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South African *Moringa oleifera* Lam: a Review of its Phytochemistry, Commercialization and Quality Control

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Abstract: *Ayurvedic traditional medicine postulates that Moringa oleifera Lam. can prevent about 300 diseases. The plant is use in water clarifation, anti-malnutritional and therapeutic properties, a function of its phytochemistry have been explored. Peer-reviewed articles, using South African Moringa oleifera" and Moringa "compound isolation", ''phytochemistry, ''commercialization'' and ''quality control'' separately as search term ("all fields") were retrieved from popular search engines and reviewed. The nutrients content of South African Moringa oleifera are well documented even though this is from fewer studies in comparison to that conducted in other African Countries. However, phytochemical isolation and purification studies conducted using the South African specie are insufficient. A compromised quality, efficacy and safety of Moringa based raw materials and products is a possibility in South Africa in contravention of WHO quality standards for herbal medicines. Further research is pivotal to further improve on the usage and commercialization of the malnutrition supressing nutritional plant.*

Keywords: *South African, Moringa oleifera, phytochemistry, commercialization, quality control, nutrients, standard compound.*

1. INTRODUCTION

1.1. Species in the Genus

Moringaceae, a monogeneric family, with the single genus *Moringa* comprises 13 species of dicotyledonous tropical and sub-tropical flowering trees [1]. This species include *M. peregrina* indigenous to Read Sea and Horn of Africa, *M. concanensis* and *M. oleifera* indigenous to Sub-Himalayan tracts of Northern India, *M. rivae* indigenous to Kenya and Ethiopia, *M. arborea* indigenous to Kenya, *M. borziana* indigenous to Somalia and Kenya, *M. pygmaea* indigenous to Somalia, *M. ruspoliana* indigenous to Ethiopia, *M. hildebrandtii* and *M. drouhardii* indigenous to Madagascar, *M. stenopetala* indigenous to Kenya and Ethiopia, *M. ovalifolia* indigenous to Namibia and Angola, *M. longituba* indigenous to Kenya, Ethiopia and Somalia [2]. Nearly all *Moringa* species seem to have Asia, Africa and Middle East as their mainstay, but have since been pioneered into several Countries of the tropics. These Countries include Madagascar, South Western Angola, Egypt, Bangladesh and Afghanistan in the North western region of the Himalayans as well as Countries in the Horn of Africa [1]. *Moringa* species are also cultivated in other parts of Africa such as Ghana, Malawi and South Africa [3]. Within the entire family of Moringaceae, *Moringa oleifera* Lam (syn. *M. ptreygosperma* Gaertn.), is one of the commonest, most studied and most widely distributed and naturalized species of a monogeneric family Moringaceae [4]. Its multiple uses and potentials attracted the attention of farmers and researchers in the past historical eras. Ayurvedic traditional medicine postulates that *M. oleifera* can prevent up to 300 diseases and its leaves have been exploited both for preventive and curative purposes. Moreover, a study in the Virudhunagar district of Tamil Nadu India, reports M. *oleifera* among the species utilized by traditional Siddha healers. Ancient Egyptians used *M. oleifera* oil for its cosmetic value and skin preparation and even if the species never became popular among Greeks and Romans, they were aware of its medical properties. *M. oleifera* has been grown and consumed in its native populations until recently (the 1990s) when a few researchers began to study its potential use in the treatment of water. Later, its nutritional and therapeutic properties were "discovered" resulting in the species spreading throughout almost all tropical countries.

In 2001, the first international conference on *M. oleifera* was held in Tanzania and since then the number of congresses and studies augmented and disseminated the information about the incredible properties of *M. oleifera*. In South Africa, *M. oleifera* is cultivated in Limpopo Province, Free State, Mpumalanga, KwaZulu-Natal and Gauteng [5]. This plant tends to sprout in any type of soil, characterized with heavy clay and waterlogged, with pH ranging between 4.5 and 8.0, at an altitude up to 2000 m^2.

The relevant literature was collected by searching the major databases including Science Direct, SciFinder and Google Scholar. Using "*Moringa*, *Moringa oleifera*, *Moringa* compound isolation, *Moringa* HPLCand South African *Moringa oleifera"* as separate search term ("all fields"), peer-reviewed articles were retrieved from the databases with no specific time frame set to limit the search. In addition, relevant literature and various books were consulted that contained phytochemical, commercialisation and quality control information on *Moringa oleifera* Lam.

1.2. Botanical Aspects

1.2.1. History

The genus *Moringa* is predominantly native to north Western India but also grows in some tropical and subtropical Countries of Africa, South Central America, Mexico, Hawaii and Asia. Its name comes from a Tamil, Teugu or Malayalam word murungai, munakkai or muringa, which translate to drumstick, a term that seemingly describes the padded head of the branch of the young vegetable or seed pods that is slender and curved like the stick that is used for drumming. The plant is also called a horseradish tree probably due to the slender and thin shape of the immature fruits that resembles a siliqua of a radish. Other common names include radish and West Indian Ben [6]. The crop was first grown by the Dravidians and later Aryans of north Western India but is well cultivated in Egypt, Phillipines, Ceylon, Thailand, Malaysia, Burma, Pakistan, Sigapore, West Indies, Cuba, Jamaica, Nigeria, South Africa just to mention but a few.

1.2.2. Morphology

M. oleifera, also known as the "horseradish tree", is a rapid growing, small, hardy tree producing a tuberous taproot. In the wild, it ranges in height, between 5 to 12 m. It has a straight trunk (about 10 to 30 cm thick) with whitish bark and an open, umbrella- shaped crown. The leaves appear feathery, green to dark green in colour and 1 to 2 cm long. The flowers are 10 to 25 cm long and white to cream colours. Immature pods are green or reddish in colour [6]. It is little to medium-sized tree; with corky bark, soft and glabrous tuberous roots. Its leaves are 25 to 45 cm long and arranged spirally with large overfilled at the end of its branches. It is characterized by long-petioled that are incompletely tripinnate in the rachises. The glands is located between the pinnae and the leaflets while leaflets stalks are ovate with an acute base that may also appear rounded in dull green colours on both sides. The beneath could be lighter colour with pinnate nerves at first that may shortly become grey, pubescent but soon glabrous in the range 0.9-1.8 x 0.5-1.2 cm. The Flowers are fragrant, bisexual, oblique, well stalked and united into erected axillary. The panicles have many-flowers that are densely pubescent and interconnected beneath the apex that is mostly 0.7-1 cm long. The plant calyx is deeply 5-partite with tube that is somewhat angular, a cupular-cyathiform that is oblique with a characteristic green colors with densely short pubescent on both sides. The sepals have unequal size in the range of 0.7-1.4 x 0.25-0.5 cm. It has 5 unequal petals colored yellowish white with a greenish base and thin veins. The 2 hindmost and the two lateral ones reflexed, ovate or obtuse, with a canaliculate base on the inner hairy side of the base or otherwise glabrous and 1-1.7 x 0.5-0.6 cm long. The foremost petal is erect, obovate, obtuse, glabrous on the inside and outside with longitudinal rows of hairs that are 1.4-1.6 x 0.6-0.8 cm. There are 5 stamens alternating with 5 stabulate staminodes that appears densely pilose at the base with the hindmost stamen usually the longest by 0.8-0.9 cm. its ovary is stalked, densely clothed with rather long appressed hairs, terete, with 3 longitudinal furrows, an I-celled and 3 placentae that bears a double row of ovules; style thin, that is curved white, shortly pubescent and hollowed shaped at the apex. Capsules are pendulous, linear, acuminate, obtusely trigonous, ribbed; usually 20-45 cm long or sometimes up to 120 cm long. Seeds are numerous, globular and approximately 1 cm in diameter, 3-wings are usually produced at the base and the apex, 2-2.5 cm long, 0.4-0.7 cm wide, scarious with the outer walls of the epidermis of thick testa. Below the epidermis lies a parenchyma area where the cell walls have numerous pits, hence presenting a reticulate presence. This often followed by a region of fibres, up to 150 µm in length, containing crystals. The rest of the testa consists of parenchyma similar in structure to the outer zone, although they are longer in longitudinal section and have longer intercellular spaces. The endosperm is a single layer with oil drops and tiny aleurone grains. Associated with the aleurone layer are 2-3 layers of flattened cells.

1.2.3. Taxonomy and Distribution

The 13 species of *Moringa* fit into three broad categories that reflect life form and geography. The first category is the bottle trees which are massive trees with bloated water- storing trunks and small radially symmetrical flowers. These tress are restricted to the Southern hemisphere and include *M. drouhardii*, *M. hildebrandtii* of Madagascar, *M. ovalifolia* of Namibia and Angola and *M. stenopetala* of Kenya and Ethiopia. The second category are trees with a tuberous juvenile stage and cream to pink slightly bilaterally symmetrical flowers otherwise called slender trees *M. concanensis*, *M. oleifera* of India and *M. peregrine* of the Red Sea, Arabia and the Horn of Africa are members of this group. The remaining eight *Moringa* species are found in Northeast horn of Africa where the plant is most diverse [7]. *Moringa* species in this class are tuberous adults or juveniles that could mature to fleshy rooted adults that are often colourful with bilaterally symmetrical flowers. Members here, generally classified as trees (Figure 1), shrubs and herbs are *M. arborea* of Kenya, *M. borziana* of Kenya and Somalia, *M. longituba* of Kenya, Ethiopia and Somalia, *M. pygmaea* of Somalia, *M. rivae* of Kenya, Ethiopia and *M. ruspoliana* of Kenya, Ethiopia and Somalia.

Fig 1. *Moringa oleifera tree*

Although the *Moringa* tree is well distributed across the tropics, around farms and compounds and usually used as fence especially in Limpopo, not much has been done to enhance its large-scale production, processing, marketing and investment as an industrial raw material in Countries including South Africa [8]. The plant is cultivated in Limpopo Province, Free State, Mpumalanga, KwaZulu-Natal and Gauteng [5]. As indicated in the cultivation distribution map, The Southern Africa Development Community (SADC) Countries with its economic leader, South Africa, cultivates only a sparse amount (one specie only of *Moringa oleifera* and two species of *M. hildebrantii* and *M. drouhardii* cultivated in Madagascar. When compared with a Country like Kenya in the Horn of Africa, that cultivates and commercialise five species of *M. rivae. M. longituba*, *M. aubora*, *M.*

borziana, and *M. stenopetala,* the South African Government needs to invest more on the cultivation of this multi-nutrients producing plants.

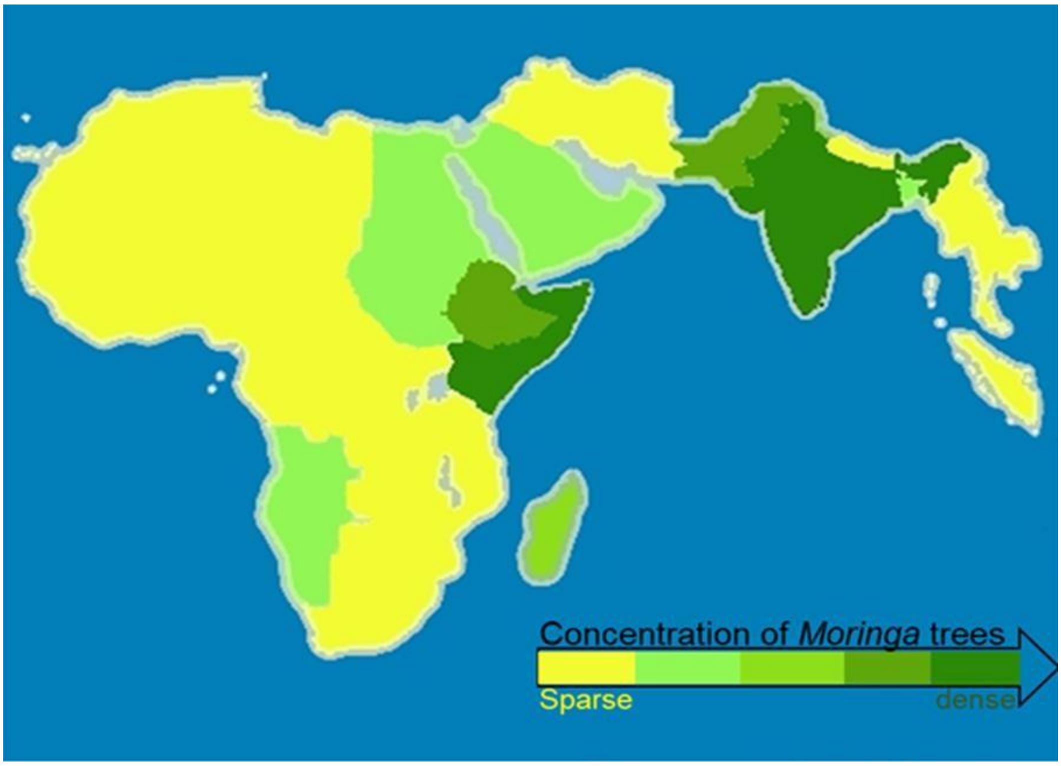


Fig 2. *Cultivation distribution of Moringa across Africa and Southern Asia.*

1.3. Phytochemistry

1.3.1. Nutritional Content

The identification and in some cases quantification of nutrients, macro and some micro elements in various parts of the *Moringa oleifera* is well documented as summarized in Table 1. As far our search is concern, of the 23 peer reviewed articles revised under this content, there are four analysed South African *Moringa oleifera* samples. Mogalaka and co-workers [9], determined the macronutrients present in *M. oleifera* harvested from Limpopo and Mpumalanga as Mg (> 500), K (> 1000), Ca (> 14000), P(> 2000), S (> 9000) and I (>3000) mg/Kg. In 2012, Vusumzi and co-workers [10] investigated and recorded that the leaves and flowers of South African *Moringa oleifera* contains calcium (Ca 18 500 mg/kg), magnesium (Mg 5500 mg/kg), myricertin (1296.6 mg/kg), quercetin (1362.6 mg/kg) and kaempferol (1933.7 mg/kg). Crude protein levels of 30.3% and 19 amino acids were found as part of the leaf content of the South African *Moringa oleifera* in a separate study conducted by Moyo et al [11]. Calcium (Ca, 3.65%), phoshorus (P, 0.3%), magnesium (Mg, 0.5%), potassium (K, 1.5%), sodium (Na, 0.164%), sulphur (S, 0.63%), zinc (Zn, 13.03 mg/kg), copper (Cu, 8.25%), manganese (Mg, 86.8 mg/kg), iron (Fe, 490 mg/kg), selenium (Se, 363 mg/kg) and 17 fatty acids including α-Linolenic acid (44.57%), heneicosanoic (14.41%), g-linolenic (0.20%), palmiteic acid (0.17%) and capric acid (0.07%) were quantified from the leaves. In addition, vitamin E (77 mg/100 g), beta-carotene (18.5 mg/100 g), neutral detergent fibre (NDF) (11.4%), acid detergent fibre (ADF) (8.49%), acid detergent lignin (ADL) (1.8%), acid detergent cellulose (ADC) (4.01%), condensed tannins with a value of 3.2%, and total polyphenols (2.02%) are also said to be present in the leave of the plant [11]. The fourth documented study on South African *Moringa oleifera* reported the presence of sucrose, glucose, Raffinose, total anti-oxidant (TAO) (1.8 mg g^{-1}), leaf-ascorbic acid (AsA) (2.0 mg g^{-1}), and total phenols (TP) (64.1 mg g^{-1}); stem-TAO (1.2 mg g^{-1}); root-carotenoids (29.7 mg g^{-1}), TP (57.3 mg g^{-1}); seed-tocopherol (28.57 mg g^{-1}), total crude protein in the seed (110.4 mg g^{-1}) and leaf (76.1 mg g^{-1}) [12]. Studies on the nutritional content of South African *Moringa oleifera* when compared to similar investigation on the same species in other African Countries like Nigeria seems insufficient. Whereas seven studies were conducted in Nigeria within the period under review, only four was the case in South Africa. However, some of the nutrients, macro and micro-elements present in South African *Moringa oleifera* are present in the same species cultivated and naturalised in other Countries. These published data seems to support South African *Moringa oleifera* leaves as a valid food and vitamins supplements for combating malnutrition. In its 2014/2015 annual report, the Agricultural Research Council (ARC) of South Africa, tested 13 *M. oleifera* samples from Thailand, Taiwan, the USA and South Africa for antioxidant, antimicrobial and other chemical properties. A Thai cultivar had the highest antioxidant activity, while all cultivars showed good antibacterial activity and low antifungal activity. The South African cultivar reportedly indicated highest level of phenols and this would means having an equal level of antioxidant as the Thai specie, that is suitable and should be adopted for cultivation in South Africa [13]

Moringa pods are very rich in concentrations of specific phytochemicals such as ascorbic acid, oestrogenic substances and β-sitosterol, iron, calcium, phosphorus, copper, vitamins A, B and C, α-tocopherol, riboflavin, nicotinic acid, folic acid, pyridoxine, β-carotene, protein, and specifically essential amino acids such as methionine, cystine, tryptophan and lysine that render it an ideal and valuable dietary supplement to combat malnutrition [14].

Table1. *Nutrients and phytochemicals identified and/or quantified from different parts of Moringa oleifera specie*

Year	Nutrients/Phytochemicals Identifie	Plant Part	Research Groups/Article Authors	*Moringa* Sample Origin
2016	Quercetin-3,7-diglucoside [(traces-41.45), Quercetin-3,7-dig lucoside (traces-41.45) isomer (traces-50.13), Apigennin-8-C-glucoside (traces- 7.78), quercetin-3-glucoside (3.90-8.76) Apigennin-7-C-glucoside (traces-29.07), Kaemferol-3,7-digl ucoside (traces- 33.22), Apigennin-7-rutinoside (trac es-21.-05), Quercetin-3-rhamnoside (traces-7.36), Quercetin-3-sop-horoside (traces-53.37), Quercetin-3-acetyl-glucoside (traces -51.98), Kaemferol-glucoside (25.67-39.81), Kaemfe rol-glu coside (traces-61.99)] µg/g dw. Total: Dicaffeoylqui nic acid (traces-39.76), 5-affeoylquinic acid (traces-8.05), 3-affeoylq uinic acid (57.07-103.30), 3-*p*- oumaroyl acid (trac es18.87), Feruloylquinic acid (traces-71.14) µg/g dw.	Leaves	[15]	**Pakistan**
2014	Flavonoids, anthraquinone, alkaloids, saponins, steroids, terp enoids, cardiac glycosides, nthocyanin, tannins and carotene-ids) iron(0.03g/100g), calcium (2.09g/100g), magnesium (0.48g/100g), potassium, (1.62g/100g), phosphorus (0.04g/ 100g), zinc (0.005g/100g), copper (0.01g/100g) and sulphur (0.85g/100g).	Leaves	[16]	**Nigeria**
2014	Defatting *Moringa oleifera* seeds increased the fibre, carbohydrate, vitamins B and C, iron and zinc, cyanogenic glycosides content and significantly reduced the calcium, potassium, phosphate, tannin, alkaloids, saponin, phytate, oxalate levels.	Seeds	[17]	**Nigeria**
2014	N (0.05-0.11 %), P (4.61-9.36 mg/kg), K (202.67-207.00 mg/kg), Ca (505.33-813.33 mg/kg), Mg (136.18-202.50 mg/kg).	Leaves	[18]	**Ghana**
2013	Crude protein (CP) (104 g/Kg DM), higher crude fiber, neutral detergent fiber, cellulose and hemicellulose, Calcium (3.34-2.74 g/Kg DM),Phosphorus, Magnesium, Zinc, Iron, Copper (9.3-9.6 mg/Kg DM).	Seeds	[19]	**Ethiopia**
2013	Ash, crude fibre, fat and moisture contents of dry *Moringa oleifera* were 0.04, 0.00, 0.001 and 96.68%, respectively. The protein (0.66%), carbohydrate (2.63%). Iron (2.07 mg), calcium (33.35mg, vitamin C (6.26 mg) and beta-carotene (223RE) flavonoids (0.20%), and alkaloids (0.07%).		[20]	**Nigeria**
2012	1 % of alkaloids, tannin, flavonoids and phenol in the leaf and, contained appreciable quantity of calcium, magnesium, iron and 45.4 % carbohydrate, 16.2 % protein and 9.68 % fibre	Leaf	[21]	**Nigeria**

2012	Ca (18 500 mg/kg) and Mg (5500 mg/kg), myricertin (1296.6 mg/kg), quercetin(1362.6 mg/kg) and kaempferol (1933.7 mg/kg).	Leaf and flowers	[3]	**South Africa**
2011/ 2012	High crude protein (17.01% ± 0.1) and carbohydrate (63.11% ± 0.09). The leaves also contained appreciable amounts of crude fibre (7.09% ± 0.11), ash (7.93% ± 0.12), crude fat (2.11% ± 0.11) and fatty acid (1.69% ± 0.09). The total ash content showed it contained minerals, Ca (1.91% ± 0.08), K (0.97% ± 0.01), Na (192.95 ± 4.4), Fe (107.48 ± 8.2), Mn (81.65 ± 2.31), Zn (60.06 ± 0.3) and P (30.15 ± 0.5) parts per million (ppm). Magnesium (0.38% ± 0.01) and copper (6.10 ± 0.19) were the least. The results of phytochemical analysis and anti-nutrients showed presence of tannins (21.19%± 0.25), phytates (2.57% ± 0.13), trypsin inhibitors (3.0% ± 0.04), saponins (1.60% ± 0.05), oxalates (0.45% ± 0.01) and cyanide content ((0.1% ± 0.01).	Leaves	[22]	**Nigeria**
2011	Crude protein levels of 30.3% and 19 amino acids: calcium (3.65%), phoshorus (0.3%), magnesium (0.5%), potassium (1.5%), sodium (0.164%), sulphur (0.63%), zinc (13.03 mg/kg), copper (8.25%), manganese (86.8 mg/kg), iron (490 mg/kg) and selenium (363 mg/kg). 17 fatty acids were observed with α-Linolenic acid (44.57%), heneicosanoic (14.41%), g-linolenic (0.20%) palmiteic (0.17%) and capric acid (0.07%). Vitamin E (77 mg/100 g), beta-carotene (18.5 mg/100 g dried leaves. Neutral detergent fibre (NDF) (11.4%), acid detergent fibre (ADF) (8.49%), acid detergent lignin (ADL) (1.8%) and acid detergent cellulose (ADC) (4.01%). Condensed tannins had a value of 3.2%, and total polyphenols (2.02%).	Leaves	[23]	**South Africa**
2011	Cold matter: proteins (11.9%), moisture (73.9%), fat (1.1%), carbohydrate (10.6%). Dry matter, the contents in proteins (27.2%), moisture (5.9%), fat (17.1%), and carbohydrate (38.6%), mg for 100 g. Cold matter: Ca(847.1); Mg (151.3); K (549.6); Fe (17.5); Zn (1.3) and P (111.5) mg/100 g. Ca (2098.1), Mg (406.0), K (1922.0), Fe (28.3), Zn (5.4) and P (351.1) mg.100 g of dry matter.	Leaves	[24]	**Burkina Faso**
2011	Sucrose, glucose, Raffinose, Total anti-oxidant (TAO) (1.8 mg g-1), leaf-ascorbic acid (AsA) (2.0 mg g^{-1}), and total phenols (TP) (64.1 mg g-1); stem-TAO (1.2 mg g^{-1}); root-carotenoids (29.7 mg g^{-1}), TP (57.3 mg g^{-1}); seed-tocopherol (28.57 mg g^{-1}). total crude protein, seed (110.4 mg g^{-1}) and leaf (76.1 mg g^{-1}).	Leaf, stem and root	[25]	**South Africa**
2010	19.15-28.80 % of protein; 2.06-2.47 % of fat; 16.30-23.89 % of fiber; 8.52-13.53 % of moisture. Ca (1510.41-2951.13 mg), K (1504.23-2054.05 mg and Fe (20.31-37.60 mg /100 g dry weight.	Leaves	[26]	**Thailand**
2010	Rhamnose and acetyl-rhamnose-substituted glucosinolates, complex flavonoid profile consisting of glucosides, rutin-osides, malonylglucosides and traces of acetylglucosides of kaempferol, quercetin and isorhamnetin, palmitic (16:0) and linolenic (18:3) acid, oleic acid (18:1), Potassium, magnesium and calcium, selenium.	Leaves, seeds and roots	[27]	**Ghana**
2010	Ca [(1.99- 1.96), Mg (7.67 -7.71), K (0.47 -0.44), Na (0.13 - 0.10), Al (0.03 -0.02), %Organic carbon (2.75 -2.74), CEC (4.19- 4.20), Acidity (0.04- 0.05)] meq/100 g/soil, Mn [(6.39-6.41), Fe (20.12- 21.14), Cu (1.56 -1.63), Zn (3.40 - 3.47] mg L^{-1}).	L eaves, pods & seeds	[28]	**Nigeria**
2006-2012	Per 30 moringa leaf powder: Ca = 60%, Mg = 37%, Fe = 84%, Cu = 19%, K = 11.3%, P = 9%, Vitamin A = 163%, vitamin B1 = 52 8%, vitamin B3 = 13%, vitamin C = 8.6%, vitamin E = 226% and protein = 12.8%	Leaves	[29]	**Not indicated**

2010	Contained chlorogenic acid, rutin, quercetin glucoside, and kaempferol rhamnoglucoside, whereas in the root and stem barks, several procyanidin.	Leave	[30]	**Nigeria**
2010	Tannins, steroids and triterpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugars.	Leaves	[31]	**Uganda**
2009	Aspartate [15.8 ± 1.5 7.4 ± 0.3 12.3 ± 0.9, Glutamate 17.1 ± 1.4 14.6 ± 2.3 17.0 ± 2.2, Serine 9.4 ± 0.5 7.5 ± 1.8 7.5 ± 0.4, Histidinea 7.0 ± 0.4 2.0 ± 0.3 3.1 ± 0.4, Glycine 10.3 ± 0.7 4.3 ± 0.5 6.5 ± 0.3, Threoninea 7.9 ± 0.4 3.3 ± 0.5 5.4 ± 0.2, Alanine 12.5 ± 0.6 4.2 ± 0.7 8.1 ± 0.5, Proline 12.4 ± 0.9 4.0 ± 0.6 6.6 ± 0.5, Tyrosinea 4.8 ± 0.9 0.4 ± 0.1 0.4 ± 0.1, Arginine 12.2 ± 0.8 8.1 ± 2.5 20.1 ± 1.2, Valine 11.3 ± 1.1 4.3 ± 1.0 6.4 ± 0.6, Methioninea 1.4 ± 0.3 0.9 ± 0.2 1.0 ± 0.2, Isoleucinea 8.9 ± 0.7 3.1 ± 0.4 5.2 ± 0.5, Leucinea 17.5 ± 0.2 5.6 ± 0.5 8.7 ± 0.9, Phenylalaninea 8.9 ± 0.3 2.3 ± 0.4 3.8 ± 0.5, Lysinea 15.3 ± 0.6 2.5 ± 0.6 4.6 ± 0.5] mg dw^{-1}. Fatty acids: C8:0 0.05 ± 0.01 0.24 ± 0.06 0.09 ± 0.03, C12:0 0.12 ± 0.02 0.11 ± 0.02 0.09 ± 0.01, C14:0 0.96 ± 0.18 0.26 ± 0.04 0.59 ± 0.03, C14:1w 5 0.53 ± 0.11 0.15 ± 0.03 1.96 ± 0.22, C16:0 23.28 ± 1.38 26.48 ± 0.5 23.43 ± 0.84, C16:1w7 0.43 ± 0.07, C18:0 4.08 ± 0.15 3.10 ± 0.13 4.52 ± 0.09, C18:1w7 1.15 ± 0.16 1.00 ± 0.2 2.00 ± 0.21, C18:1w9 5.12 ± 0.18 17.00 ± 1.32, 21.55 ± 0.97, C18:2w6 6.11 ± 0.83 23.50 ± 1.01 18.96 ± 0.58, C18:3 w 3 56.87 ±1 .57 26.15 ± 0.74 23.01 ± 0.38, C20:0 0.72 ± 0.08 0.39 ± 0.02 0.98 ± 0.08, C 20:1 w 9 nd 0.24 ± 0.03 0.75 ± 0.08, C20:4 w 6 0.21 ± 0.02 0.24 ± 0.03 0.19 ± 0.03, C22:0 0.70 ± 0.06 1.06 ± 0.10 2.06 ± 0.19, Saturated FAs 29.89 ± 1.40, 31.64 ± 0.53 31.76 ± 0.87., Monounsaturated FAs 7.23 ± 0.27, 18.39 ± 1.33 26.26 ± 1.01, Polyunsaturated Fas, 63.19 ± 1.77 49.89 ± 1.25 42.16 ± 0.69, Unsaturated FAs 70.42 ± 1.79 62.28 ± 1.83 68.42 ± 1.23.	Leaves, pods and flowers	[32]	**Mexico**
2008	Crude protein was 27.51%, crude fibre was 19.25%, crude fat was 2.23%, ash content was 7.13%, moisture content was 76.53%, carbohydrate content was 43.88%, and the calorific value was 1296.00 kJ/g (305.62 cal/g), Calcium 2,009.00 and iron 28.29 mg/100 dry weight.	Leaves	[33]	**Ghana**
2005	Oil content (ranged from 33.23 to 40.90%), Protein, fiber, moisture, and ash contents were found to be 28.52-34.00, 6.52-7.50, 5.90-7.00, and 6.52-7.50%, respectively. Tocopherols (a, g, and d) accounted for 114.50-140.42, 58.05-86.70, and 54.20-75.16 mg/kg, respectively, of the oils. The major sterol fractions of the oils were campesterol (14.13-7.00%), stigmasterol (15.88-19.00%), b-sitosterol (45.30-53.20%), and D5-avenasterol (8.84, 11.05%). oleic acid (up to 76.00%), followed by palmitic, stearic, behenic, and arachidic acids up to levels of 6.54, 6.00, 7.00, and 4.00%, respectively.	Seeds	[34]	**Pakistan**
2003	Oil content of *Moringa oleifera* seeds ranged from 38.00 to 42.00%. Protein, fiber, and ash contents were found to be 26.50-32.00, 5.80-9.29, and, 5.60-7.50%, respectively. Tocopherols (R, *ç*, and *ä*) in the oil were up to 123.50-161.30, 84.07-104.00, and 41.00-56.00 mg/kg, respectively. The oil was found to contain high levels of oleic acid (up to 78.59%) followed by palmitic, stearic, behenic, and arachidic acid up to levels of 7.00, 7.50, 5.99, and 4.21%, respectively.	Seed	[35]	**Pakistan**

Gupta, J. [37] and his research team determined that *M. oleifera* stem-bark contains alkaloids, glycosides, flavonoids, steroids and so forth while the seeds content of the plant are known to be rich in amino acids, proteins, vitamins and mineral making it a supplement of choice for stress and malnourished populations. The oil squeezed from the nuts is useful for cooking and can be added to other dishes for nutrients [37] as well as in cosmetics formulation.

1.3.2. Compounds isolated from M. oleifera.

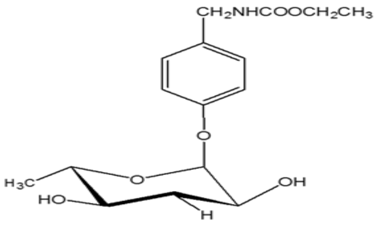
Factors including the lack of commercial standards is critical for the development of quality control protocol for herbal medicines. Herbal medicines could contain at least two or more markers or pharmacologically active components. These compounds frequently interact synergistically, making isolation of the active principles complex and sometimes-unfeasible [38]. The issue of variation of active components in response to genetic traits, environmental conditions, harvesting season, geographical locality and processing methods remains an obstacle to the augmentation of safety, efficacy and quality of herbal medicines. For instance, the concentration of magnesium was recorded as (Mg, 5500 mg/kg) and (Mg, 86.8 mg/kg) by [10-11] respectively. *M. oleifera* is known to contain significant amounts of compounds that are rich in simple sugar, rhamnose called glucosinolates and isothiocyanates [39]. It has been established that *M. oleifera* leaves are rich in tannins, steroids and triterpenoids, flavonoids, saponins, anthraquinones, alkaloids and reducing sugars which are phytochemicals highly important for its medicinal use [40]. The greatest ability of *Moringa* leaves to act as a valued source of natural antioxidant is attributable to different types of antioxidant compounds such as ascorbic acid, flavonoids, phenolics and carotenoids present in the leaf component [41]. The first authors that attempted the isolation and purification of secondary metabolites from *M. oleifera* reported that nitrile, mustard oil glycosides and thiocarbamate glycosides have been isolated from *Moringa* leaves [42]. Bioassay guided fractionation of the active ethanol extract of *Moringa* leaves rendered isolation of four pure compounds, i.e. niazinin A, niazinin B, niazimicin [32] and niazinin A + B which indicated a blood pressure lowering effect in rats mediated possibly through a calcium antagonist effect [42]. Analysis of the phytochemistry of *Moringa oleifera* stem bark showed the existence of flavonoids, alkaloids, steroids and tannis [43]. One study investigated the presence of a bioactive nitrile glycosides niaziridin and niazirin **25** in *M. oleifera*. The two nitrile glycosides were only detected in leaves and pods but not the stem bark [44] and in a 2016 recent studies, Chokwe [45] underscores the fact that about 30 secondary metabolites has been reportedly isolated from the seeds of *M. oleifera*. We collated and compiled to the best of our search tools a list of compounds (Table 2) isolated from *Moringa oleifera.* In1999, *O*-ethyl-4-(α-L-rhamnosyloxy)benzyl carbamate **1,** together with known other compounds which include 4(alpha-L-rhamnosyloxy)-benzyl isothiocyanate **2**, niazimicin **31**, niazirin **24**, beta-sitosterol **15**, glycerol-1-(9-octadecanoate) **64**, 3-*O*-(6'-Oleoyl-β-D-glucopyranosyl)-β-sitosterol **16**; and beta-sitosterol-3-O-β-D-glucopyranoside **17**, 3-*O*-(6'-*O*-oleoyl-β-D-glucupyranosyl)-β-sitosterol **65** were isolated from seeds of *M. oleifera of the* Philippines by Guevara and co-workers [46]. Between 1999 and 2016, several compounds (Table 2) have been isolated and purified from *M. oleifera.* Eighteen years later in 2017, Giacoppo [47] reported on the isolation of isothicyanate [4-(α-L-rhamnopyranosyloxy) benzyl GL **70**; and moringin [98] from *Moringa oleifera* harvested from Egypt. This compound indicated potentials for anti-Inflammatory activity in the treatment of Murine Sub-acute Parkinson's. In the same year, polysaccharides (ML1,MLP2 and MLP3) consisting of xylose, mannose, glucose, galactose and arabinose in different molar ratios were purified and isolated from *Moringa oleifera* species from China [48]. Reviewing the samples collection sites over the last 18 years, unravelled the fact that no record is available in literature for isolation studies using *M. oleifera* samples harvested in South Africa. Only two studies on isolation and purification, as far as we know were carried out in two South African Universites-University of South Africa [45] and the University of kwa-Zulu-Natal [49] over this period. Whereas Chokwe and co-workers [45] isolated 3-caffeoylquinic acid **67**, *O*-ethyl-[4-(α-L-Rhamnosyloxy) benzyl] thiocarbamate **3**, *O*-butyl-[4-(α-L-Rhamnosyloxy) benzyl] thiocarbamate **71**, 4 (α-L-rhamnosyloxy)-benzyl isothiocyanate **2**, quercetin-3-*O*-glucoside **51**, 4-(β-D-glucopyranosyl-1→4-α-L-rhamnopyranosyloxy)-benzyl isothiocyanate **72**., lutein **56** and β-sitosterol **66** were reported by Chepkoech and co-authors [49]. However, samples used for the two separate studies were harvested from Zambia and Kenya respectively. The lack of isolation studies using South African *Moringa oleifera* seems to underscore the unavailability or insufficient commercial standards or bioactive compounds in *Moringa oleifera* based herbal products of South African origin in the market. This could translate to inherent poor quality and compromised safety of *Moringa oleifera* based commercial products that floods the South Africa market. Would there be a slim possibility that the marketers of such products imported the raw materials or finished products from Countries were *M. oleifera* is well standardized? Whatever the answers is to these questions, one requires the isolation of marker compounds from South African *M. oleifera* in order to validate both *M. oleifera* raw materials extracts and products available in the South Africa market. The structures of some of the randomly selected compounds isolated from *M. oleifera* samples collected across both natural and cultivated *Moringa* oleifera populations in different Countries, except South Africa are shown in Figure 3.

Table2. *Compounds isolated from Moringa oleifera from other Countries except South Africa with potential use as standards for commercial products quality control and standardization of raw materials.*

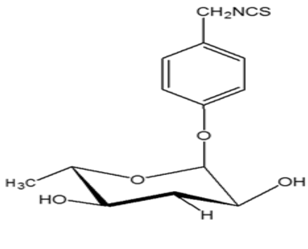
Year	Name of isolated compound(s)	Plant part used	Research group(s)/article authors	Sample collection site(s)
2017	[4-(a-L-rhamnopyranosyl benzyl isothicyanate; moringin.	Seeds	[47]	**Egypt**
2017	Polysaccharides (ML1, MLP2 and MLP3) consisting of xylose, mannose, glucose, galactose and arabinose but with differing molar ratios.	Leaves	[48]	**China**
2016	3-caffeoylquinic acid, O-ethyl-[4-(α-L-Rhamnosyl oxy) benzyl] thiocarbamate, O-butyl-[4-(α-L-Rhamno- syloxy) benzyl] thiocarbamate, 4(α-L-rhamnosyloxy)-benzyl isothiocyanate.	Seeds	[45]	**Zambia**
2015	β-carotene, phytyl fatty acid ester, polyprenol chlor-ophyll a, β-sitosterol, triacylglycerols, fatty acids, fatty alcohols, and saturated hydrocarbons	Leaves	[50]	**Philippines**
2015	Aliphatic alcohol.	Leaves	[51]	**Nigeria**
2014	Quercetin-3-O-glucoside, 4-(β-D-glucopyranosyl 1→ 4-α-L-rhamnopyranosyloxy) -benzyl isothiocyanate, lutein and β-sitosterol.	Leaves and seeds	[49]	**Kenya**
2014	Glucomorigin	seeds	[52]	**Egypt**
2013	Saponin	pods	[53]	**India**
2011	Unusual glycosides of pyrrole alkaloid (pyrrol emarumine 4″-*O*-α-l-rhamnopyranoside) and 4′-hydroxyphenylethanamide (marumosides A and B) were isolated from leaves of *Moringa oleifera* along with eight known compounds; niazirin, methyl 4-(α-l-rhamnopyranosyloxy)benzylcarbamate, benzyl β-d-glucopyranoside, benzyl β-d-xylopyranosyl-(1 → 6)-β-d-lucopyranoside, kaempferol 3-*O*-β-d-glucopyra noside, quercetin 3-*O*-β-d-glucopyranoside, adeno-sine and l-tryptophan.	Leaves	[54]	**Thailand**
2011	lupeol acetate , β-amyrin , α-amyrin, β-sitosterol, β-sitosterol-3-O-glucoside, apigenin, rhamnetin, neochlorogenic acid, rhamnetin-3-O-rutinoside, and 6-methoxy-acacetin-8-C-β-glucoside.	leaves	[55]	**Egypt**
2011	Kaempferide 3-O-(2",3"-diacetylglucoside), kaempf eri- de 3-O-(2"-Ogalloylrhamnoside), kaempf eride 3-O-(2"-O-galloylrutinoside)-7-O-alpha-rham noside, kaempferol 3-O-[beta-glucosyl-(1→2)]-[alpha-rhamn osyl (1→6)]-beta-glucoside-7-Oalpharhamnoside and kaempf erol 3-O-[alpha-rhamnosyl-(1→2)]-[alpha-rhamnosyl-(1→4)]-betaglucoside-7-O-alpharhamno-side together with benzoic acid 4-O-beta-glucoside, benzoic acid 4-O-alpha-rhamnosyl-(1→2)-beta-glucoside andenzald- ehyde 4-O-beta-glucoside. kaempferol 3-O-alpha-rhamnoside, kaempferol, syringic acid, gallic acid, rutin and quercetin 3-O-beta-glucoside.	Leaves Draw structures	[56]	**Senegal**

2009	aurantiamide acetate 4 and 1, 3-dibenzyl urea 5. Both these compounds were isolated for the first time from this genus.	roots	[57]	**India**
2009	Monoterpenoid compounds.	oils	[58]	**Nigeria**
2009	Gallic acid, chlorogenic acid, ellagic acid, ferulic, acid, kaempferol, quercetin and vanillin.	Fruit/seeds	[59]	**India**
2009	Gallic acid, chlorogenic acid, ellagic, acid, ferulic acid, kaempferol, quercetin and rutin	leaves	[60]	
2004	hexadecanoic acid, Ethyl palmitate, Palmitic acid ethyl ester, 2, 6-Dimethyl-1, 7-octadiene-3-ol, 4-Hexadec- en-6-yne, 2-hexanone, 3-cyclohexyliden-4-ethyl - E2- Dodecenylacetate, Hi-oleic safflower oil, Safflower oil Roridin E, Veridiflorol, 9-Octadecenoic acid. From the flowers, 9- Octadecen –1- ol, cis - 9 – Octadecen – 1 –ol, Oleol, Satol, Ocenol, Sipo, Decanoic acid, Dodecanal wer Moringyne, 4-(α-L-rhamnosyloxy) benzyl isothiocyanate & several amino acids.	Leaves Seed seed	[61] [62] [62] [63]	**Nigeria** **Nigeria** **India** **India**
2008	β-sitosterol-3-O-β-D-glucopyranoside, β-sitosterol, linoleic sitosteroate, linoleic acid, 1,2,3-triolein, a mixture of 1,3-dilinoleoyl-2-olein, 1,3-dioleoyl-2-linolein and 1,2,3-trilinolein and thiocyanatometh-ylbenzene	Not indicated	[64]	**Not indicated**
2007	quercetin glucosides, rutin, kaempferol glycosides and chlorogenic acids	Leaves	[65]	**Senegal**
2007	D-galactose, 6-O-Me-D-galactose, Dgalacturonic acid, l-arabinose, and l-rhamnose.	Pods	[66]	**India**
2007	Sterols, tocopherols and fatty acids	Seed/ seed oils	[67]	**Pakistan**
2007	Niaziridin & niazirin	Leaves, pods and bark	[68]	**India**
2007	Fourty-four compounds from the essential oils	Leaves	[69]	**Taiwan**
2006	aldotriouronic acid (O-(β-D-glucopyranosyluronic acid) (1→6)-β-D-galactopyranosyl (1→6)-Dgalactose. Aspartic acid, glutamic acid, glycine, threonine, alanine, valine, leucine, isoleucine, histidine, lysine, phenylalanine, tryptophan, cysteine and methionine.	Gum Leaves	[63]	**India**
2003	4-(alpha-l-rhamnopyranosyloxy)-benzylglucosinolate. 4-(alpha-l-rhamnopyranosyloxy)-benzylglucosinolate and benzyl Glucosinolate. 4-(alpha-l-rhamnopyr anosyloxy)-benzylglucosinolate and three monoacet yl isomers of this glucosinolate. Quercetin-3-O-glucoside and quercetin-3-O-(6"-malon yl-glucoside, kaempferol-3-O-glucoside, kaempferol-3-O-(6"-malonyl-glucoside), 3-caffeoylquinic acid and 5-caffeoylquinic acid. 4-(α-L-rhamnopyranosyloxy)-benzylglucosinolate.	Seeds Roots Leaves bark	[70]	**Nicaragua, Malawi, Tanzania and Senegal**
2003	quercetin and kaempferol	leaves	[71]	**India, Nicaragua, and Niger**
2003	aglycone of Deoxy-Niazimicine which is characterized as N-benzyl; S-ethyl thioformate	Root Barks	[72]	**Bangladesh**

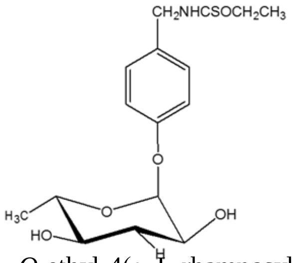
1999	O-ethyl-4-(alpha-L-rhamnosyloxy)benzyl carbamate together with seven known compounds, 4(alpha-L-rhamnosyloxy)-benzyl isothiocyanate, niazimicin, niazirin, β-sitosterol, glycerol-1-(9-octadecanoate), 3-O-(6'-Oleoyl-beta-D-glucopyranosyl)-beta-sitosterol and beta-sitosterol-3-O-beta-D-glucopyranoside 3-*O*-(6'-*O*-oleoyl-β-D-glucupyranosyl)-β-sitosterol and β-sitosterol-3-O-β–D-glucopyranoside	seeds	[46]	**Philippines**



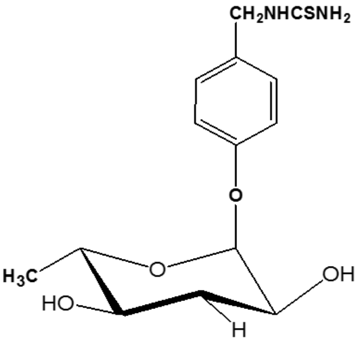
O-ethyl-4-(α-L-rhamnosyloxy) benzyl Carbamate **1** [45]



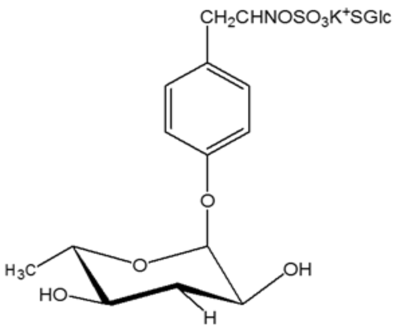
4-(α-L-rhamnosyloxy) benzyl isothiocyanate **2** [46]



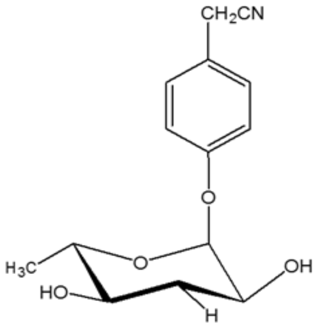
O-ethyl-4(α-L-rhamnosyloxy benzyl thiocarbamate **3** [46]



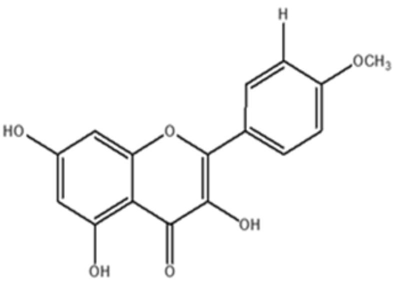
4-(α-L-rhamnosyloxy benzyl Thiocarbamide **4** [70]



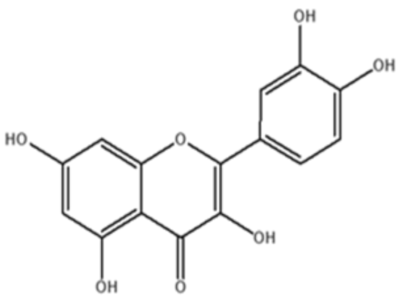
4-(α-Lrhamnosyloxy benzyl glucosinolate **5** [70]



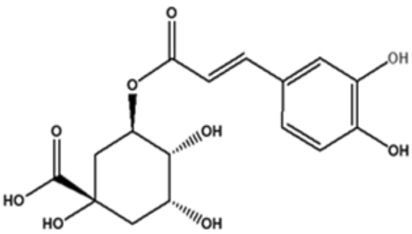
4-(α-L-rhamnosyloxy phenylacetonitrile **6** [70]



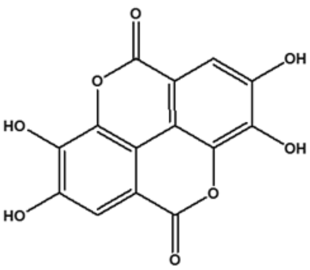
Kamferol **7** [73]



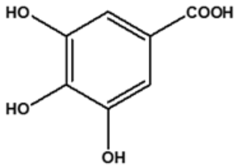
Quercetin **8** [73]



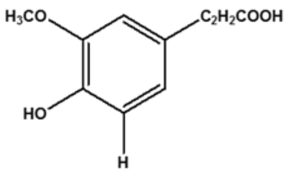
Chlorogenic acid **9** [73]



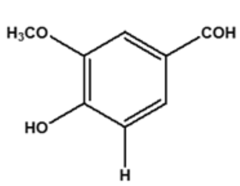
Ellagic acid **10** [73]



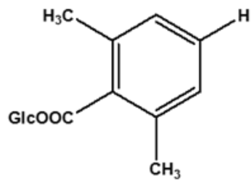
Gallic acid **11** [73]



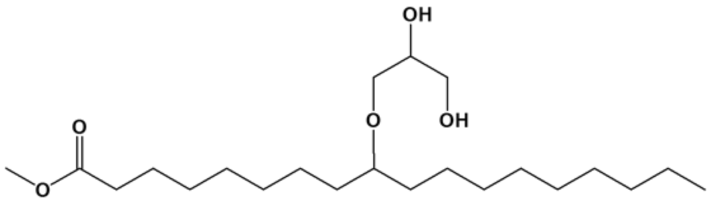
Ferulic acid **12** [73]



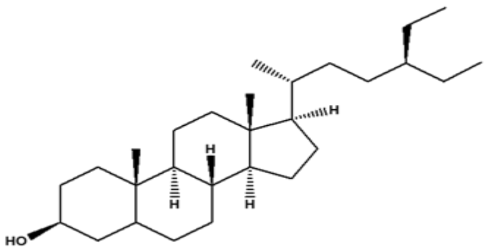
Vanillin **13** [73]



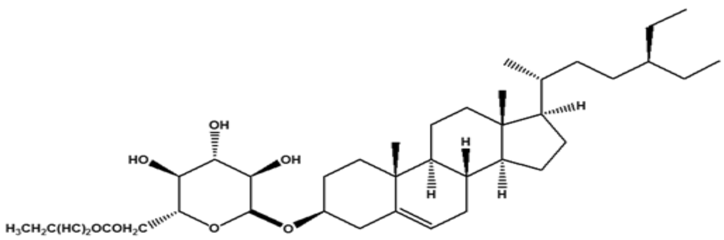
Moringyne **14** [59]



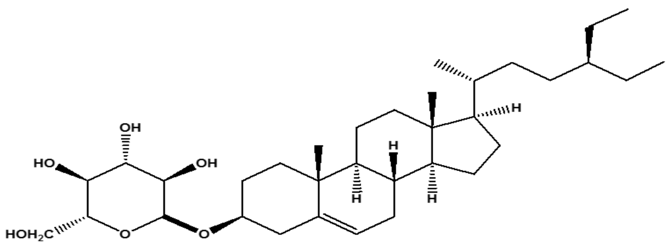
Glycerol-1-(9-octadecanoate) **15** [46]



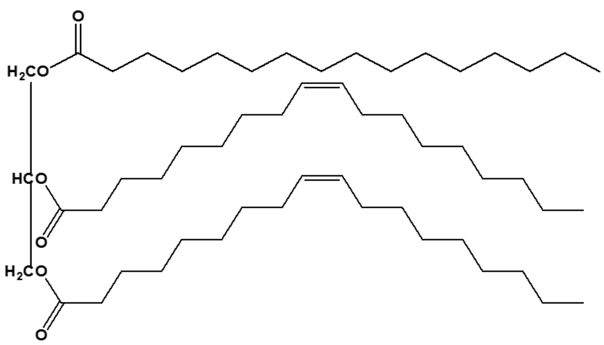
β-Sitosterol **16** [46]



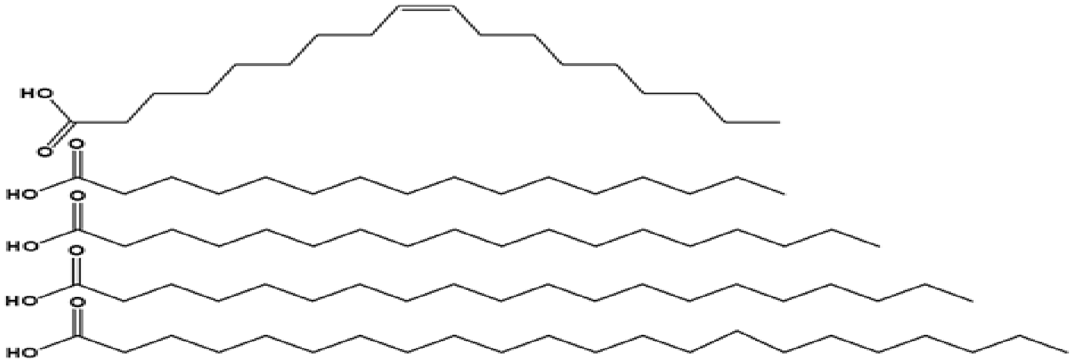
3-*O*-(6'-*O*-oleoyl-β-D-glucopyranosyl)-β-sitosterol **17** [46]



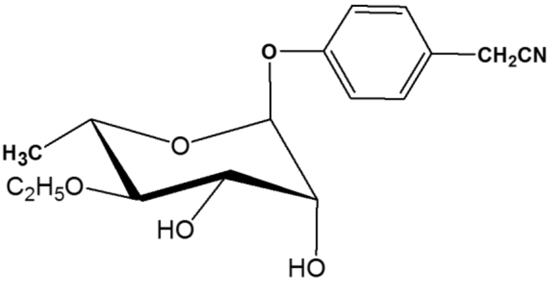
. β-Sitosterol-3-O-β-D-glucopyranoside **18** [47]



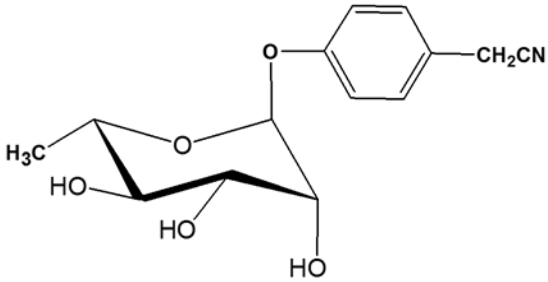
Mono-palmitic, di-oleic triglyceride **19** [70]



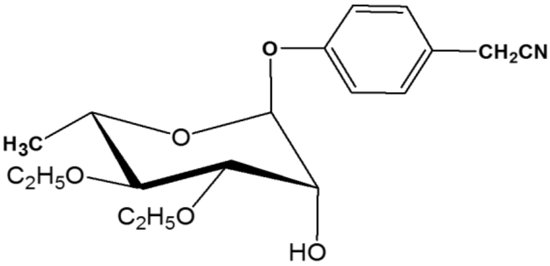
Top to bottom: Oleic **20**, Palmitic **21** [51], Stearic **22**, Bechenic **23**, Arachidic acids **24** [36]



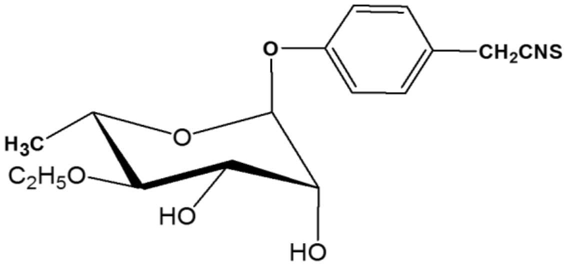
Niazirin **25** [57]



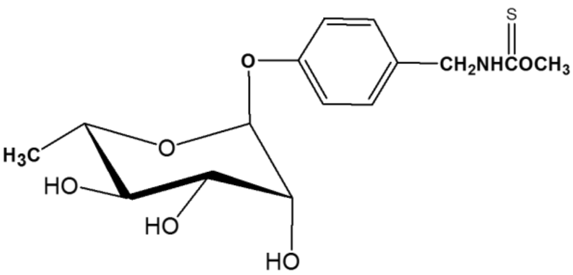
Niazirinin **26** [74]



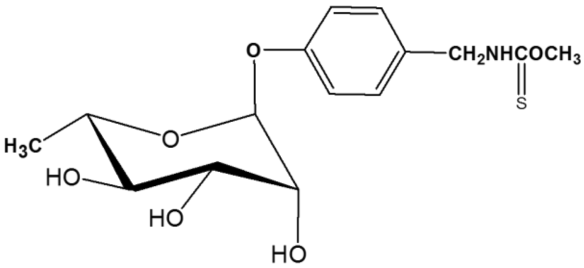
Niazirin di-*O*-acetate **27** [74]



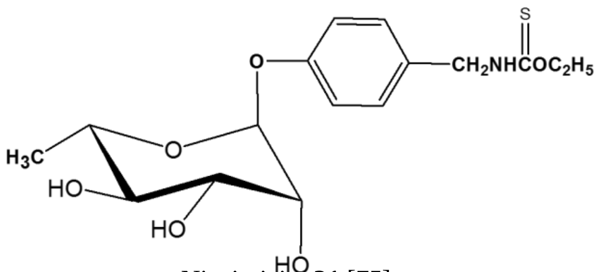
O-acetyl-α-L-rhamnosyloxy)benzylisothiocyanate **28** [74]



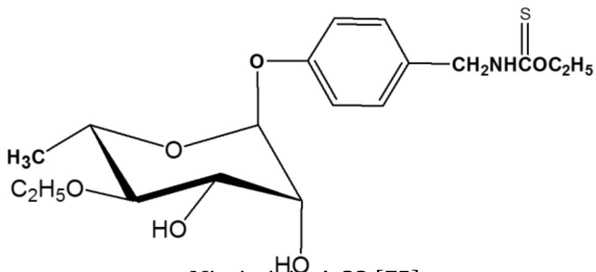
NiazininA **29**[75]



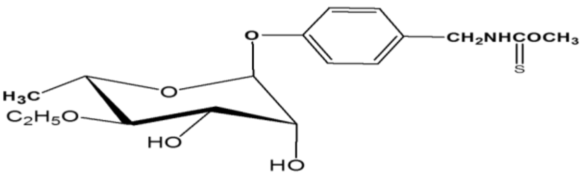
Niazinin B **30** [75]



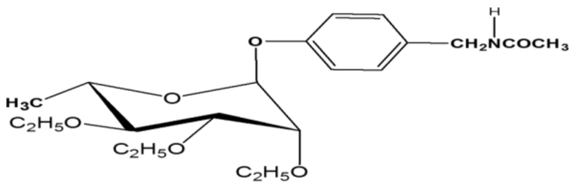
Niazimicin. **31** [75]



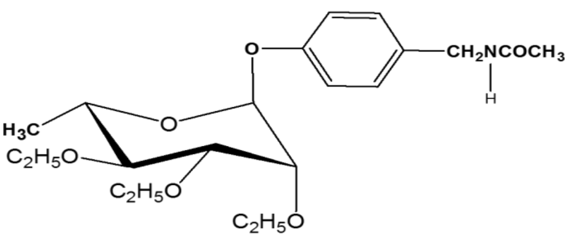
Niaciminin A **32** [75]



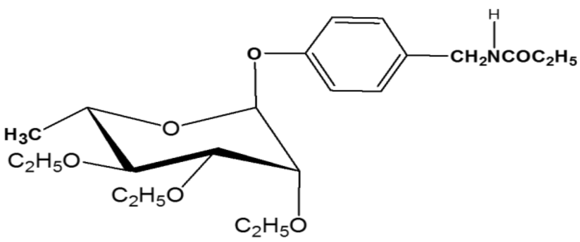
Niaciminin B **33** [75]



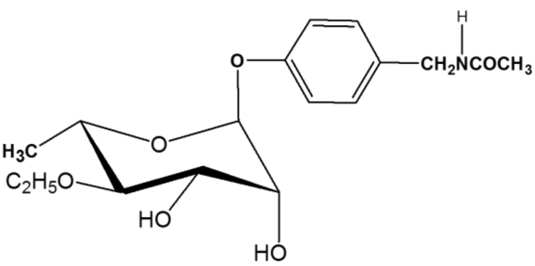
O-methyl, 4-[(2',3',4'-tri-O-acetyl-α-L-rhamnosyloxy) benzyl carbamate (E) **34** [76]



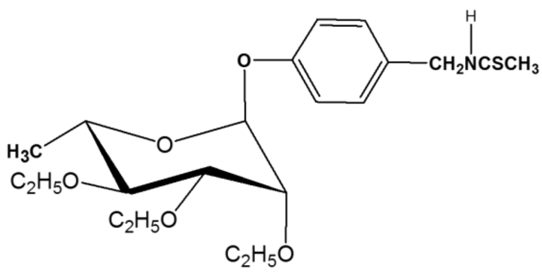
O-methyl, 4-[(2',3',4'-tri-*O*-acetyl-α-L-rhamnosyloxy) carbamate (*Z*) **35** [76]



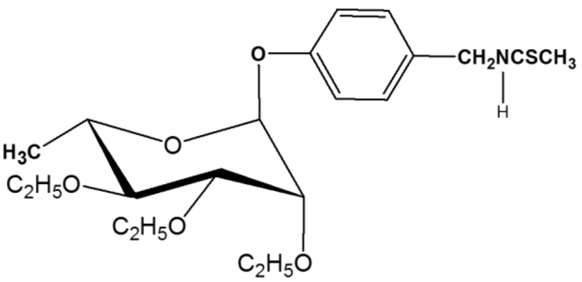
O-ethyl, 4-[(2',3',4'-tri-*O*-acetyl-α-L- benzyl] rhamnosyloxy) benzyl] carbamate (*Z*) **36** [76]



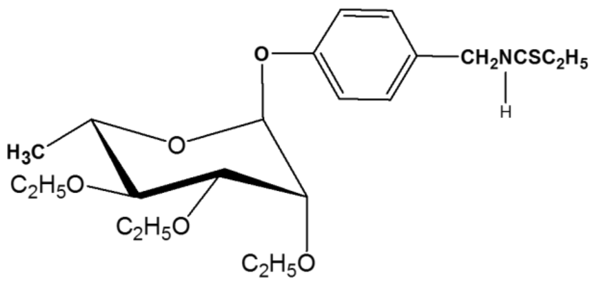
O-methyl 4-[4'-*O*-acetyl-α-L-rhamnosyloxy) Lrhamnosyloxy)benzyl] carbamate (*E*) **37** [76]



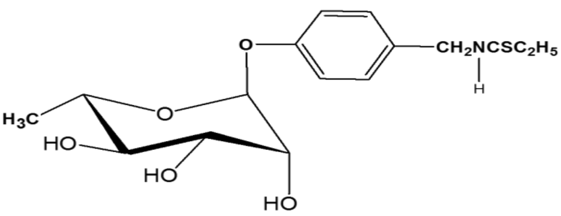
O-methyl, 4-[(2',3',4'-tri-*O*-acetyl-α- benzyl] thiocarbamate (*E*) **38** [76]

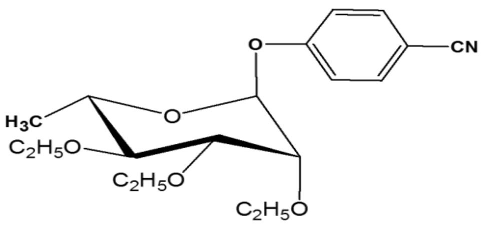


O-methyl, 4-[(2',3',4'-tri-*O*-acetyl-α-L-rhamnosyloxy) thiocarbamate (*Z*) **39** [76]



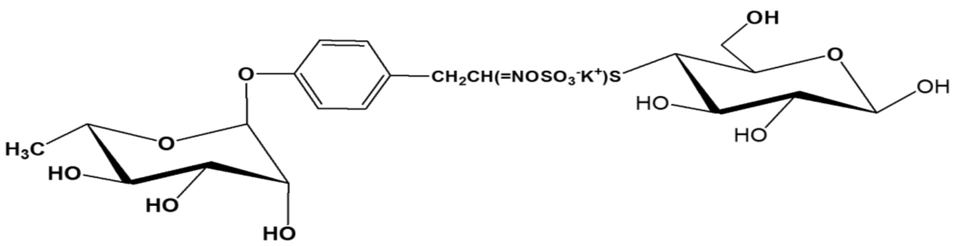
O-ethyl, 4-[(2',3',4'-tri-*O*-acetyl-α-L- benzyl] rhamnosyloxy) benzyl] thiocarbamate (*Z*) **40** [76]



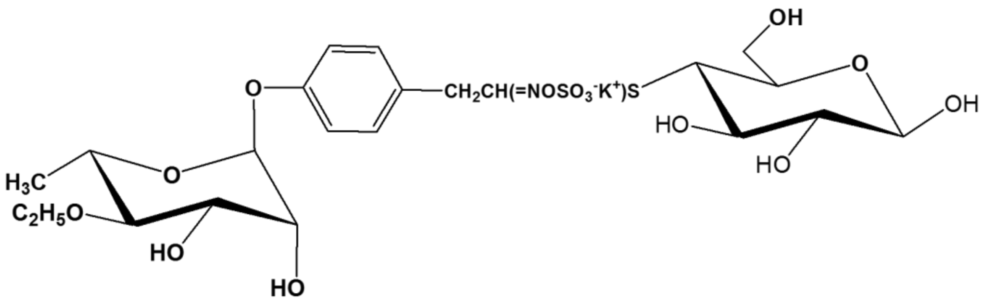


Niazimicin B **41** [76]

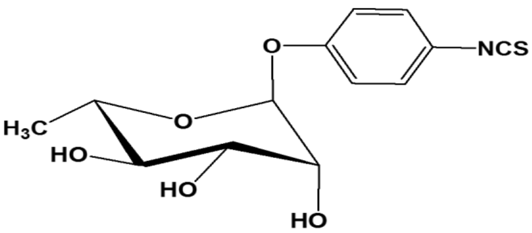
4-[(2',3',4'-tri-*O*-acetyl-α-L-rhamnosyloxy) benzyl nitrile **42** [76]

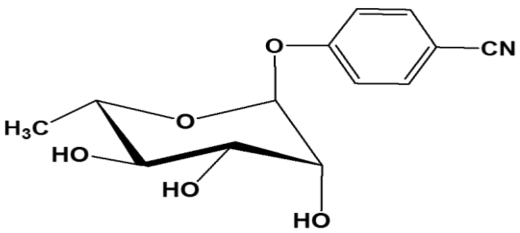


4-(®-L-Rhamnospyranosyloxy) -Benzylglucosinolate **43** [70]



4''Acetyl-4-(α-L-Rhamnospyranosyloxy)-Benzylglucosinolate **44** [70]

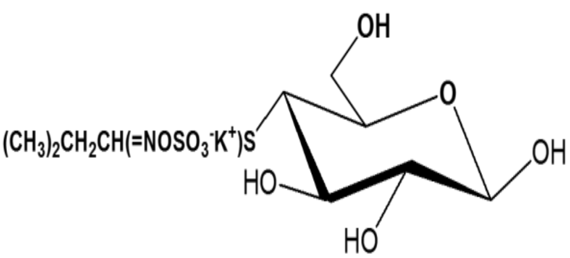


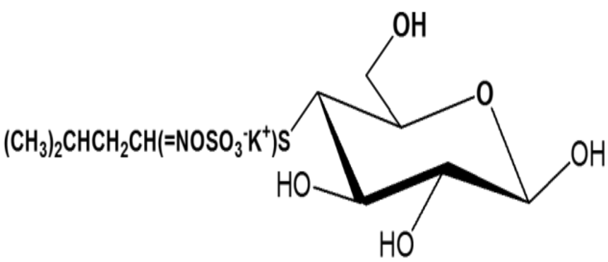


4-(α-L-Rhamnospyranosyloxy)-Benzylisothiocynate

4-(α-L-Rhamnospyranosyloxy) **45**[70]

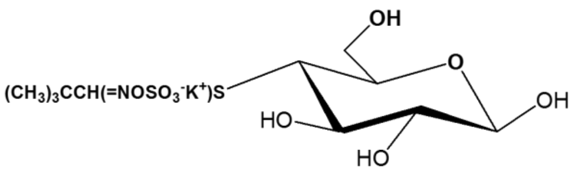
Benzylcyanide **45** [70]



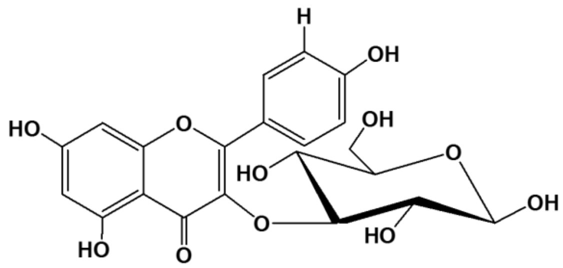


Isopropylglucosinolate **47** [70]

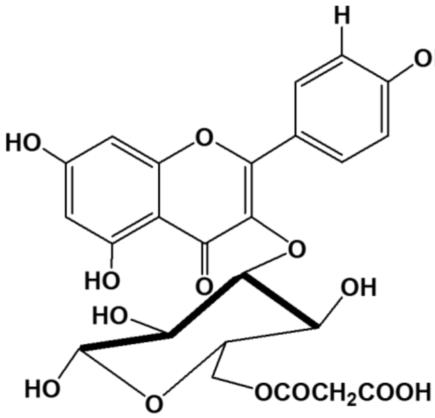
2-Methylpropylglucosinolate **48** [70]



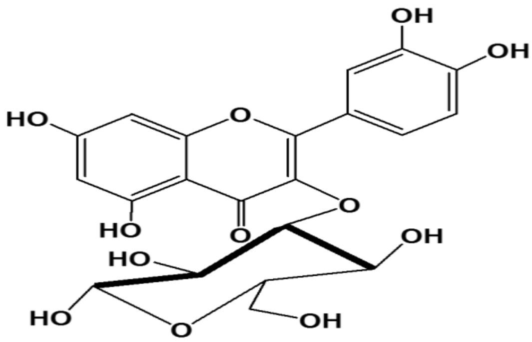
Isobutylglucosinolate **49** [70]



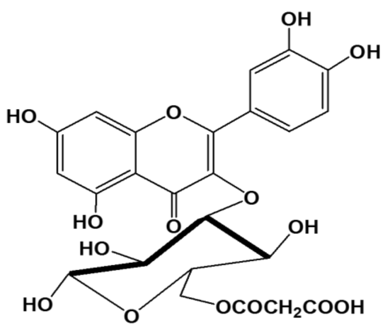
Kaemferol-3-*O*-glucoside **50** [70]



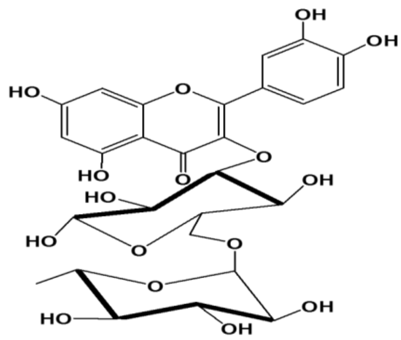
Kaemferol-3-*O*-(6''-malonylglucoside) **51** [70]



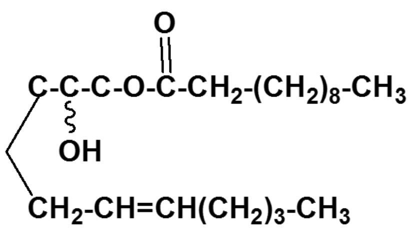
Quercetin-3-*O*-glucoside **52** [70]



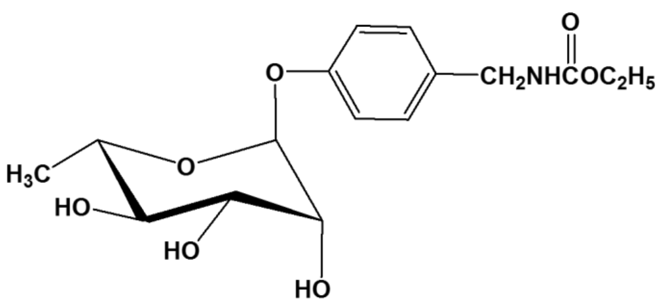
Quercetin-3-*O*-(6''-malonylglucoside) **53** [70]



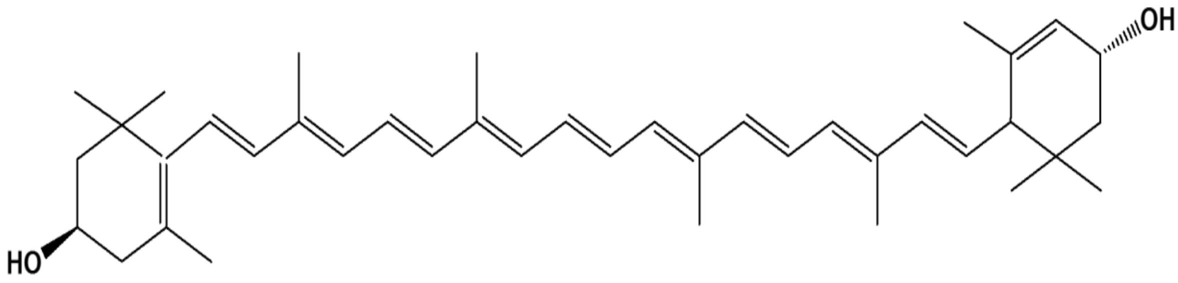
Rutin **54**, [70, 50]



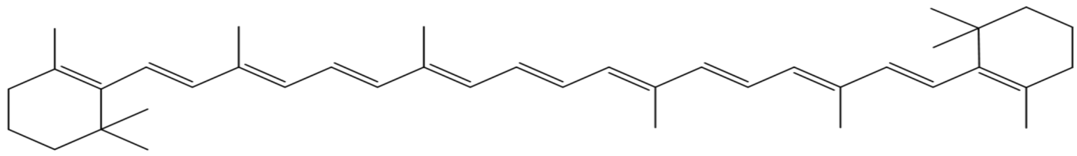
O-[2'Hydroxyl-3'-(2''heptenyloxy)]-propoyl Undecanoate **55** [70]



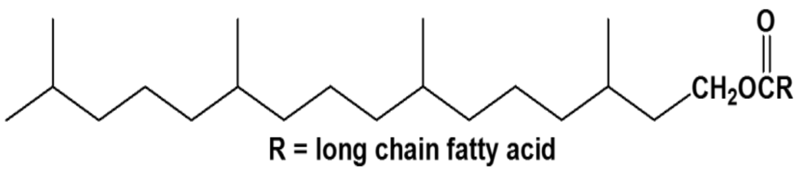
O-Ethyl-4-[(α-L-rhamnosyloxy)benzyl] carbamate **56** [77]



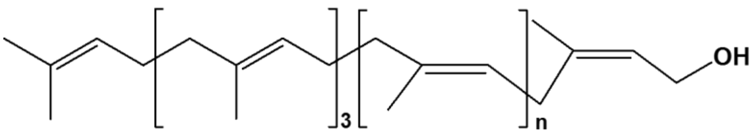
*Lutein **57** [50]*



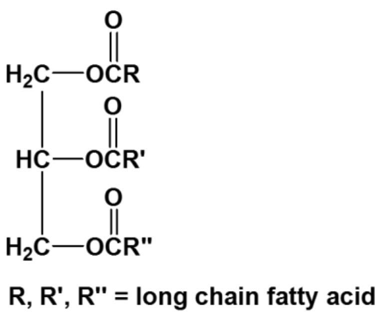
*β-carotene **58** [50]*



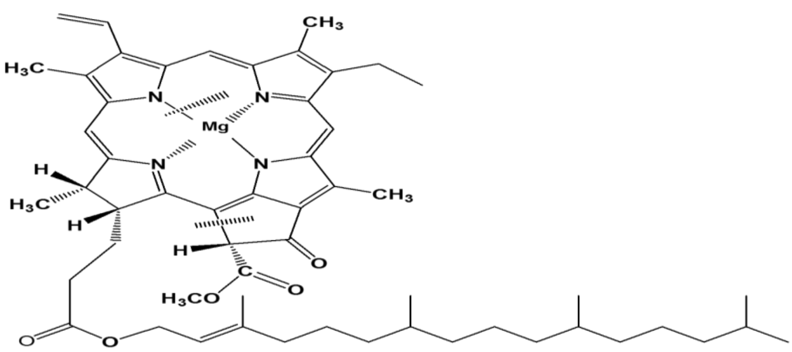
*Phytyl fatty acid ester **59** [50]*



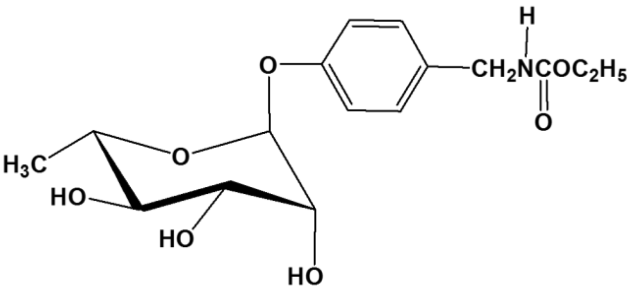
Polyprenol **60** [50]

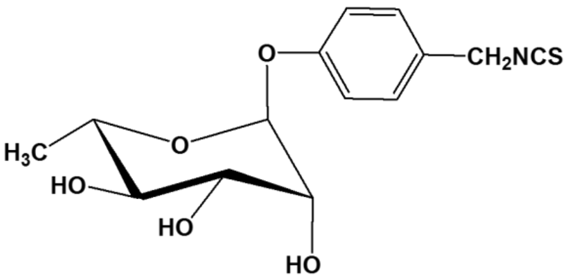


Triacylglyceriols **61** [50]

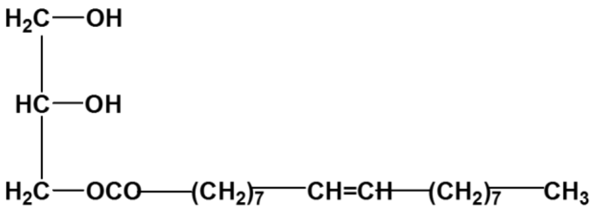


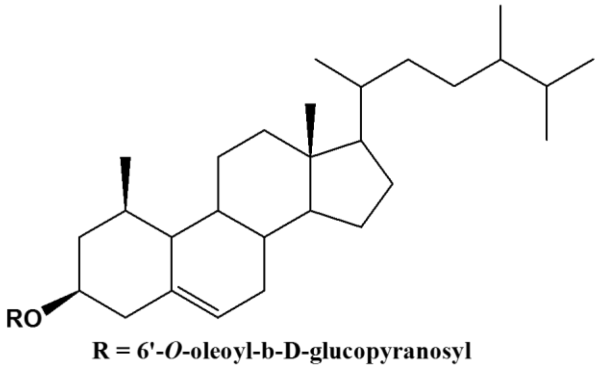
Chlorophyll a **62** [50]



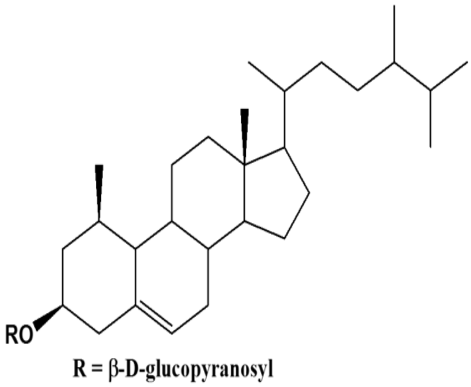


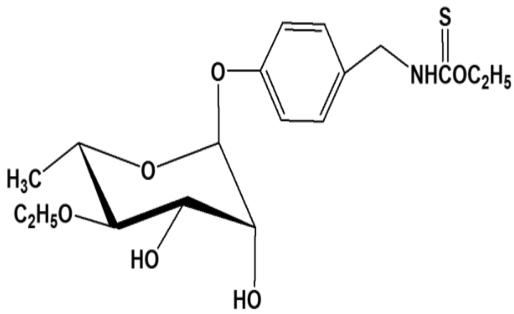
O-Ethyl-4-(α-L-rhamnosyloxy)benzyl carbamate **63** [46] 4-(α-L-rhamnosyloxy)-benzyl Isothiocyanate **64** [46]



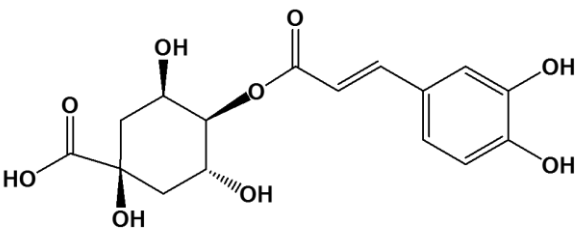


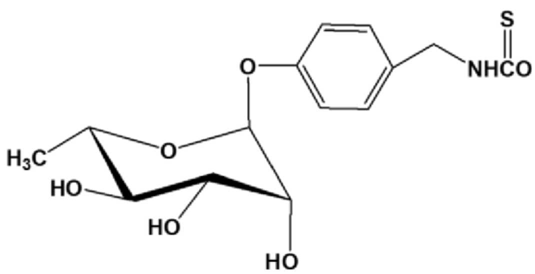
Glycerol-1-(9-octadecanoate) **65** [46] 3-*O*-(6'-*O*-oleoyl-β-D-glucupyranosyl)-β- sitosterol **66** [46]



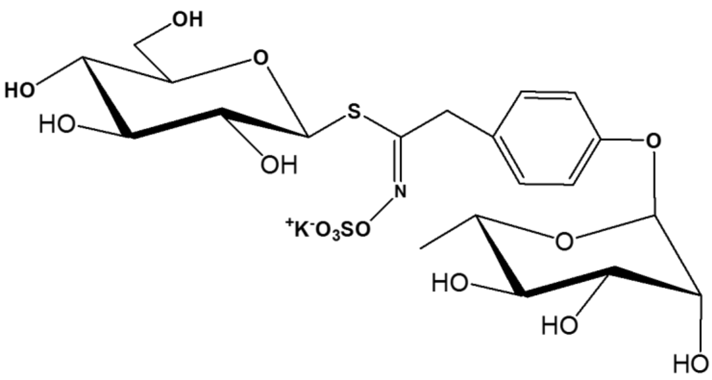


β-Sitosterol-3-*O*-β-D-glucopyranoside **67** [46] Niaziminin **68** [74]

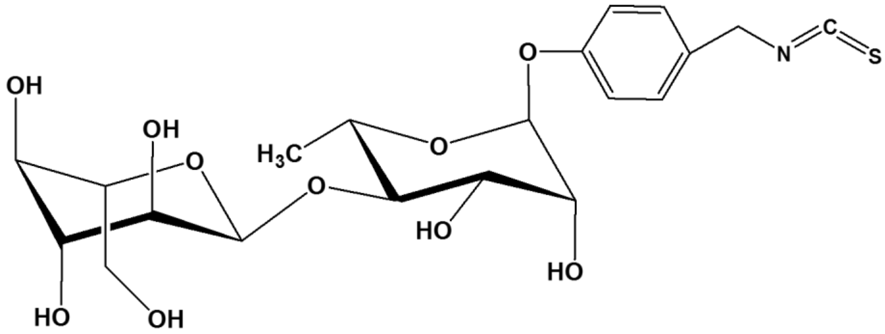




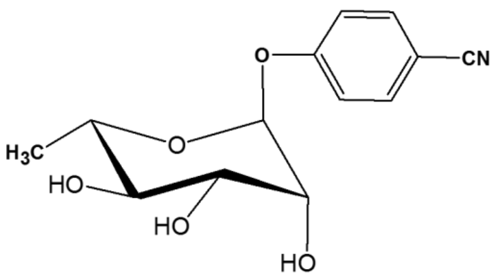
3-caffeoyl quinic acid **69** [75] *O*-butyl-[4-(α-L-Rhamnosyloxy) benzyl]-Thiocarbamate **70** [46]



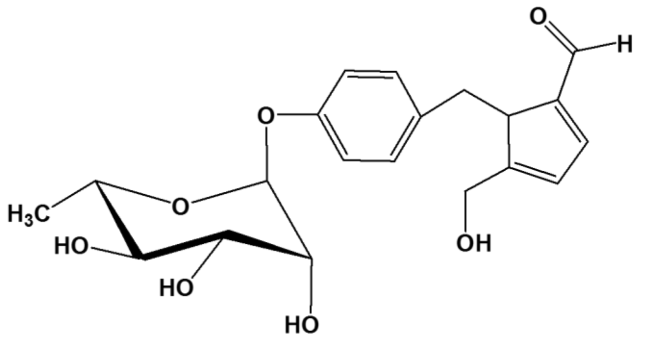
Glucomoringin, [4-(α-Lrhamnopyranosyloxy) benzyl GL] **71** [47]



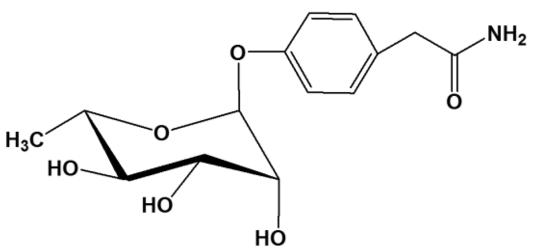
4-(β-D-glucopyranosyl-1→4-α-L-rhamnopyranosyloxy)-benzyl isothiocyanate **72** [49]



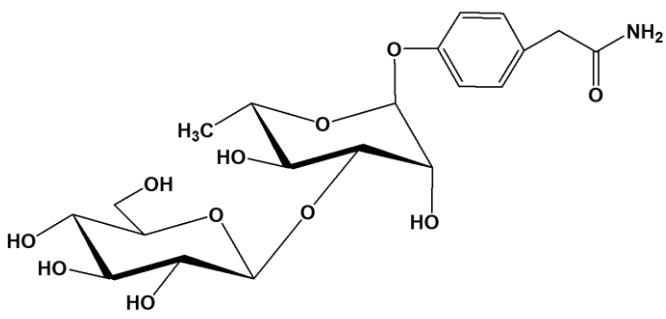
niazirin (4–(α-L-rhamnopyranosyloxy)phenylacetonitrile, **73** [79]



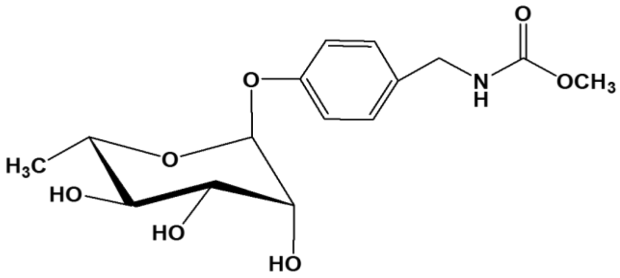
pyrrolemarumine 4-O-α-L-rhamnopyranoside **74** [54]

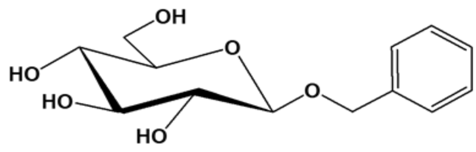


4-hydroxyphenylethanamide-α–L-rhamnopyranoside, (arumoside A). **75** [54]



4-hydroxyphenylethanamide-α-L-rhamnopyranosyl-3 *O*-β-D-glucopyranoside (marumoside B) **76** [54]

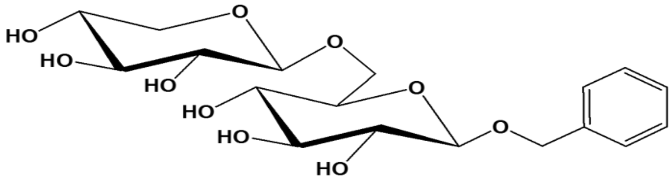


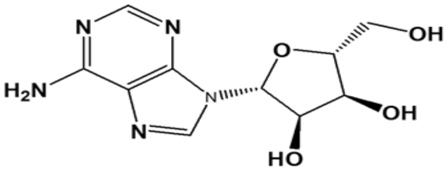


methyl 4-(α-L-rhamnopyranosyloxy)-

benzylcarbamate, Benzyl -β–D-glucopyranoside **78** [54]

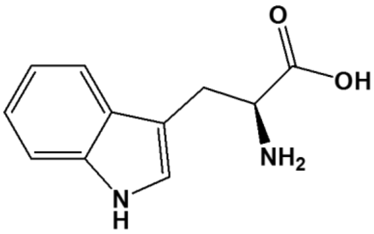
77 [76]

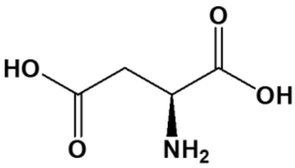


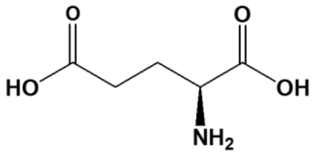


Benzyl ◎-D-xylopyranosyl -(1-6)-◎-D-glucopyranoside **79** [54]

Adenosine 80 [54]



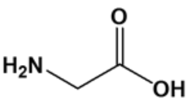


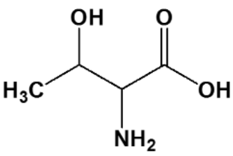


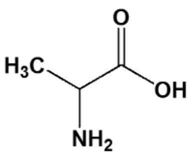
L-tryptophan **81** [54]

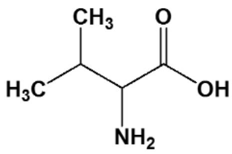
Aspartic acid **82** [63]

Glutamic acid **83** [63]







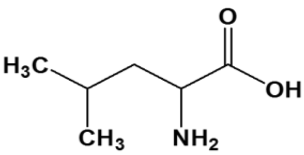


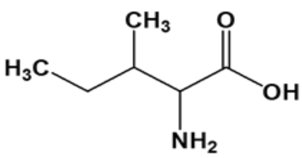
Glycine **84** [63]

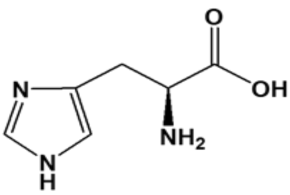
Threonine **85** [63]

Alanine **86** [63]

Valine **87** [63]



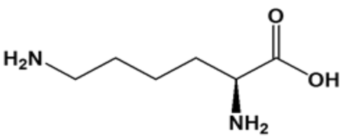


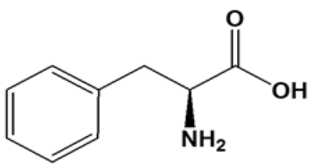


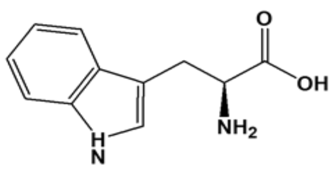
Leucine **88** [63]

Isoleucine **89** [63]

Histidine **90** [63]



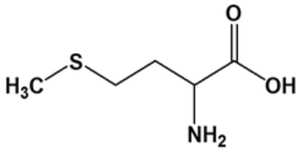




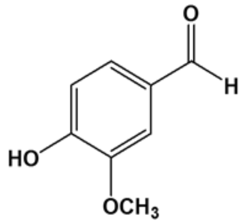
Lysine **91** [63]

Phenylalanine **92** [63]

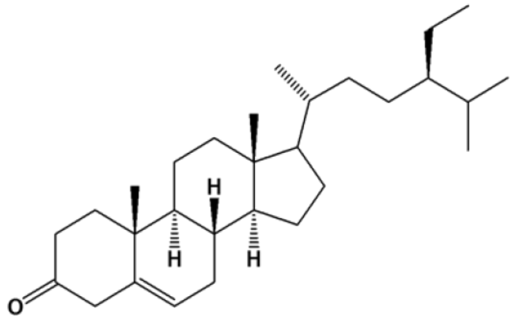
Tryptophan **93** [63]



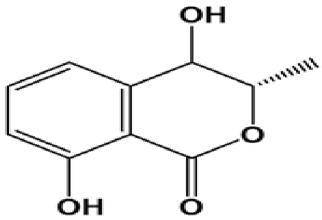
Methionine **95** [63]



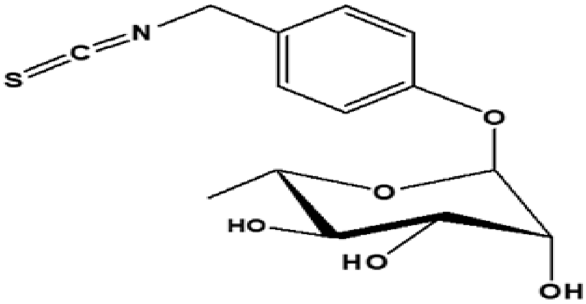
Vanillin **96** [63]



β-sitosterone **97** [62]



4-Hydroxy mullein **98** [63]



Moringin **98** [63]

Fig 3. *Structures of compounds isolated from non-South African Moringaoleifera*

1.4. Commercialisation of *Moringa* Plant Parts

In Africa, the majority of people depend on herbal medicines to meet their primary health care needs. In countries, including Ghana, Mali, Zambia and Nigeria, herbal medicines are used as the first line of treatment for 60% of children suffering from high fever and other malaria-related diseases [79]. The concomitant use of herbal medicines with their orthodox counterparts was approved by health Departments of Southern African Development Community [80] including South Africa. The alternative medicines market in South Africa is worth R25 billion annually with 27 million South Africans believed to regularly consult traditional healers. While the WHO [81]estimated that 70% of people living with HIV/AIDS have used herbal medicine, either alone or in combination, it has been proposed that 50% of the South African population source medicines from the country's rich flora [83]. In most of the developed economies of the world, the trade in herbal and other phytomedicines are well regulated. The Food and Drug Administration (FDA) of the USA, Natural Health Products Directorate (NHPD) of Canada, the European Scientific Cooperation on Phytomedicines (ESCOP) of EU Countries, the Medicines and Healthcare products Regulatory Agency (MHRA) of the UK, Nutrition Improvement Law (Japan), Traditional Medicines Evaluation Committee (TMEC) of Australia, the 1940 Drugs and Cosmetics Act and Cosmetics Rules of 1954 (India) are some of the regulatory agencies and acts whereby governments have attempted to ensure the quality and safety of phytomedicines. Underdeveloped countries, such as Pakistan, most African countries and South Africa in particular, do not have strong regulatory systems to oversee the trade in herbal medicines. However, the African Herbal Pharmacopoeia, published by the Association for African Medicinal Plants Standards (AAMPS), and the South African Health Product Regulatory Authority (SAHPRA) have contributed to the improvement of the quality, safety and efficacy of African herbal medicines [83]. To better the unregulated system for South African Complementary and Alternative Medicines (CAM), the Minister of Health published an amendment to the Medicines and Related Substances Act [84]in July 2011, to include the regulatory control of all complementary or alternative medicines.

This amended Act, was launched in 2013 by the South African Department of Health (DOH), in collaboration with the MCC, as a roadmap for the regulatory control of complementary medicines in the Government Gazette No 37032 Notice R870. This act applies equally to products for human and veterinary use [83]. In spite of attempts to regulate the industry, it has been reported that 55% of herbal products advertised on the internet make fraudulent health claims [85] and from 2002-2010, 155 000 CAMs, submitted to the Department of Health in South Africa were without proper testing.

The simultaneous intake of herbal medicine and certain synthetic drugs has resulted in toxic effects [86]. The erroneous identification of plants, processing and marketing of the products thereof, under the pretext of another product, may give rise to compromised health systems [87]. For example, in Belgium, end-stage renal failures resulted from the concomitant administration of a nephrotoxin and orthodox acetazolamide. The cause of the condition was traced to the substitution of *Stephania tetranda* with *Aristolochia frangchi*, which produces aristolochic acid, a potent nephrotoxin [88]. Central nervous system (CNS) disorders, heart palpitations, respiratory complications [89] and several other adverse effects, resulting from the concurrent use of herbal medicines and prescription drugs, have been documented [90]. It is believed that the quantity, quality, safety and efficacy data on traditional medicines are far from sufficient to justify the global patronage of herbal drugs. A lack of adequate, accepted and validated methods for evaluating traditional medicine has been cited as a contributing factor for these deficient data [91]. The use of boiling water for the extraction of herbal medicine to mimic the preparation of decoctions makes their safety and quality assurance more difficult than for western medicines [39].

Although there is general consensus that herbal medicines contain multiple active metabolites [39], there are still no national or international strategies for evaluation of the efficacies of such herbal medicines [80]. According to the WHO, quantitative analytical methods should be mandatory for the standardisation of herbal medicines [81]. *Moringa oleifera* is one of the most commercialised herbal drugs in the World. The large scale production and sales of young *moringa oleifera* pods is enormous in India, with about 1.3 million metric tons of the processed plant produced on 38 000 hectares. The trade in *Moringa oleifera* parts in n South Africa is not well document as evident in literature search. Hence, only a few companies trades in *Moringa* seeds. The available import and export data of South African *moringa* raw materials and finished products is insufficient for comparisons with other countries. However, some South African producers export *Moringa* seedlings to neighbouring countries like Botswana and Namibia. Little information is also available for South African traders that import *moringa* seeds from India which they in turn sell to local farmers and other stakeholders [92]. Several products claiming to contain any of the plants part-flowers, leave, seed, seed coates, stem and stem bark are marketed in health shops across South Africa and on the World wide web. A search text "*moringa*" in a price comparison site-pricecheck and compiling the available online commercial products in the first three pages of the site turn in the products listed in Table 3. The disheartening facts remains that at the exorbitant cost of *Moringa oleifera* based products available in the South Africa market, there is insufficient scientific validated studies for standardization and quality control of these products.

Table3. *Online Moringaoleifera products*

Products	Category	Price (ZAR)	Available at:
Seeds for Africa Moringa	Seeds and plants	12.00	Seedsfor Africa
Good Life moringa Leaf powder	Vitamins and minerals	69.00	Faithful to nature
Akan Moringa Products	Vitamins and minerals	209.00	Faithful to nature
Significant Moringa	Skin Care	195	Faithful to nature
Biosil Moringa	Vitamins and minerals	119.00	takealot.com
Moringa 500 vegan capsules	Vitamins and minerals	209.00	Faithful to nature
Organic Moringa Powder 250g	Vitamins and minerals	182.00	takealot.com
Moringa 5000 Herbal Balm	Health Aids	115.00	Faithful to nature
Organic Moringa energy bar	Vitamins and minerals	427.00	takealot.com
Herbal Draught Traditional herbal tea Moringa 25g	Health Aids	39.95	Clicks
Biosil Moringa capsules 180s	Vitamins and minerals	229.00	takealot.com
Akan MoringaProducts Akan Moringa Powder 3g	Nutrition	4.50	Faithful to nature
Akan MoringaProducts Akan Moringa Tea	Nutrition	49.00	Faithful to nature
Moringa4Africa Sx desire capsule	Condoms & Lubes	150.00	Takealot.com
Moringa 5000	Organic Food	159.00	Faithful to nature
Earthtribe Moringa seed oil	Skin Care	145.00	Faithful to nature
Moringa 5000 moringa tincture	Health Aids	144.00	Faithful to nature
Organic moringa Aloe moringa 250 ml	Vitamins and minerals	106	Takealot.com

Health connection moringa leaf 150 g	Organic Food	63.95	2 Shoga
Super foods moringa	Organic Food	126.00	Exxcentially natural
Health connections wholefoods whole connection moringa leaf	Organic Food	82.00	Exxcentially natural
SA vitamins moringa 380 mg	Vitamins and minerals	99.00	Takealot.com
Akan moringa powders 100 mg	Nutrition	77.00	Organics
Body shop moringa slower gel 250 mL	Bath & Shower	99.00	Clicks
Organic india moringa leaf powder	Organic food	265	Faithful to nature
Amaorganic moringa multi-nutrients	Health & Beauty	210.00	Faithful to nature
The body shop moringa soap	Bath & Shower	40.00	Clicks
Biosil moringa seed 100 ml	Vitamins & Minerals	139.00	Takealot.com
CNT lab moringa	Health Aids	119.00	Clicks
Make skincare make face glow roselph and vitamin E face oil with rose and geranium and sandalwood	Skin Care	549.00	2 Shoga
Rooibos Aromatic moringa crunch	Nutrition	30.00	Faithful to nature
Rooibos Aromatic moringa oil	Camping Sloves	70.00	Faithful to nature
Rooibos Aromatic moringa Treats	Camping Sloves	36.00	Faithful to nature
Biosil moringa seed 50 ml	Vitamins and minerals	119.00	Takealot.com
The body shop moringa body butter 200 ml	Skin Care	175.00	Clicks
Essentially natural moringa oil cold pressed	Miscellaneous Personal Care Accessory	285.00	Exxcentially natural
Moringa 4 Africa Hormone capsules	Condoms & Lubes	150.00	Takealot.com
The body shop moringa beautifying oil 100 ml	Skin Care	124.00	Clicks
Akan moringa sachets 90 g 30 sachets	Organic food	119.00	Organics
Malawi moringa organic moringa 1 kg	Vitamins & Minerals	315.00	Takealot.com
Natures choice moringa 100 g	General	37.95	Dis-Chem
Ornagiv moringa Aloe moringaline 100 ml	Vitamins & Minerals	66.00	Takealot.com
Moringa Extract Boost Pea yield	Nutrition	1355.00	takealot.com
Organic moringa Health Boost	Vitamins & Minerals	149.00	takealot.com
Moringa 5000 moringa and lemongrass Soap	Bath &Shower	49.00	Faithful to nature
LIV moringa 120 caps	General	179.95	Dis-Chem
Earth Trip moringa powder	Organic Food	169.00	Exxentially natural
Organic moringa powder 125 mg	Vitamins & Minerals	118.00	takealot.com
Earthtrip moringa leaf powder	Health & Beauty	165.00	Faithful to nature
Organic moringa vanilla shake 600 g	Vitamins & Minerals	266.00	takealot.com
Akan Moringa powder 250 g	Uncategorised	169.00	Organics
The body shop moringa milk body lotion 250 mL	Skin Care	125.00	Clicks
Organic moringa chocolate shake 1.2 kg	Vitamins & Minerals	480.00	Takealot.com
Vita Aid Morbar Moringa bar 33 g	Health Aids	17.95	Clicks
Nadir moringa 500 mL Carafe & Glass	Crockery	64.00	Binuna
Nautica Organic Moringa organic oil	Skin Care	250.00	Faithful to nature
The body Shop Moringa body Scrub 200 ml	Skin Care	99.00	Clicks
The body Shop body mist moringa 100 mL	Perfumes & Aftershaves	120.00	Clicks
Akan Moringa moringa powder 250 g	Organic Food	179.00	Faithful to nature
The body Shop body Scrub Moringa 200 mL	Skin Care	190.00	Clicks
Kale & Moringa Raw Activated Nibbles 40 g	Uncategorised	15.99	Woolworths
Akan Moringa Soap 100 g		42.00	Organics
Amorganic Natural Supplements Amorganic moringa leaf powder	Bath & Shower	175.00	Faithful to nature
Malawi Moringa Organic Moringa Powder 250 g	Vitamins & Minerals	175.00	takealot.com
Biosil Moringa Powder – 150 g	Vitamins & Minerals	71.00	Takealot.com

The body Shop Moringa-Hand Cream 30 mL	Nail Care	280.00	Markado
Akan Moringa Products Akan Moringa Soap	Bath & Shower	50.00	Faithful To Nature
Akan Moringa Tea 40 g 20 Tea bags	Organic Food	45.00	organics
Organic Moringa Chocolate Shake 600 g	Vitamins & Minerals	266	Takealot.com
Akan Moringa Products Akan Moringa Powder 30 day Supply sachets 90 g	Nutrition	125.00	Faithful to nature
Moringa4Africa Moringa 4 Africa Magnesium Capsules	Vitamins & Minerals	150.00	Takealot.com
Moringa4Africa Moringa 4 Africa Diabetic Capsules	Vitamins & Minerals	150.00	Takealot.com
Nautica Moringa Oil Organic	Miscellaneous Personal Care Accessory	295.00	Excellently Natural
The Body Shop Hand Cream Moringa 30 mL	Skin Care	48.00	Clicks

1.5. Quality Control Aspects

The development and validation of methods for the analysis of herbal medicines require the isolation of as many active compounds or biomarkers as possible from the herbal extract and using such compounds as standards for method development and validation. Once developed, the analytical protocols should be registered as an official standard operating procedure (SOP) or monograph. Generally, enhancing the safety and quality of herbal medicines involve visual inspection (microscopic and macroscopic) by a Botanist most often and chemical analysis involving the use of thin layer chromatography (TLC), high performance thin layer chromatography (HPTLC), high performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC-MS), liquid chromatography-mass spectrometry (LC-MS), near-infrared (NIR) or mid-infrared (MIR) spectroscopy. Some of these methods, namely TLC, HPLC-UV, HPLC-DAD, PLC-MS, GC-MS (Table 4) have been developed and used for the analysis of the phytometabolites and/or standards found in Moringa oleifera in all its process forms. However, from the origin of samples, which tells of the sample collection site, there is insufficient record as far our search is concern that links any of the quality control researches on Moringa oleifera to a single sample that was collected from South Africa. There is only one recorded study conducted in the University of South Africa [45] that involved the isolation of compounds from M. olefera. The compounds were used as standards to develop and validated an HPLC-UV method for standardisation of the plants. Surprisingly, the Moringa oleifera investigated by the authors were harvested from Zambia. This further underscores the importance of quality control protocols to be developed and use for the analysis and of South African M. oleifera.

Table 4.*Quality control methods used for raw material standardization and commercial products quality assurance*

Year	Quality control method	Plant part studied	Authors and article reference	M. oleifera Sample origin
2017	Moringa oleifera leaf extracts inhibit 6β-hydroxylation of testosterone by CYP3A	Root/Leaves	[93]	**Zimbabwe**
2016	Methodology development of quality control, quality assurance and standards for Moringa oleifera seeds using Liquid chromatography	Seeds	[45]	**Zambia**
2016	Anti-quorum sensing potential of Moringa oleifera seed extract	flower, pod, bark, leaves and seed	[94]	**India**

2015	Competing Role of Bioactive Constituents in Moringa oleifera Extract and Conventional Nutrition Feed on the Performance of Cobb 500 Broilers	leaves	[95]	**Malaysia**
2015	Development of a reliable extraction and quantification method for glucosinolates in Moringa oleifera	Seed	[96]	**Taiwan**
2015	Development of a reliable extraction and quantification method for glucosinolates in Moringa oleifera	Seed	[96]	**Taiwan**
2015	Nutritional Content and Elemental and Phytochemical Analyses of Moringa oleifera Grown in Mexico	Leaves	[97]	**Mexico**
2015	Quality control standardization of the bark of Moringa oleifera lam.	bark	[98]	**India**
2014	Moringa oleifera: study of phenolics and glucosinolates by mass spectrometry'	Seed	[52]	**Egypt**
2014	Simultaneous HPLC Quantitative Analysis of Active Compounds in Leaves of Moringa oleifera Lam		[99]	**Thailand**
2013	Determination of flavonoids by lc/ms and anti-inflammatory activity in Moringa oleifera	leaves	[100]	**Ghana, Senegal, Zambia**
2013	Phenolic composition, antioxidant and antimicrobial activities of free and bound phenolic extracts of Moringa oleifera seed flour	seeds	[101]	**India**
2013	Isolation and characterization of saponins from Moringa oleifera (Moringaeceae) pods	Seed	[102]	**India**
2013	Identification of Bioactive Candidate Compounds Responsible for Oxidative Challenge from Hydro-Ethanolic Extract of Moringa oleifera Leaves	Leaves	[103]	**Malaysia**
2012	Antioxidant activity of methanolic leaf extract of Moringa peregrina (Forssk.) Fiori.	Leaves	[104]	**Iran**
2012	HPLC quantitative analysis of three major antioxidative components of Moringa oleifera leaf extracts		[105]	**a***
2012	Ameloriation of ionizing radiation induced liquid peroxidation in mouse liver by Moringa oleifera Lam leave extract	Leaves	[106]	**India**
2011	Simultaneous determination of quercetin, rutin and kaempferol in the leaf extracts of Moringa oleifera Lam. and Raphinus sativus Linn. by liquid chromatography tandem mass spectrometry	Leaves	[107]	**India**
2011	Influence of Moringa oleifera on pharmacokinetic disposition of rifampicin using HPLC-PDA method: a pre-clinical study	pods	[108]	**India**
2010	Evaluation of the Polyphenol Content and Antioxidant Properties of Methanol Extracts of the Leaves, Stem, and Root Barks of Moringa oleifera Lam.	Leaves, Stem, and Root Barks	[109]	**Nigeria**

2009	Oxidative DNA damage protective activity, antioxidant and anti-quorum sensing potentials of Moringa oleifera	Leaves, fruit and seed	[110]	**India**
2009	In vitro and in vivo antioxidant properties of different fractions of Moringa oleifera leaves	Leaves	[111]	***a**
2007	Antioxidant activity of the crude extracts of drumstick tree (Moringa oleifera lam.) and sweet broomweed (scoparia dulcis l.) leaves	Leaves	[112]	**India**
2007	Determination of bioactive nitrile glycoside(s) in drumstick (Moringa oleifera) by reverse phase HPLC	leaves, pods and bark	[113]	**Pakistan**
2006	High-performance liquid chromatography method to measure α- and γ-tocopherol in leaves, flowers and fresh beans from Moringa oleifera	Leaves, flowers and beans	[114]	**Mexico**
2003	Antioxidant Properties of Various Solvent Extracts of Total Phenolic Constituents from Three Different Agroclimatic Origins of Drumstick Tree (Moringa oleifera Lam.) Leaves Separation of Flavonoids in Moringa by HPLC	Leaves	[71]	**India, Nicaragua, and Niger**
2002	Extraction and Identification of Natural Antioxidant from the Seeds of the Moringa oleifera Tree Variety of Malawi Stavros	Seeds	[115]	**Malawi/Kenya**
2002	Characterization of Moringa oleifera Seed Oil Variety ''Periyakulam 1''	Seed	[116]	**Kenya**
1999	Characterization of Moringa oleifera Variety Mbololo Seed Oil of Kenya	Seed	[117]	**Kenya**
1998	Characterisation of Moringa peregrina Arabia seed oil	Seed	[118]	**Saudi Arabia**

2. CONCLUSIONS

Variations in biotic and abiotic factors could and usually does lead to variations in the type and concentrations of secondary metabolites in the plant metabolome. If one is to take this into account, it is hypothetical to then say that the South African Moringa oleifera could have secondary metabolites that might differ or similar to those that has been isolated from the same species from other Countries. However, why is a plant drug (South African Moringa oleifera) with limited information on its chemistry be marketed in a very large scale to South Africans? Would such a practice not constitute a compromised Public Health system?. The phytoconstituents in South African Moringa oleifera should be isolated and used as quality control standards in order to develop analytical methods to validate the efficacy and safety of the various products available in the market.

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AUTHOR CONTRIBUTIONS

Kokoette Bassey, conceived the idea, gathered most, reviewed all the articles and wrote the manuscript. Alley Semenya, Morgan Mabuza and Malebelo Mabowe afforded some preliminary information on M. oleifera leaves, stem bark and seeds respectively for review**.**

REFERENCES

[1] Padayachee, B; Baijnath. An overview of the medicinal importance of Moringaceae. J. Med. Plants Res. 2012, 6, 5831-5839.

[2] Leone A; Spada, A; Battezzati, A; Schiraldi, A; Aristil, J; Bertoli, S; Cultiation, S. Genetic, ethnopharmacology, phytochemistry and pharmacology of Moringa oleifera leaves: An overview. Int. J. Mol. Sci. 2015, 16, 12791-12835.

[3] Pakade, V; Cukrowska, E; Chimuka, L. Metal and flavonol contents of Moringa oleifera grown in South Africa. S Afr J Sci. 2013, 109, 3-4.

[4] Nouman, W; Anwar, F; Gull, T; Newton, A; Rosa, E; Domínguez-Perles, R. Profiling of polyphenolics, nutrients and antioxidant potential of germplasm's leaves from seven cultivars of Moringa oleifera Lam.Ind Crops Prod.2016,83, 166-176.

[5] Department of Agriculture, Forestry and Fisheries. 2013. Medicinal plant of South Africa, Pretoria, South Africa.

[6] Ramachandran, C; Peter, KV; Gopalakrishnan, P. K. Drumstick (Moringa oleifera): A Multipurpose Indian Vegetable. Econ Bot. 1980, 34, 276-283.

[7] Lost Crops of Africa: Volume II: Vegetables (2006) Chapter: 14 Moringa. http:// www.nap.edu/read/ 11763/chapter/16. Accessed: 14th June, 2018.

[8] Ojiako, F. O.; Adikuru, N. C.; Emenyonu, C. A. Critical issues in investment, production and marketing of Moringa oleifera as an industrial agricultural raw material in Nigeria. http:// www.ajol.info/index.php/ jard/article/view/8433. Accessed: 30th July, 2018.

[9] Mokgalaka, N. S.; Aphane, M. Y.; Cele, L. M.Characterization of Major Phytochemical Compounds in Moringa oleifera Leaves Harvested from Trees Growing in Different Regions of South Africa Using Atomic and Vibrational Spectroscopy. https://www.eposters.net/poster. Acessed: 01st August, 2018.

[10] Pakade, V; Cukrowska, E; Chimuka, L. Moringa oleifera and inflammation: a mini-review of its effects and mechanisms. S Afri J. Sci. 2012, 09, 1-6.

[11] Moyo, B.; Masika, P. J.; Hugo, A.; Muchenje, V. Nutritional characterization of Moringa (Moringa oleifera Lam.) leaves.Afr J Biotechnol. 2011,10, 12925-12933.

[12] Tesfay, S. Z.; Bertling, I.; Odindo, A. O.; Workneh, T. S.; Mathaba, N. Levels of anti-oxidants in different parts of Moringa (Moringa oleifera) seedling. Afr. J. Agri. Res. 2011, 6, 5123-5132.

[13] www.arc.agric.za/Pages/ARC-Annual-Report-.aspx. Accessed: 11/07/2017.

[14] Makkar, H. P.S.; Becker, K. Nutrional value and anti-nutritional components of whole and ethanol extracted Moringa oleifera leaves. Anim Feed Sci Technol. 1996, 63, 211-228.

[15] Noumana, W.; Anwar, F.; Gull, T.; Newton, A.; Rosaf, E.; Domínguez-Perles, R. Profiling of polyphenolics, nutrients and antioxidant potential of germplasm's leaves from seven cultivars of Moringa oleifera LaM. Ind Crops Prod. 2016, 83, 166-176.

[16] Nweze, N. O.; Nwafor, F. I. Phytochemical, proximate and mineral composition of Leaf extracts of Moringa oleifera Lam. from Nsuka, South-Eastern Nigeria.Int. J. Pharm. Biol. Sci. 2014, 9, 99-103.

[17] Taiwo, P.; Philip, O.; Alikwe, C. N. Proximate analysis and chemical composition of raw and defatted Moringa oleifera Kernel. Adv. Life Sci. Technol. 2014,24: 92-99.

[18] Asante, W.J.; Nasare, I. L.; Tom-Dery, D.; Ochire-Boadu, K. K.; Kentil, K. B. Nutrient composition of Moringa oleifera leaves from two agro ecological zones in Ghana. Afr. J. Plant Sci. 2014,8, 65-71.

[19] Melesse, A.; Berihun, K. Chemical and mineral compositions of pods of Moringa stenopetala and Moringa oleifera cultivated in the lowland of Gamogofa Zone. J. Environ. Occup. Sci.Sci.2013,2,3-38.

[20] Madukwe, E. U.; Ezeugwu, J. O.; Eme, P. E. Nutrient composition and sensory evaluation of dry Moringa oleifera aqueous extract. IJBAS. 2013,13, 100-102.

[21] Oluduro, A. O. (2012) Evaluation of Antimicrobial properties and nutritional potentials of Moringa oleifera Lam. leaf in South-Western Nigeria. Malays J Microbiol. 2012,8, 59-67.

[22] Pakade, V.; Cukrowska, W., Chimuka, L. Title??? S. Afr. J. Sci. 2012,109, 1-6.

[23] Ogbe, A. O.; Affiku, J. P. Proximate study, mineral and anti-nutrient composition of moringa oleifera leaves harvested from Lafia, Nigeria: potential benefits in poultry nutrition and health. J. microbiol. biotechnol. food sci.2012,1, 296-308.

[24] Moyo, B.; Masika, P. J.; Hugo, A.; Muchenje, V. Nutritional characterization of Moringa (Moringa oleifera Lam.) leaves. Afri. J Biotechnol. 2011, 10, 12925-12933.

[25] Yaméogo, C. W.; Bengaly, M. D.; Savadogo, A.; Nikiema, P. A.; Traore, S. A. Determination of chemical composition and nutritional vales of Moringa oleifera Ieaves, Pak. J. Nut.2011,10: 264-268.

[26] Tesfay, S. Z.; Bertling, I.; Odindo, A. O.; Workneh, T. S.; Mathaba, N. Levels of anti-oxidant in defferent part of Moringa (Moringa oleifera) seedling. Afr. J. Agri. Res. 2011,6, 5123-5132.

[27] Jongrungruangchok, S.; Bunrathep, S.; Songsak, T. Nutrients and minerals content of eleven different samples of Moringa oleifera cultivated in Thailand. J. Health Res. 2010,24, 123-127.

[28] Amaglo, N. K.; Bennett, R. N.; Lo Curto, R. B.; Rosa E. A. S.; Lo Turco, V. L; Guiffrida, A.; Curto, A. L.; Crea, F.; Timpo, G. M. Profiling selected phytochemicals and nutrients in different tissues of the multipurpose tree Moringa oleifera L., grown in Ghana, Food Chem.2010,122, 1047-1054.
[29] Anjorin, T. S.; Ikokoh, P.; Okolo, S. Mineral composition of Moringa oleiferaleaves, pods and seeds from two regions in Abuja, Nigeria. Int'l J. Agri. & Biol.2010,12, 431-434.
[30] www.moringaleafpowder.co.za/analysis.html. Accessed: 14/06/2018.
[31] Atawodi, S. E.; Atawodi, J. C.; Idakwo, G. A.; Pfundstein, B. R.; Haubner, R.; Wurtele, G.; Bartsch, H.; Owen, R. W. Evaluation of the polyphenol content and antioxidant properties of methanol extracts of the leaves, stem, and root barks of Moringa oleifera Lam.Med. Food. 2010,3, 710-716.
[32] Kasolo, J. N.; Bimenya, G. S.; Ojok, L. J.; Ochieng, J.; Ogwal-Okeng, J. W. Phytochemicals and uses of Moringa oleifera leaves in Ugandan rural communities. J. Med. Plant. Res.2010, 4, 753-757.
[33] Sánchez-Machado, D. I.; Núñez-Gastélum, J. A.; Reyes-Moreno, C.; Ramírez-Wong, B.; López-Cervantes, J. Nutritional quality of edible parts of Moringa oleifera. Food Anal Methods. 2010,3, 175-180.
[34] Oduro, I.; Ellis, W. O; Owusu, D. Nutritional potential of two leafy vegetables: Moringa oleifera and Ipomoea batatas leaves. Sci. Res. Essay. 2008,3, 057-060.
[35] Anwar, F.; Ashraf, M.; Bhanger, M. I. Interprovenance variation in the composition of Moringa oleifera oilseed from Pakistan. JAOCS. 2005,82, 45-51.
[36] Anwar, F.; Bhanger, M. I. Analytical Characterization of Moringa oleifera seed oil grown in temperate regions of Pakistan. J Agric. Food Chem. 2003,51, 6558-6563.
[37] Gupta, J.; Gupt, A.; Gupta, A. K. Determination of trace metals in the stem bark of Moringa oleifera Lam. Int. J. Chem. Stud. 2014,2,39-42.
[38] Ganatra, T. H.; Joshi, U. H.; Bhalodia, P. N.; Desai, T. R.; Tirgar, P. R. A panaromic view on pharmacology, nutritional therapeutic and prphylactic values of Moringa oleifera.IRJP,2012,3,8470-8410.
[39] Kennedy, D. O.; Wightman, E. L. Herbal extracts and phytochemicals: plant secondary metabolites and the enhancement of human brain function. Adv. Nutr. 2011,2, 32-50.
[40] Fahey, J. W.; Zalcmann, A. T.; Talalay, P. The chemical diversity and distribution of glucosinolates and isothiocyanates among plants. Phytochemistry, 2001,56, 5-51
[41] Kasolo, J. N.; Bimenya, G. S.; Ojok, L.; Ochieng, J.; Ogwal-Okeng, J. W. Phytochemicals and uses of Moringa oleifera leaves in Ugandan rural communities. J. Med. Plants Res. 2010, 4, 753-757.
[42] Iqbal, S.; Bhanger, M. I. Effect of season and production location of antioxidant activity of Moringa oleifera leaves grown in Pakistan. J. Food Compos. Anal. 2006,19, 544-551.
[43] Dubey, D. K.; Dora, J. K.; Gulsan, R. K. A multipurpose tree-Moringa oleifera. Int. J. pharm. Chem. Biol. Sci. 2013, 2, 415-423.
[44] Kumbhare, M. R.; Guleha, V.; Sivakumar, T. Estimation of total phenolic content, cytotoxicity and in-vitro antioxidant activity of stem bark of Moringa oleifera. Asian Pac J Trop Dis. 2012, 2, 144-150.
[45] Chokwe, R. C. 2016. Methodology development of quality control, quality assurance and standards for Moringa oleifera seeds using liquid chromatography. Masters thesis. University of South Africa. South Africa.
[46] Guevara, A. P.; Vargas, C.; Sakurai, H.; Fujiwara, Y.; Hashimoto, K. Maoka, T.; Kozuka, M.; Ito, Y.; Tokuda, H.; Nishino, H. An antitumor promoter from Moringa oleifera Lam. Mutat Res. 1999,440, 181-188.
[47] Giacoppo, S.; Rajan, T. S.; De Nicola, G. R.; Iori, R.; Rollin, P. Bramanti, Placido.; Mazzon, E. The isothiocyanate isolated from Moringa oleifera shows potent anti-inflammatory activity in the treatment of murine subacute Parkinson's disease. Rejuvenation Res. 2017,20, 50-63.
[48] Chen, C.; Zhanga, B.; Huanga, Q.; Fua, X.; Liua, R. H. Microwave-assisted extraction of polysaccharides from Moringa oleifera Lam. leaves: Characterization and hypoglycemic activity. Ind Crops Prod.2007, 100, 1-11.
[49] Chepkoech, M. F. 2014.Phytochemistry and anti-cancer potential of compounds isolated from Kenyan Medicinal Plants, Moringa oleifera and Prunus African. Masters thesis. University of Kwa-Zulu-Natal. South Africa.
[50] Ragasa, C. Y.; Medecilo, M. P.; Shen, C. -C. Chemical Constituents of Moringa oleifera Lam. Leaves. Der Pharma Chemica. 2015.20, 7395-399.
[51] Ogundele, V. A.; Fadeyi, O. E. Isolation, characterization and derivatization of some bioactive components in Moringa Oleifera Leaves. Nat. Prod. Chem. Res.2015,3, 1-4.
[52] Maldini, M.; Maksoud, S. A.; Natella, F.; Montoro, P.; Petretto, G. L.; Foddai, M.; De Nicola, G. R.; Cheassa, M.; Pintore, G. Moringa oleifera: study of phenolics and glucosinolates by mass spectrometry. J Mass Spectrome. 2014,49, 900-910.
[53] Sharma, V.; Paliwal, R. Potential Chemoprevention of 7,12-Dimethylbenz[] anthracene induced renal carcinogenesis by Moringa oleifera pods and its isolated Saponin. Indian J Clin Biochem. 2014,29, 202-209.

[54] Sahakitpichana, P.; Mahidola, C.; Disadeea, W.; Ruchirawata, S.; Kanchanapoom, T. Unusual glycosides of pyrrole alkaloid and 40-hydroxyphenylethanamide from leaves of Moringa oleifera. Phytochemistry. 2011, 72: 791-795.

[55] El-Alfy, T. S.; Ezzat, S. M.; Hegazy, A. K.; Amer, A. M. M.; Kamel, G. M. Isolation of biologically active constituents from Moringa peregrina (Forssk.) Fiori. (family: Moringaceae) growing in Egypt.Pharmacogn Mag. 2011, 7, 109-115.

[56] Manguro, L. O.; Lemmen, P. Phenolics of Moringa oleifera leaves. Nat. Prod. Res. 2007,21, 56-68.

[57] Sashidhara, K. V.; Rosaiah, J. N.; Tyagi, E.; Shukla, R.; Raghubir, R. Rajendran, S. M. Rare dipeptide and urea derivatives from roots of Moringa oleifera as potential anti-inflammatory and antinociceptive agents. Eur J Med Chem.2009,44, 432-436.

[58] Ogunbinu, A. O.; Flamini, G.; Cioni, P. L.; Adebayo, M. A.; Ogunwande, I. A. Constituents of Cajanus cajan (L.) Millsp. Moringa oleifera Lam., Heliotropium indicum L. and Bidens pilosa L. from Nigeria. Nat Pro Commun. 2009,4, 573-578.

[59] Singh, B. N.; Singh, B. R.; Singh, R. L.; Prakash, D.; Dhakarey, R., Upadhyay, G.; Singh, H. B. Oxidative DNA damage protective activity, antioxidant and anti-quorum sensing potentials of Moringa oleifera. Food Chem Toxicol.2009,47,1109-1116.

[60] Verma, A. R.; Vijayakumar, M.; Mathela, C. S.; Rao, C. V. In vitro and in vivo antioxidant properties of different fractions of Moringa oleifera leaves. Food Chem Toxicol. 2009,47, 2196-3001.

[61] Nepolean, P.; Anitha, J., Renitta, R. E. Isolation, analysis and identification of phytochemicals of antimicrobial activity of Moringa oleifera Lam., Current biotica. 2009, 3, 33-39.

[62] Gupta, A. K. Quality standards of Indian medicinal plants. Indian Council of Medical Research, New Delhi. 2008,1,130-135.

[63] Rastogi, R. P.; Mehrotra, B. N. Compendium of Indian medicinal plants. Central Drug Research Institute, Lucknow and National institute of science communication and information resources. New Delhi. 2004, IV: 484.

[64] Yammuenart, D.; Chavasiri, W.; Pongrapeeporn, K. A review on commercial, traditional uses, phytoconstituents and pharmacological activity of Moringa oleifera, Global J Trad Med Sys. 2013,2, 1-13.

[65] Ndong, M.; Uehara, M.; Katsumata, S.; Suzuki, K. Effects of oral administration of Moringa oleifera Lam on glucose tolerance in Goto-Kakizaki and Wistar Rats.J Clin Biochem Nutr.2007, 40, 229-233.

[66] Roy, S. K.; Chandra, K.; Ghosh, K.; Mondal, S.; Maiti, D.; Ojha, A. K.; Das, D.; Mondal, S.; Chakraborty, I.; Islam, S. S. Structural investigation of a heteropolysaccharide isolated from the pods (fruits) of Moringa oleifera (Sajina). Carbohydr Res.2007, 342, 2380-2389.

[67] Anwar, F.; Umer, R. Physico-chemical characteristics of Moringa oleifera seeds and seed oil from a wild provenance of Pakistan.Pak. J. Bot.2007, 39, 1443-1453.

[68] Shanker, K.; Gupta, M. M.; Srivastava, S. K.; Bawankule, D. U.; Pal, A.Khanuja, S. P.S. Determination of bioactive nitrile glycoside(s) in drumstick (Moringa oleifera) by reverse phase HPLC. Food Chem. 2007, 105, 376-382.

[69] Chuang, P. H.; Lee, C. W.; Chou, J. Y.; Murugan, M.; Shieh, B. J.; Chen H. M. Anti-fungal activity of crude extracts and essential oil of Moringa oleifera Lam. Bioresource Technol. 2007, 98, 232-236.

[70] Bennett, R. N.; Mellon, F. A.; Foidl, N.; Pratt, J. H.; Dupont, M. S. et al. Profiling glucosinolates and phenolics in vegetative and reproductive tissues of the multi-purpose trees Moringa oleifera L. (horseradish tree) and Moringa stenopetala L.,

[71] J Agric Food Chem. 2003, 51, 3546-3553.

[72] Siddhuraju, P.; Becker, K. Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (Moringa oleifera Lam.) leaves. J Agric Food Chem. 2003,51, 2144-2155.

[73] Nikkon, F.; Saud, Z. A.; Rahman, M. H.; Haque, M. E. In vitro antimicrobial activity of the compound isolated from chloroform extract of Moringa oleifera Lam. Pakistan J Biol. Sci. 2003,6, 1888-1890.

[74] Ogbunugafor, H. A.; Eneh, F. U.; Ozumba, A. N.; Igwo-Ezikpe, M. N. J.; Okpuzor, J.; Igwilo, I. O.; Adenekan, S. O.; Onyekwelu, O. A. Physico-chemical and antioxidant properties of Moringa oleifera seed oil. Pakistan J of Nutr. 2011, 10, 409-414.

[75] Faizi, S.; Siddiqui, B. S.; Saleem, R.; Siddiqui, S.; Aftab K. Gilan, A. H. Isolation and structure elucidation of new nitrile and mustard oil glycosides from Moringa oleifera and their effect on blood pressure. J. Nat. Prod. 1994, 57, 1256-1261.

[76] Faizi, S.; Siddiqui, B. S.; Saleem, R.; Siddiqui, S.; Aftab K. Isolation and structure elucidation of novel hypotensive agents, niazinin A, niazinin B, niazimicin and niaziminin A + B from Moringa oleifera: the first naturally occurring thiocarbamates. J. Chem. Soc., 1992, 1, 3237- 3241.
[77] Faizi, S.; Siddiqui, B. S.; Saleem, R.; Siddiqui, S.; Aftab K. et al. Fully acetylated carbamate and hypotensive thiocarbamate glycosides from Moringa oleifera. Photochemistry. 1995,38: 57-963.
[78] Faizi, S.; Siddiqui, B. S.; Saleem, R.; Noor, F.; Husnain, S. Isolation and Structure elucidation of a novel glycoside niazidin from the pods of Moringaoleifera. J Nat Prod. 1997,60, 1317-1321
[79] Rastogi, R. P.; Mehrotra, B. N. Compendium of Indian medicinal plants. Central Drug Research Institute, Lucknow and National institute of science communication and information resources. New Delhi. 2004,IV:484.
[80] Nair, V. D. P.; Kanfer, I. 2006. PhD thesis. University of Stellenbosch. South Africa.
[81] SADC. 2002. South African Development Community Meeting on nutrition and HIV/AIDS. Johannesburg. Available at: http://www.robertogiraldo.com/eng/papers/SADC_Report_2003. Accessed 10 July, 2013.
[82] WHO. 2011. The World Medicines Situation. Traditional Medicines: Global Situation, Issues and Challenges, Geneva. Available at: http:www.apps.who.int/medicinedocs/s18063en.pdf, 2011. Accessed 2 July, 2012.
[83] Hutchings, A. 1996. Zulu Medicinal Plants. Pietermaritzburg: Natal University Press.
[84] PPSA PERSPECTIVE. Roadmap for the registration of complementary medicines. S Afr Pharm J. 2014,8, 1
[85] ACT 101 OF 1965. Available: www.sa.co.za/./legislation/actx/medicines_and_related_sub. Accessed: 11 August 2017.
[86] Brent, S.; Ko, R. Commonly used herbal medicines in the United States: A review. Am J Med Sci. 2004, 116, 478-485.
[87] Bauer R, (1998) Quality criteria and standardization of phytopharmaceuticals: Can acceptable drug standards be achieved? Drug Inf J, 32: 101-110.
[88] Chan, K. Some aspects of toxic contaminants in herbal medicines. Chemosphere. 2003, 52, 1361-1371.
[89] Ventola, C. L. Current issues regarding complementary and alternative medicine (CAM) in the United States. Part 2: Regulatory and safety concerns and proposed governmental policy changes with respect to dietary supplements. Pharm. Ther. 2010, 35, 514-522.
[90] Bensoussan, A.; Myers, S. P.; Wu, S. M.; O'connor, K. Naturopathic and Western herbal medicine practice in Australia - A workforce survey. Complementary Therapies in Medicine. 2004, 12, 17-27.
[91] Cupp, M. J. Herbal remedies: Adverse effects and drug interactions. Am Fam Physicia. 1999, 59, 1239-1244.
[92] WHO. 2002. Traditional Medicine Strategy: 2002-2005, Geneva. Available at www.apps.who.int/ medicinedocs/pdf. Accessed: 7 July 2017.
[93] Moringa SA. 2011 .A Resource for farmers, plantations, industry and biofuel companies. Available at: http://www.moringasouthafrica.co.za/ Accessed on 15 September 2017.
[94] Monera, T. G.; Wolfe, A. R.; Maponga, C. C.; Benet, L. Z.; Guglielmo, J. Moringa oleifera leaf extracts inhibit 6β-hydroxylation of testosterone by CYP3A4. J Infect Dev Ctries. 2008,5, 379-383.
[95] Jonnalagadda, S.; Deshabathini, U. K. Anti quorum sensing potential of Moringa oleifera seed extract.J Infect Dev Ctries. 2016,8, 76-82.
[96] Karthivashan, G.; Arulselvan, P.; Abd. Alimon, R.; Ismail, I. S.; Fakurazi, S. Competing Role of Bioactive Constituents in Moringa oleifera Extract and Conventional Nutrition Feed on the Performance of Cobb 500 Broilers. Biomed Res Int. 2015,2015, 1-14.
[97] Förster, N.; Ulrichs, C.; Schreiner, M.; Müller, C. T.; Mewis, I. Development of a reliable extraction and quantification method for glucosinolates in Moringa oleifera. Food Chemis. 2015, 166, 456-464.
[98] Valdez-Solana, M. A.; Mejía-García, V. Y.; Valencia, A. T.; Arenas, G. G.; Pacheco, J. S.; Romero, J. J. A.; Campos, E. S. Nutritional Content and Elemental and Phytochemical Analyses of Moringa oleifera Grown in Mexico. J. Chem. 2015,2015, 1-10.
[99] Sarvesh, K.; Kumar, M. S.; Ankit, S.; Kumar, S. N. Quality control standardization of the bark of Moringa oleifera lam.Int J Pharm Pharm Sci. 2015, 7, 56-60.
[100] Vongsak, B.; Sithisarn, P.; Gritsanapan, W. Simultaneous Determination of Crypto-Chlorogenic Acid, Isoquercetin, and Astragalin Contents in Moringa oleifera Leaf Extracts by TLC-Densitometric Method. J Chromatogr Sci. 2014,52, 641-645.
[101] Coppin, J. P.; Xu, Y.; Chen, H.; Panb, M. –H.; Ho, C. –T.; Juliani, R. Determination of flavonoids by LC/MS and anti-inflammatory activity in Moringa oleifera. J Funct Foods.2913,5, 1892-1899.
[102] Singha, R. S. G.; Negib, P. S.; Radha, C. Phenolic composition, antioxidant and antimicrobial activities of free and bound phenolic extracts of Moringa oleifera seed flour. J Funct Foods. 2013, 5, 1883-1891.

[103]Sharma, V.; Paliwal, R. Isolation and characterization of saponins from Moringa oleifera (Moringaeceae) pods. Int J Pharm Pharm Sci. 2013,5, 179-183.

[104]Karthivashan, G.; Arulselvan, P. A.; Alimon, A. R.; Ismail, I. S.; Fakurazi, S. Competing role of bioactive constituents in Moringa oleifera extract and conventional nutrition feed on the performance of Cobb 500 broilers.Biomed Res Int.2015,2015, 1-13

[105]Dehshahri, S.; Wink, M.; Afsharypuor, S.; Asghari, G.; Mohagheghzadeh, A. Antioxidant activity of methanolic leaf extract of Moringa peregrine (Forssk.) Fiori. Res Pharm Sci. 2012,7, 111-118

[106]Vongsak, B.; Sithisarn, P.; Gritsanapan, W. HPLC quantitative analysis of three major antioxidative components of Moringa oleifera leaf extracts. Planta Medica. 2012, 78, PJ15.

[107]Sinha, M.; Das, D. K.; Datta, S.; Ghosh, S.; Dey, S. Ameloriation of ionizing radiation induced liquid peroxidation in mouse liver by Moringa oleifera Lam leave extract . Indian J Exp Biol. 2012,50, 209-215.

[108]Devaraj, V. C.; Krishna, B. G.; Viswanatha, G. L. Simultaneous determination of quercetin, rutin and kaempferol in the leaf extracts of Moringa oleifera Lam. and Raphinus sativus Linn. by liquid chromatography¬ tandem mass spectrometry. Chin J Integr Med. 2011, 9, 1022-1029.

[109]Pal, A.; Bawankule, D. U.; Darokar, M. P.; Gupta, S. C.; Arya, J. S.; Shanker, K.; Gupta, M. M.; Yadav, N. P.; Singh, KSP. Influence of Moringa oleifera on pharmacokinetic disposition of rifampicin using HPLC-PDA method: a pre-clinical study. Biomed Chromatogr. 2011, 25, 641-645.

[110]Devaraj, V. C.; Krishna, B. G.; Viswanatha, G. L. Simultaneous determination of quercetin, rutin and kaempferol in the leaf extracts of Moringa oleifera Lam. and Raphinus sativus Linn. by liquid chromatography-tandem mass spectrometry.Chin J Integr Med. 2011,9, 1022-1029.

[111]Verma, A.; Vijayakumar, M.; Mathela, C. S.; Rao, C. V. In vitro and in vivo antioxidant properties of different fractions of Moringa oleifera leaves. Food Chem Toxicol. 2009,7, 2196-2201.

[112]Pari, L.; Karamać, M.; Kosińska, A.; Rybarczyk, A.; Amarowicz, R. Antioxidant activity of the crude extracts of drumstick tree (Moringa oleifera lam.) and sweet broomweed (scoparia dulcis l.) leaves. Pol. J. Food Nutr. Sci. 2007, 57, 203-208.

[113]Machado, S.; Lopez-Cervantes, J.; Vazqez, J. R. High-performance liquid chromatography method to measure α- and γ-tocopherol in leaves, flowers and fresh beans from Moringa oleifera. J. Chromatogr A. 2006, 1105, 111-114.

[114]Stavros, Lalas, S.; Tsaknis, J. Extraction and identification of natural antioxidant from the seeds of the Moringa oleifera tree variety of Malawi. JAOCS. 2002, 79, no. 7.

[115]Lalas, S.; Tsaknis, J. Characterization of Moringa oleifera seed oil variety ‘‘Periyakulam 1’’. J Food Compost Anal. 2002,15, 65-77

[116]Tsaknis, J.; Lalas, S.; Gergis, V.; Dourtoglou, V.; Spiliotis, V. Characterization of Moringa oleifera variety Mbololo seed oil of Kenya. J. Agric. Food Chem. 1999, 47, 4495-4499 199.

[117]saknis, J. Characterisation of Moringa peregrina Arabia seed oil. Fase. 1998,49, 170-17.

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