.oleifera* has also been carried out in buffalos Nili-Ravi (Nisa *et al*, 2013). The administration of Moringa leaves to the Nili-Ravi buffalo at the beginning of lactation, apparently not only increases the intake of nutrients and digestibility but also increases milk production. Dried *M.oleifera* (DMOL) leaves have also been used as a starter feed for buffaloes in breastfeeding (Elaidy *et al.*, 2017). Buffalo calf are given hay *ad libitum* and starter ration. The starter rations are then replaced with DMOL 5, 10, 15, and 20%. Replacement of up to 15% of buffalo starter rations with DMOL increases the growth performance of nursing buffaloes, compared to 20% replacement and control.

3. Rabbit *(Pseudo Ruminant)*

Evaluation of the use of the *M.oleifera* leaves flour on the digestibility of nutrients, growth, carcasses, and blood index in weaning rabbits was done by Nuhu (2010). The M.oleifera leaves flour can increase daily body weight gain, dry matter digestibility, and crude protein. The use of the *M.oleifera* leaves flour to a level of 20% is not toxic to rabbits. The *M.oleifera* leaves flour has the potential to reduce cholesterol in blood and meat, has the potential to produce fat (lean) carcasses, and reduce fat deposition (fat) in rabbit muscle. The *M. oleifera* leaves have

also been used by Djakalia *et al.,* (2011) to assess the growth performance and health status of weaning rabbits. Rations were used in three kinds, namely *M.oleifera* 3%, mix *M.oleifera* 1.5%: the standard feed of 1.5%, and 3% standard feed. The best results were obtained in rabbits fed rations containing supplement feed *M.oleifera*. Abu et al., (2013) also used *M.oleifera* leaves to assess the morphometry of testes and the sperm quality of male rabbits. Utilization of leaves *M.oleifera* to a level of 15% in the ration no adverse effects on morphometry of testes and sperm quality in the epididymis of male rabbits.

B. THE UTILIZATION OF MORINGA LEAVES AS A FEEDS FOR NON-RUMINANT

1. Poultry

M.oleifera leaf meal (MOLM) has been used to substitute sunflower seed flour (SSM) as a source of protein in the diet of laying hen commercial strain by Kakengi *et al.,* (2007) in Tanzania. MOLM is used to replace SSM reciprocally. Rations containing SSM at levels 20, 15, 10, and 0% were replaced with MOLM at levels 0, 5, 10, and 20%. MOLM can replace SSC up to 20% without having a detrimental effect on laying hens in the production phase (*laying*). Giving at the 10% level is the most optimal, adding MOLM above 10% requires a high-energy ration for better utilization.

The effect of using leaf flour *M.oleifera* (MOLM) in rations based on *cassava chips* (cassava chips) was evaluated by Olugbemi *et al.,* (2010). It uses a cassava chip (CC) ration with a combination of various percentages of MOLM. The use of MOLM does not affect feed consumption, feed conversion ratio, and egg production percentage. The cost of feed per kilogram, the cost of feed per kilogram of egg production decreases with the inclusion of MOLM. The highest egg production on the use of 10% MOLM.

Based on the research results of Kakengi *et al.,* (2007) and Olugbemi *et al.,* (2010), the utilization of leaf flour *M.oleifera* in laying hens at a rate of 10% did not negatively influence the productive performance of laying hens. The use of higher levels (15% and 20%) is not expected to produce a detrimental effect on the laying phase.

M.oleifera leaf meal has been used by Sjofjan (2008) in broiler feed to assess the appearance of broiler strain Lohmann production. The level of use of leaf flour *M.oleifera* in feed is 0, 2.5, 5.0, 7.5, and 10%. The use of leaf flour *M.oleifera* up to 10% in feed does not harm the appearance of broiler production.

Gakuya *et al.,* (2014) have also utilized *M.oleifera* leaf meal (MOLM) at different levels in broiler chickens. Starter and finisher rations are formulated using raw materials obtained from local feed producers. MOLM is added in rations at the rates of 0% (T1), 7.5% (T2), 7.5% (T3) (without Methionine and Lysine), 15% (T4) and 30% (T5). Feed consumption, feed conversion ratio (FCR), weight gain, lipid profile, abdominal fat thickness, and digestibility of the ration were evaluated. The crude protein content of MOLM is 23.33%. The weight gain was significantly different between the various rations, with the highest body weight gain at T1 of 1,464 grams and the lowest at T5 ration of 500 grams. Supplementation of MOLM at levels above 7.5% reduces ration consumption and digestibility of dry matter. Abdominal fat thickness is significantly higher at T1 compared to T2, T4, and T5. Male chickens have *High-Density Lipid* (HDL) which is much higher than female chickens at T2, T3, and T4. The carcass yellow increases with increasing levels of MOLM. The use of MOLM in rations is well tolerated to the level of use of 7.5%. Use at higher levels will affect weight gain, feed consumption, and digestibility. The yellow color in the carcass still needs further research.

2. Pigs

M.oleifera leaf extract has been used by Oliver *et al.,* (2015) in piglets were weaned. The fermented Moringa leaf extract was then diluted in 1/250 ml of drinking water, given on days 21-28. Increase in body weight for 5 weeks for piglets who were given the *M.oleifera* leaf extracted heavier (1.16 kg) than the group control (0.61 kg). This data shows that *M. oleifera* leaf extract has a positive effect on the growth of piglets.

The use of *M.oleifera* leaf meal in phase pigs *finishing* has been investigated by Mukumbo *et al.,* (2014). Feed conversion ratios (FCR), meat quality (Physico-chemical), fatty acid composition (FA), and shelf life of pigs were observed. Pigs raised for six weeks were fed rations containing 0%, 2.5%, 5%, and 7.5% MOLM. Pigs are slaughtered at 20 weeks and measurements of backfat thickness at pH_{45min} and pH_{24h}. Muscle samples *Muscularis longissimus thoracis et lumborum* from physicochemical quality were analyzed. Muscle samples, subcutaneous fat, and feed samples were analyzed for their fatty acid composition and fat health index from *atherogenicity* (AI) and *thrombogenicity* (TI). Pigs that were fed MOLM 7.5% had higher average daily ration consumption (3.56 kg / day) compared to pigs that were fed 0%, 2.5% and 5% MOLM, respectively (3.05, 3.14 and 3.07 kg / day). FCR of pigs fed 0%, 2.5% and 5% MOLM did not differ significantly (3.34, 3.44 and 3.22). However, the FCR of pigs that were fed MOLM was 7.5% significantly lower (3.78). There were no significant differences in the characteristics of carcass and Physico-chemical quality. MOLM inclusions improve shelf-life because meat samples from pigs that are fed MOLM show the best color and odor reception for 10 days in refrigerated storage. Although the ratio of n-6: n-3 FA from diet treatments containing MOLM increased significantly (T1 = 35.45, T2 = 22.08, T3 = 14.24,

T4 = 15.90), there was no significant difference observed for this ratio of fat composition from meat and subcutaneous fat samples. Significant decreases in intramuscular fat content and stearic acid were observed with increased MOLM levels. However, all other FA profiles, fat ratios, and health indices did not differ significantly in treatment. In conclusion, MOLM up to 5% can be used in ration pork *finishing* without harming feed conversion efficiency, carcass properties, and meat quality, and can improve the shelf life of pork. An inclusion rate of 7.5% MOLM can reduce FCR. MOLM inclusion significantly improved the FA composition of the feed but did not produce the desired improvement in FA meat composition, possibly due to the heavy fat accumulation by nitric lipogenesis in pigs phase *finishing* and not the direct incorporation of food fatty acids.

Furthermore, Oduro-Owusu *et al.,* (2017) conducted a study to evaluate the value of leaf meal *M.oleifera* (MOLM) as feed ingredients on growth performance, carcass characteristics, and economic efficiency in pig weaning phases. The ration treatments used were: 0, 1, 2.5, 3.5 and 5% MOLM. Growth rates of pigs fed rations containing 5% MOLM (0.54 kg/head) were better than rations of 0% MOLM and rations containing 2.5% MOLM. This is reflected in the best feed conversion efficiency (0.3) in pigs fed rations containing 5% MOLM. Carcass parameters including cutting weight, organ weight, carcass length, waist muscle area, ham, and pork cutlet were not significantly affected by MOLM. Backfat thickness decreased from 2.2 cm in the control to 1.7 cm when MOLM administration increased to 5%. There was no difference in the level of crude protein of meat (20.2% to 24.6%), water content (69.1% to 71.3%), and pH of meat (5.3-6.0). The cost of feed decreased because the inclusion rate of MOLM in the ration increased from 0% MOLM to 5% MOLM. Therefore, MOLM can be used as feed ingredients in pig feed to reduce

production costs. MOLM has no detrimental effects on pork and has the potential to reduce fat content in pork to produce leaner carcasses.

CHAPTER 5. MORINGA OLEIFERA LEAVES CAN INCREASE LIBIDO AND SEMEN QUALITY OF THE BALI BULLS

Low libido and low semen quality are often experienced by bulls which are commonly used as sources of liquid and frozen semen and males in natural mating (Ratnawati *et al.*, 2008; Affandhy *et al.*, 2009; Ratnawati *et al.*, 2012; Sariubang and Kallo, 2014). The bulls for the source of semen and natural mating must have a good libido and semen quality because it will affect the reproductive efficiency of the cows. The bull infertility such as libido and low semen quality cause delays in conception, prolong the breeding season, reduce calf body weight, and increase the number of cows removed, resulting in economic losses, and threatens the sustainability of the livestock business (Kastelic, 2013).

Sexual behavior (libido and mountability) of bulls depends on social interactions, which are based on genetic, environmental, nutritional, and hormonal factors, as well as sensory acuity, age, and experience (Menegassi *et al.,* 2011). The semen quality of a male is influenced by nutritional factors (Martin *et al.,* 2010), age and season (Bhakat *et al.,* 2011), and breed (Lemma and Shemsu, 2015). Nutrition controls sperm production, gonadotropin secretion, and male sexual development. Testes in adult male animals producing spermatozoa and testosterone are affected by the ability of seminiferous tubules and Leydig cells or interstitial cells, stimulated by *Follicle Stimulating Hormone* (FSH) and *Luteinizing Hormone* (LH) (Martin *et al.,* 2010).

The process of spermatogenesis to produce good quality semen requires amino acids methionine, cysteine (Ebisch *et al.,* 2006; Young *et al.,* 2008), and arginine (Wu *et al.,* 2009), α-linoleic fatty acids (Zalata *et al.,* 1998; Conquer *et al.,* 2000), vitamins A, C, and E and minerals Zn and Se (Mason *et al.*, 1982; Hidiroglou and Knipfel, 1984; Cheah and Yang, 2011). The Zn mineral plays an important role in the production of various sex hormones including testosterone and *Gonadotropin-Releasing Hormone* (GnRH). The Zn mineral stimulates testicular Leydig cells to produce testosterone. This Zn is localized to the Golgi body or secretory vesicles of interstitiotrophs, folliculotrophs, and lactotrophs of the pituitary gland. This element plays an important role in the production and secretion of FSH, LH, and prolactin, in turn, regulating testosterone production (Roy *et al.,* 2013). Bioactive compounds found in plants that are responsible for increasing sexual activity and spermatogenesis are saponins, alkaloids, flavonoids, ferulic acid, and chlorogenic acid (Cauhan *et al.,* 2014). One plant that contains all the compounds needed to stimulate libido and the process of spermatogenesis is *Moringa oleifera* leaves.

Moringa oleifera is a tree plant, found in tropical countries, has the potential to be used as animal feed. Moringa leaves are a good alternative for fodder plants, especially in the dry season when no

feed is available (Nouman *et al.,* 2013). Biomass production can reach 4.2 - 8.2 tons DM/ha, a good alternative for substituting commercial rations (Nouman *et al.,* 2014) and good feed additives (Fitri *et al.,* 2015.). The leaves of this plant are rich in nutritional value. The values of amino acids, fatty acids, minerals, and vitamins reflect the desired nutritional balance. Crude protein content of 30.29%, fat 6.50%, ash 7.64%, neutral detergent fiber (NDF) 11.4%, acid detergent fiber (ADF) 8.49%, lignin detergent acid (ADL) 1, 80%, cellulose acid detergent (ADS) 4.01%, (Moyo *et al.,* 2011). Moringa leaves as a source of protein in ruminants have digestibility values such as *rumen degradable protein* (RDP) 177 g/kgDM, *acid detergent insoluble protein* (ADIP) 72 g/kgDM, *pepsin soluble protein* (PESP) 200 g/kg DM, *potentially digested protein in the intestine* (PDI) 16 g/kg DM, non-protein nitrogen (NPN) 8.3%, and *total soluble protein* (TSP) 265 g/kg DM (Kakengi *et al.,* 2005). Moringa leaf contains mineral Zn 31.03 mg/kg (Moyo *et al.,* 2011), saponin 80 g/kg (Ferriera *et al.,* 2008), phenol compound 8 mg/ml, flavonoids 27 ug/ml (Rajanandh and Kavitha, 2010), and 0.07% alkaloids (Madukwe *et al.,* 2013), ferulic acid 46.8 mg/g, and chlorogenic acid 18.0 mg/g (Fitri *et al.,* 2015). Besides, *Moringa* leaves contain 21g/kgDM tannin and 21g/kgDM phytate which can be ignored as an anti-nutrient for ruminants, and do not contain trypsin and amylase inhibitors, lectins, cyanogenic glycosides, and glucosinolates (Ferreira *et al.,* 2008).

Various studies have been carried out using *Moringa* leaves as a feed ingredient, but to increase libido and semen quality is still limited. The results of the study of Abu et al., (2013) showed that moringa leaf flour (MOLM) did not adversely affect testicular morphometry and sperm quality in the epididymis of male rabbits to a level of use of 15%. It is recommended that *Moringa* leaves can be used in rabbit rations. Raji and Njidda (2014) have observed that supplementation with *Moringa* leaves at a rate of 50% can increase gonadal sperm and extragonadal sperm reserves in Red Sokoto goats. Zn mineral content

is high in moringa leaves, so it has the potential to increase libido and semen quality. Zn mineral is one of the minerals that play an important role in activating the secretion and action of testosterone, can increase the efficiency of spermatogenic machines, and increase the number of germ cells in seminiferous tubules for the process of spermatogenesis (Abdella *et al.*, 2011).

Therefore, the author tries to use *Moringa* leaves to increase the libido and semen quality of Bali bulls. The author also tries to see whether the high Zn-minerals in *moringa* leaves play a role in increasing the libido and quality of the semen. The following is an explanation of the use of the *Moringa* leaves.

A. UTILIZATION OF MORINGA LEAVES AS FEED CONCENTRATE TO INCREASE THE SEMEN QUALITY OF THE BALI BULLS

Moringa leaves have been used as constituent feed ingredients to improve the quality of fresh semen of Bali bulls. The quality of fresh semen of bulls was compared before being given Moringa leaves with after being given *Moringa* leaves and after giving *Moringa* leaves were stopped. The application of *Moringa* leaves does not increase the volume of semen but can maintain volume in the normal category. During the period of collecting the semen the rate of volume decreases, but the application of Moringa leaves can reduce the rate of decrease in the volume of the semen. This may be because *Moringa* leaves contain high Zn-minerals which play a role in increasing the volume of semen. Several studies have shown that the administration of Zn minerals can increase the volume of semen.

Moringa leaf administration also did not provide a significant difference in color, consistency, pH, mass movement, and total motility of the semen. However, the semen is still included in the normal category.

B. UTILIZATION OF MORINGA LEAVES AS FEED SUPPLEMENT FOR INCREASING LIBIDO AND SEMEN QUALITY OF THE BALI BULLS

Moringa leaves have been used as feed supplements to increase libido and the quality of fresh semen and frozen semen of Bali bulls. Testosterone, libido, and semen quality levels of Bali bulls were compared before and after being given *Moringa* leaves for eight weeks. Moringa leaves are given as much as 15% of the concentrate feed weight by giving 1% concentrate on body weight and straw *ad libitum rice.*

1. Hormone Testosterone and Libido

Levels diurnal changes in Bali bull testosterone levels before and after being given Moringa leaf supplement feed with an interval of eight hours is presented in Figure 17.

Moringa leaf supplement feeding increases the levels of the hormone testosterone in Balinese bulls throughout the day during the administration of *Moringa* leaves. The high Zn content in *Moringa* leaves is strongly suspected as one of the possibilities that affect the high testosterone during the administration of *Moringa* leaves. This is because Zn is an important component of a protein involved in the synthesis and secretion of testosterone. Libido (the time needed from approaching anglers to ejaculation) Bali bulls who were given Moringa leaves were shorter than those who were not given Moringa leaves, namely 3.49 ± 0.40 vs. 7.20 ± 1.49 minutes. Because libido is influenced by testosterone levels, the feeding of *Moringa* leaf supplements can increase testosterone levels thereby increasing libido.

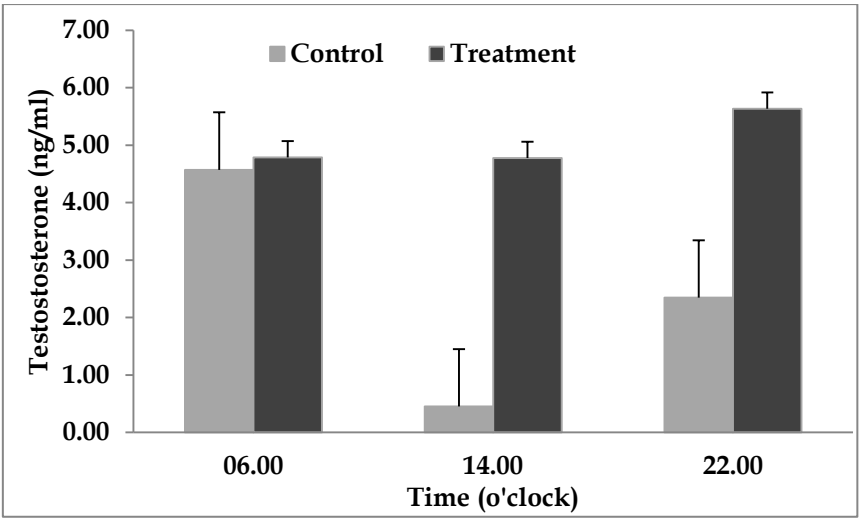


Figure 17. The Bali bull testosterone levels before and after being given *Moringa* leaf supplement feed.

The bulls that were not given *Moringa* leaves were maintained for eight weeks decreased libido, so the time needed for ejaculation is increasing, whereas in bulls that are given *Moringa* leaves occur the opposite. The rate of increase in time required for ejaculation is 0.11 minutes, while the reverse is the rate of time decreasing by 0.11 minutes. This can mean that Bali bulls fed with rations according to the standard requirements if carried out by collecting semen every week there will be a decrease in libido. However, the addition of *Moringa* leaves in the ration can increase the libido.

2. The Quality of Fresh Semen

The quality of fresh semen macroscopically and microscopically of bulls given *Moringa* leaves are better than those without *Moringa* leaves. The average volume of semen which was given before *Moringa* leaves were 3.1 ± 0.21 ml and after given *Moringa* leaves were 3.4 ± 0.26 ml. The volume is in the normal category. The color of semen before being given *Moringa* leaves 82.14% milk-white and 17.87% cream, and after being given *Moringa* leaves

100% milk-white. The colors are all in the normal category. The degree of acidity (pH) of semen before and after being given *Moringa* leaves is 7.0. This value is in the normal category. The consistency of bulls semen before being given Moringa leaves was 67.86% thick, 10.71% moderate and 21.43% watered, while after being given *Moringa* leaves were 100% thick. According to Feradis (2010), normal bull semen has a consistency from moderate to thick, so that only 78.57% of normal bull semen is given *Moringa* leaf. The average concentration of semen before being given *Moringa* leaves is 791 million/ml while after being given *Moringa* leaves is 817 million/ml. The concentration is included in the normal category because according to (Setchell, 2014) the normal concentration of bull semen is 300 - 2,000 million/ml. Normal and proper sperm mass movements to be processed into frozen semen are positive 2 (++) and positive 3 (+++) on a scale of 0 - 3 (- to +++) (Susilawati 2011). There is 89.29% ejaculate on cow semen before given *Moringa* leaf and there is 96% ejaculate on bull semen after given *Moringa* leaf has normal mass movement and is suitable for processing into frozen semen. The average total motility of sperm before being given *Moringa* leaves is 71.60% while after being given *Moringa* leaves is 83.59%. Total motility is an indicator of semen quality assessment before being frozen. According to Susilawati (2011), normal semen contains 70-90% motile spermatozoa, so that semen from both groups is suitable for processing into frozen semen and is used for AI. The average progressive motility of sperm before given *Moringa* leaves is 45.16%, whereas after given Moringa leaves is 66.36%. Progressive motility is an indicator of sperm fertility. Fertile males have progressive motility 50 - 80% (Feradis 2010). These results indicate that giving *Moringa* leaves can increase the fertility of Bali bulls.

The supplementation of *Moringa* leaves can maintain the sperm concentration of Bali bulls at normal levels. The results obtained are in line with those reported by Priyadarshani and Varma (2014) and Prabsattroo *et al.,* (2015) in mice. They found that in hyperglycemic mice and stressed mice, *Moringa* leaf supplementation significantly increased their sperm concentration. The sperm concentration of mice experiencing hyperglycemia and stress returned to normal after administration of moringa leaf flour. These results indicate that administration of *Moringa* leaves can maintain and restore normal sperm concentration.

Total motility of sperm before given *Moringa* leaves by 71.60%, increased to 83.59% after given *Moringa* leaves. These results indicate that feeding of *Moringa* leaf supplement can increase the total motility of the sperm of Bali bulls. The bulls that are carried out by collecting semen every week in a row will experience a decrease in total motility and progressive motility of sperm. The results obtained indicate that the administration of *Moringa* leaves slows down the rate of a progressive decrease in sperm motility.

3. The Motility Characteristics of Fresh Semen

Assessment of sperm motility characteristics is a follow-up assessment after total motility and progressive sperm motility using Casa *(Computer Assisted Sperm Analysis). Moringa* leaf supplementation increases sperm mileage in one second in DCL, DSL, and DAP, velocity in VCL, VSL, and VAP as well as the amplitude (ALH) of sperm of Bali bulls. According to Susilawati (2011), there are three sperm motility patterns, namely the hyperactivation group having a VCL value ≥ 100 μm/sec, LIN <60% and ALH ≥ 5 μm/sec, non-hyperactivation if it has a VSL value ≥ 40 μm / sec, LIN ≥ 60% and ALH <5 μm/sec, and transition groups that have values in between. Based on this category, the Bali bulls sperm given *Moringa* leaves are not

included in the hyperactivation group but are close to hyperactivation, because the VCL value is only 91.24 μm/sec. Testing hyperactivation motility patterns using CASA can be a good effort to predict the ability of spermatozoa fertilization. Hyperactivation of spermatozoa is needed shortly before the acrosome reaction in vitro, which is the movement in the oviduct during fertilization. The characteristics of sperm motility are positively correlated with fertility (Perumal et *al.,* 2014), so they can be used to predict the ability of sperm fertilization. VAP, VSL, and LIN values are indicators of progressive motility, and VCL, ALH, and BCF values are indicators of sperm rigor. VAP and VCL values are good predictors for the ability of sperm fertilization in vitro (Susilawati, 2011). The values of these parameters in male sperm given *Moringa* leaves are higher than those not given *Moringa* leaves, so it is likely to produce more fertile sperm.

4. The Quality of Frozen Semen

Moringa leaf supplement feeding increases *post thawing motility* in the form of total motility and progressive motility of frozen semen of Bali bulls. *Post-thawing motility* higher may be due to the administration of *Moringa* leaves which contain nutrients that are important for motility such as fresh semen, which also affects frozen semen. According to Zhinian (1998) and Bindari *et al.,* (2013) that, Zn supplementation significantly increases the motility of fresh and frozen sperm. Asadpour *et al.,* (2011) also explained that the addition of vitamins C and E in diluents can increase sperm motility after *thawing*. Therefore, the increase in the value of *post-thawing motility* in the Bali bull sperm is thought to be because *Moringa* leaves contain various nutrients that contribute to sperm motility after freezing. Further research is still needed to find out which nutrients play the most role in motility.

C. THE ROLE OF ZINC-MINERALS IN MORINGA LEAVES TO IMPROVING THE SEMEN QUALITY OF THE BALI BULLS

Moringa leaves have been known to increase the libido and semen quality of the Bali bulls, so this study trying to evaluate the role of Zn-minerals in *Moringa* leaves on libido and the quality of fresh semen and frozen semen of the Bali bulls. Libido and the quality of fresh semen and frozen semen of Bali bulls are compared before being given *Moringa* leaves, after being given *Moringa* leaves, and after being given Zn minerals which are equivalent to Zn-minerals found in *Moringa* leaves.

1. Libido and the Fresh Semen Quality

The libido of Bali bulls after being given *Moringa* leaves and after being given Zn-minerals was significantly higher than before being given *Moringa* leaves, and there was no difference between after being given *Moringa* leaves and after being given Zn-minerals (Figure 18). The time needed for Bali bulls to start approaching anglers until ejaculation is shorter is 2.53 minutes and 3.21 minutes with 5.53 minutes. This proves that Zn-minerals found in *Moringa* leaves play a role in increasing the libido of the Bali bulls.

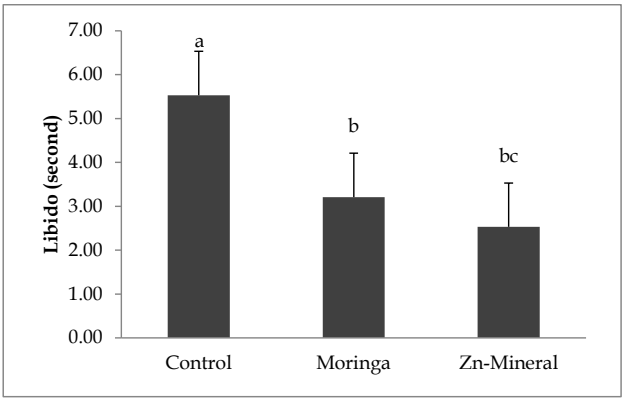


Figure 18. The Libido of the Bali bulls before given *Moringa* leaves, given *Moringa* leaves, and given the Zn-mineral.

The libido of the Bali bulls which were given and *Moringa* and Zn-mineral was higher than that which were given the main feed of palm oil waste (Ratnawati and Affandhy, 2013) which was 5.61 minutes, but not much different from before being given *Moringa* leaves. The Bali bull's libido averaged 4.7 minutes (Ratnawati *et al.,* 2008) or 4.5 minutes (Susilawati, 2011). This shows that Zn-minerals in *Moringa* leaves play a role in restoring the libido of the Bali bulls if given low-quality feed such as rice straw or palm oil waste.

The supplementation of *Moringa* leaves and Zn-minerals increased the semen volume of the Bali bulls from 2.71 ml to 3.78 ml and 4.19 ml. The volume semen of the Bali bull cattle given *Moringa* leaves and Zn-minerals did not show a significant difference. This can prove that the Zn-mineral contained in *moringa* leaves play a role in increasing the semen volume of the Bali bulls.

The degree of acidity (pH) of the semen before being given *Moringa* leaves, after being given *Moringa* leaves, and after being given Zn-minerals did not show a significant difference. The color of semen before being given *Moringa* leaves 69% milk-white and 31% cream, while given *Moringa* leaves 73% milk-white and 27% cream, and after being given Zn-minerals 100% milk-white. These colors show statistical differences, but all are still in the normal category. Garner and Hafez (2000) state that, the normal color of a cow's semen is milky-white to creamy. The research results of Susilawati *et al*. (1993) also showed that 10% of normal ejaculations in FH and Bali bulls were creamy and the rest was milky-white.

The thickness (consistency) of semen before being given *Moringa* leaves is 47% thick, 24% moderate, and 29% thin, whereas after being given *Moringa* leaves become 73% thick, 20% moderate, and 7% thin, and after being given Zn mineral 100% thick. The

consistency of the Bali bull semen is moderate to thick (Ratnawati *et al*., 2008), and bull semen normal has consistency from moderate to thick (Feradis, 2010). Based on this, the normal thickness of semen before being given *Moringa* leaves 61%, whereas after being given *Moringa* leaves 93%, and after being given Zn-minerals 100%. This shows that the Zn-mineral in *Moringa* leaves can play a role in increasing the thickness of the semen. The mechanism of Zn minerals can increase viscosity still needs further research. The administration of *Moringa* leaf and Zn- minerals did not significantly increase the sperm concentration of the Bali bulls. This can prove that the Zn- mineral contained in *Moringa* leaves does not play a role in increasing the sperm concentration of the Bali bulls. The mass movement of semen before being given *Moringa* leaves 44% positive 3 (+++), 50% positive 2 (++), and 6% positive 1 (+), whereas after being given *Moringa* leaves it becomes 81% (+++), 16 % (++), and 3% (+), and after being given Zn-minerals 81% (+++) and 19% (++). The mass movements sperm normal to be processed into frozen semen are (++) and (+++) on a scale (-) to (+++) (Susilawati, 2011). There is 94% ejaculate before given *Moringa* leaves, and 97% ejaculate after given *Moringa* leaves and 100% after given Zn-minerals which have normal mass movement and are suitable for processing into frozen semen. There is no significant difference in the mass movement of the three semen groups to be suitable for processing into frozen semen.

The supplementation of *Moringa* leaves and Zn-minerals significantly increased the total motility of the sperm of the Bali bulls from 70.32% to 85.49% and 89.37%. The total motility of the sperm of the Bali bulls which were given *Moringa* leaf and Zn-minerals did not show a significant difference. This can prove that the Zn-minerals found in *Moringa* leaves play a role in increasing the total motility of the sperm of Balinese cattle.

However, according to Susilawati (2011) that, the normal range of total motility of sperm that is suitable for processing into frozen semen is 60-80% so that the three groups of semen are eligible to be processed into frozen semen. The administration of *Moringa* leaves and Zn-minerals also significantly increased the progressive motility of the sperm of the Bali bulls from 58.14% to 77.12 and 76.43%. The progressive motility of the sperm of the Bali bulls fed with *Moringa* leaf supplement with Zn-minerals did not show a significant difference. This can prove that the Zn-minerals found in *Moringa* leaves play a role in increasing the progressive motility of the sperm of the Bali bulls. The results obtained are in line with the results of Janicki and Cygan-Szczegielniak (2008) research that, there is a positive correlation between increased Zn concentration with sperm motility in bulls. Likewise, the results of the study of Cupic *et al.,* (1998) giving Zn-minerals of 50, 100, and 150 ppm in FH cattle, significantly increased the progressive motility of sperm from 69.72% to 77.78% and 84.44%. Progressive motility plays an important role in the success of fertilization. According to Feradis (2010) that, fertile males have progressive motile sperm 50-80%, so the results obtained indicate that, the Bali bulls used are male cows that are fertile and giving Moringa leaves are likely to increase fertility.

2. The Characteristics of Sperm Motility

Results of the assessment of sperm motility characteristics using CASA obtained characteristics of sperm motility after administration of *Moringa* leaves and Zn-minerals, significantly better than before being given *Moringa* leaves, but there was no significant difference between the administration of *Moringa* leaves and Zn-minerals. This can prove that the Zn-minerals found in *Moringa* leaves play a role in increasing the sperm motility characteristic values of the Bali bulls. Based on Susilawati (2011),

sperm after *Moringa* leaf and Zn-minerals were hyperactivated, because the VCL value was ≥ 100 μm/sec, LIN <60%, and ALH ≥ 5 μm/sec. The results of testing the hyperactivity motility pattern using CASA can be a good effort to predict the ability of spermatozoa fertilization. Hyperactivation of spermatozoa is needed shortly before the acrosome reaction in vitro, which is the movement in the oviduct during fertilization. Hyperactivated sperm motility is positively correlated with the ability to penetrate zones. The fertility rate of the hyperactivation group has higher success compared to the non-hyperactivation group (Susilawati, 2011). Based on this, the Zn-mineral in *Moringa* leaves can cause hyperactivation, so it can increase the sperm fertility of the Bali bulls.

3. The Quality of Frozen Semen

Post Thawing Motility in the form of the total motility and the progressive motility of sperm as well as the characteristics of *post thawing motility* sperm before given *Moringa* leaves, *Moringa* leaves were given, and given the Zn-mineral did not show a significant difference. This shows that the Zn-minerals found in *Moringa* leaves do not play a role in increasing *post thawing motility of* frozen semen and characteristics of *post thawing motility* frozen semen.

CHAPTER 6. MORINGA LEAVES CAN IMPROVE LIBIDO AND THE SEMEN QUALITY OF THE ETAWAH CROSSBREED (PE)

The etawah crossbreed goat (PE) is the result of a cross between an etawah (Jamnapari) goat and a kacang goat, the dual-purpose type, which is a meat and milk producer. PE goats are generally kept by small breeders with a scale of between 3 - 7 per farmer. Most of the feed given was in the form of legume leaves (*Calliandra, Gliricidia, Leucaena*) and food plant leaves (banana leaves, jackfruit leaves, papaya leaves, and others). The demand for PE goats in various regions in Indonesia is increasing from year to year. The high demand for meat tends to deplete the existing population. The conception rate

for PE goats in people's farms is 69 - 100% (Budiarsana, 2005). Goats can give birth three times in two years if the mating system is well managed (Sutama, 2011). Good breeding management can be done by improving the quality of buck semen both for natural mating and for artificial insemination. The quality of buck semen is influenced by nutritional factors (Martin *et al.,* 2010), age (Bhakat *et al.,* 2011), season (Benia *et al.,* 2018), and breed (Lemma and Shemsu, 2015). Nutrition controls sperm production, gonadotropin secretion, and male sexual development (Martin *et al.,* 2010).

The feed supplement technology as a form multi-nutrient block has long been developed and proven to increase the productivity and reproducibility of ruminants, especially in goats. The multi-nutrient blocks have been shown to improve the production and reproduction performance of goats (Faftine and Zanetti, 2010 and Salman *et al.,* 2017). The feed supplement multi-nutrient block can also be used in lactating goats and can partially replace the concentrate (Farias Ramos *et al.,* 2019). Block multi-nutrient supplement feed technology in the form of Urea Molasses Multinutrient Block (UMMB) has been shown to improve the composition of milk and the quality of goat's milk (Mohd Nor *et al.,* 2020).

Moringa leaves contain high and complete nutrition. *Moringa* leaves contain 19 amino acids, 17 fatty acids, 6 macro-minerals, and 6 micro-minerals (Moyo *et al.,* (2011), and 15 vitamins (USDA, 2015). *Moringa* leaves contain the mineral Zn 31, 03 mg/kg, and Se 363.00 mg/kg (Moyo *et al.,* 2011) which are important for the process of spermatogenesis (Cheah and Yang, 2011). The mineral Zn can function to stimulate Leydig cells in the testes to produce the hormone testosterone. Mineral Se functions as a strong antioxidant combining amino acids to form seleno-proteins and enzymes to form seleno-enzymes affecting sperm quality by preventing oxidative damage (Cheah and Yang, 2011). *Moringa* leaves contain the amino

acid arginine 30.28 mg/g of dry matter (Nouman *et al.,* 2014) for the process of spermatogenesis, putrescine precursors, spermidine, and the synthesis of spermin which are important for sperm motility (Lefèvre *et al.,* 2011) the capacity of sperm fertilize an egg (Lenis *et al.,* 2017). *Moringa* leaves contain unsaturated long-chain fatty acids (*polyunsaturated fatty acid/PUFA*) *a-linolenic* amounting to 44.57% (Moyo *et al.,* 2011) functions to maintain sperm cell survival, sperm maturation, and fertility (Conquer *et al.,* 2000). *Moringa* leaves contain vitamin A 16.3 mg/100 g, vitamin C 17.3 mg/100g, and vitamin E 113.0 mg/100g (Argarwal, 2014) which play an important role in the spermatogenesis process (Cheah and Yang, 2011).

Several research results on the use of *Moringa* leaves as animal feed has shown positive results. *Moringa* leaves have been used as feed to improve testicular morphometry and rabbit sperm quality (Abu *et al.,* 2013), rabbit sperm fertility (Khalifa *et al.,* 2016), increase libido and sperm quality in Bali cattle (Syarifuddin *et al.,* 2017), as well as the characteristics of sperm in buffalo (Wafa *et al.,* 2017).

Based on the results of these studies, the authors have developed a feed supplement technology by utilizing *Moringa* leaf flour as a building block for multi-nutrient supplement feed in the form of *Urea Moringa Molasses Multinutrient Block* (UMMMB) in PE bucks to increase libido and semen quality. The results showed that the UMMMB was successful in increasing the libido and semen quality of the PE bucks.

A. Composition and Nutritional Content of the Feed Supplement UMMMB

Urea Moringa Molasses Multi-nutrient Block (UMMMB) is a feed supplement containing urea, moringa leaves, molasses, and a mixture of minerals and vitamins made in solid form (blocks) which can be given to ruminants (cattle, buffalo, goats, and sheep) to improve digestion, growth, and reproduction.

The composition and nutritional content of the UMMMB that has been used to increase libido and semen quality for the PE goat are presented in Table 10 and Table 11.

Table 10. Composition of UMMMB raw materials.

No	Raw Material	Composition (%)
1.	Moringa leaf flour	30
2.	Refined rice bran	33
3.	Molasses	20
4.	Lime	5
5.	Salt	5
6.	Urea	5
7.	Mineral Mix	2
	Total	**100**

Table 11. The nutritional content of UMMMB.

No	Nutritional Content	(%)
1.	Dry matter	66.68
2.	Ash	14.14
3.	Crude Protein	21.27
4.	Crude Fibre	7.72
5.	Ether extract	2.45
6.	Calcium (Ca)	4.21
7.	Phosphorus (P)	2, 72
8.	Nitrogen Free Extract (NFE)	54.42
9.	Total Digestible Nutrient (TDN)	73.60

Notes: Analyzed by Laboratory of Nutrition and Animal Feedstuff, Faculty of Agriculture, University of Lambung Mangkurat.

B. Results of the UMMMB Supplementary Feed Trial

PE male goats are kept for eight weeks, given rations according to the nutritional requirements of male goats (Nutrient Requirement of Small Ruminant, National Research Council, 2007). Four tails were given swamp forage mixed with *Polygonum barbatum* L and *Ischaemum polystachyum* J. Presl as the main feed plus supplemental feed of the *Urea Molasses Multinutrient Block* (UMMB) one block weighing 200 grams as control compared to four animals given swamp forage plus one block UMMMB weighing 200 grams as treatment. The UMMB and UMMMB were given in the morning before giving forage. The Forage is carried out after the supplement feed is exhausted. Adlib provision of forage feed and drinking water.

1. Production Performance.

The bucks were fed supplement with UMMMB obtained the consumption of DM rations, crude protein, and TDN were above requirements of the NRC (2007) and obtained higher body weight gain than controls. This shows that the needs of the goats are met from the rations given. The bucks who were fed with UMMMB supplements obtained blood plasma urea, blood glucose, and blood cholesterol levels were in the normal range. This shows that the ration given to goats does not interfere with the digestion process to absorption into the circulatory system and metabolic processes, does not interfere with the work of the kidneys, does not interfere with the process of spermatogenesis and the formation of reproductive hormones, especially concerning the process of spermatozoa formation and libido.

2. Libido

The bucks that were supplemented with UMMMB obtained a greater increase in scrotal circumference than the control. This shows that the ration given does not interfere with the growth process of the testes where spermatozoa and testosterone are

formed. Testosterone levels also increased after five weeks of feeding with UMMMB supplements.

The provision of UMMMB as the feed supplement significantly increased the libido of PE bucks. The trial results showed that the time required for bucks to ride a fishing rod and ejaculate in an artificial vagina was significantly shorter than that of the control (13.73 ± 1.54 seconds vs 13.73 ± 1.54 seconds). Thus, feeding UMMMB supplements can increase the libido of PE bucks.

3. Fresh Semen Quality

The bucks that were fed with UMMMB feed supplement did not significantly affect the quality of fresh semen in the form of semen volume, consistency, pH, concentration, mass movement, and abnormalities, but semen volume, consistency, pH, mass movement concentration, and abnormalities the resulting were still categorized as normal. Utilization of UMMMB feed supplement significantly affected the semen color of PE bucks. The color of the semen obtained was yellowish, creamy, and milky white, but all of the semen colors belonged to the normal category. The color of semen of PE bucks that was given UMMMB contained 42.86% ejaculate yellowish. It is suspected that the moringa leaves contain high beta-carotene which can affect the color of the resulting semen. The trial results showed that feeding with UMMMB supplements significantly increased the total motility and the percentage of live spermatozoa. The mean of the total motility of sperm PE bucks fed with UMMMB was significantly higher than the control group, namely 73.82% vs 70.36%. The total motility is an indicator of the assessment of semen quality before freezing, which is at least 70% motile spermatozoa. The average of live spermatozoa of PE bucks who were fed UMMMB feed supplement was 84.59, significantly higher than the control group at 80.41%.

The test results indicate that the fresh semen produced in the form of volume, color, consistency, pH, mass movement, and concentration is normal. The fresh semen produced had a higher percentage of total motility and a higher percentage of live spermatozoa and a lower percentage of abnormalities. The fresh semen is suitable for processing into frozen semen and liquid semen. Thus, the provision of UMMMB feed supplement can improve the quality of fresh semen for PE bucks. This trial still needs to be continued to test the fertility of liquid semen and frozen semen by processing it into liquid semen and frozen semen and then inseminating the females.

4. Liquid Semen Quality

In general, UMMMB supplementation in PE bucks can improve the quality of spermatozoa during preservation at 3-5°C. The percentage of total motility, percentage of live spermatozoa, and percentage of the intact plasma membrane (IPM) of spermatozoa during preservation until the fifth day of treatment were higher than that of the control. This is due to differences in the quality of fresh semen spermatozoa. All of the fresh semen quality variables obtained in the treatment were higher than the control. Spermatozoa with better quality before being processed into liquid semen, are better able to adapt to environmental changes that occur especially during preservation at low temperatures. The increased quality of PE buck's fresh semen is thought to be because those *Moringa* leaves contain various nutrients that play a role in the process of spermatozoa formation (spermato-genesis).

5. Conception Rate

To test the fertility of the resulting liquid semen, it was followed by artificial insemination of the acceptor female goat,

which was first synchronized in oestrus. Pregnancy diagnosis is done by looking at the cycle of oestrus twice in a row. The acceptor who showed no symptoms of oestrus after two consecutive cycles of oestrus was diagnosed as pregnant. The results of artificial insemination showed that acceptor inseminated using liquid semen from bucks supplemented with UMMMB 80.77% were diagnosed as pregnant, while the acceptor inseminated using liquid semen from bucks supplemented with UMMB was only 38.46% diagnosed as pregnant. This shows that UMMMB supplementation can increase the conception rate in PE goats.

CHAPTER 7. CONCLUSION

Moringa oleifera is a native plant from the foot of the Himalayas that have spread to various tropical and subtropical countries. Moringa is a boon plant with a high and complete nutritional content so that it can be used for various human needs and livestock.

Moringa leaves have been used as animal feedstuff both in ruminants (cows, buffaloes, goats, and sheep) and rabbits as well as in non-ruminant animals (poultry, and pigs). Moringa leaves in ruminants are generally used to improve ration efficiency, growth performance, reproductive performance, meat production, and milk production. Likewise, non-ruminant animals are used to improve feed efficiency, growth performance, and egg production. The author in particular has succeeded in utilizing Moringa leaves to increase libido and improve the quality of semen of the Bali bulls. The author has also succeeded in increasing libido, fresh semen quality, liquid semen quality, and conception rate in PE goats by utilizing Moringa leaves as an ingredient constituent UMMMB as a feed supplement.

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