Uttaranchal Journal of Applied and Life Sciences

U. J. App. Life. Sci. Vol: 4 (1): 37-68 Dec 2023

STUDY OF *MORINGA OLEIFERA* HAVING NUTRACEUTICAL PROPERTIES AND THEIR BAKERY PRODUCTS

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Received: (17 August 2023) Revised: (15 Oct 2023) Accepted: (10 Nov 2023)

ABSTRACT

Moringa oleifera is one of the beneficial trees found in the genus (moringa). It comes under the category of non-succulent perennials as they avert themselves from drought and are also easily grown plants. There are thirteen species of the genus Moringa which is mostly found and used for many purposes. This review's objective is to provide the classified and recent data about their edible parts, nutrient composition, nutraceutical properties and their uses in bakery products. *Moringa oleifera* are rich in many nutrients due to which they prohibited malnutrition and research studies showed that they have many bioactive compounds like glucosinolates, tannins, flavonoids etc. which helps in the prevention and cure of various diseases like cancer, obesity, diabetes mellitus, inflammation and nephropathy. It also provides a barrier against microorganisms like bacteria, and virus, so, acts as an antimicrobial agent and also prevent from malnourishment. Nowadays, bakery products are also seen as a staple food and are consumed by all categories of people. But generally, many bakery products like bread and cake are not rich in other nutrients except carbohydrates and fats. So, bakery products can be fortified or enriched by plant sources like *Moringa oleifera* edible parts as they are rich in many nutrients and also rich in bioactive compounds. We can use other plant sources according to their ease of availability. Data for this review paper is collect from google scholar and research gate journal papers (2009-2022).

Keywords: *Moringa oleifera*, Nutrition, Nutraceutical, Bakery products.

1. INTRODUCTION

Moringa oleifera is one of the most important vegetable crops belongs to the Moringaceae family and brassica order (Shahbaz et al., 2021). *Moringa oleifera*, known as the "miracle plant", is one of the most common plants in West African regions (Bolarinwa et al., 2017). It can thrive in any tropical or subtropical climate at temperatures of 18 to 28 degrees Celsius, in soils with a pH of 4.5 to 8, and at elevations of up to 2000 meters (Barichella et al., 2018). It was called the "Miracle Tree" because of its healing properties in wounds and also protects against about chronic disease (Shahbaz et al., 2021). Worldwide, it is referred to by many well-known terms, including "Guiligandja," "Gagawandalahai", "drumstick tree" and "horseradish tree."(Saa et al., 2019).

Moringa oleifera “moringaceae” is a valuable tree common to many tropics and subtropics countries (Simeon et al., 2021). Currently, Moringa has been introduced and grown in more than 30 nations worldwide. China's provinces of Guangdong, Hainan, Guangxi, Sichuan, and Yunnan imported Moringa oleifera seedlings or growing techniques from nations like India and Myanmar (Liang et al., 2019). There are 13 species in the genus Moringa, which are found in Madagascar, southwest Asia, southwest Africa, and northeast Africa. Only, *Moringa stenopetala*, *Moringa concanensis*, *Moringa oleifera* and *Moringa peregrina* are the focus of current research out of the 13 species. Due to the fact that, the remaining species are found only in Northeast Africa and Madagascar, less research is presently done to find naturally occurring bioactive substances there. *Moringa drouhardii, Moringa ovalifolia Moringa hildebrandtii,* and *Moringa stenopetala* are often referred to as "bottle trees" because to their inflated water trunks. Concurrently, *Moringa concanensis, Moringa oleifera* and *Moringa peregrina* has wispy stems**.** Bulbous shrubs that are native to Northeast Africa make up the remaining species. There are also drought-tolerant types of moringa that grow swiftly and require little upkeep (Abd Rani et al., 2018).

Because the Moringa tree may be utilized in almost every aspect of business, medicine, and food, it is one of the most beneficial trees on the planet. Even though the pods, flowers, and leaves of the tree are used to make vegetables, the tree also has a lot of potential to improve nutrition, make food safer, and help rural development (Roni et al., 2021). The soil type, harvest stage, growth environment, and processing method may all play a role in the substantial variation in nutritional content (Patil et al., 2022).

The fruits, seeds, leaves, flowers, bark, and roots of the Moringa tree are all associated with the presence of one or more benefits (Gandji et al., 2018). Moringa has elevated doses of phenolic substances, vitamins, minerals (including calcium and potassium), amino acids, proteins, carbohydrate, and oils (Redha et al., 2021). Different Moringa species contain a variety of phytoconstituents, including alkaloids, tannins, saponins, steroids, glucosinolates, phenolic acids, flavonoids, and terpenes (Abd Rani et al., 2018). The essential amino acids (lysine, phenylalanine and leucine) and flavonoids (kaempferol glycosides and quercetin), which have antioxidant properties, are abundant in the moringa species (Baek and Lee, 2021). This plant has been shown to have anti-inflammatory, analgesic, anticancer, antioxidant, hepatoprotective, gastroprotective, anthelmintic, cardiovascular, anti-obesity, antipyretic, antiepileptic, immunomodulatory, antidiarrheal, local anesthetic, anti-allergic, anti-ulcer, wound healing, nootropic, antimicrobial, anti-asthmatic, and diuretic properties in numerous pharmacological study (Bhattacharya et al., 2018).

Numerous studies have demonstrated the potential utilization of various *Moringa oleifera* components in the preparation of functional foods like bread, cake, stiff dough made from yam four, and biscuits (Fapetu et al.,2022). As a result, wheat-based foods like cookies, and pasta, dairy products, and soups all contain *Moringa oleifera* leaf powder (MOLP). Previous studies on wheat-based cookies and pasta demonstrated that a 10–15 percent MOLP addition can boost the nutritional value of the product as a whole (Giuberti et al., 2020). After being supplemented with defatted moringa seed powder, the enriched bread contains greater amounts of carbohydrates, minerals, and vitamin A (Eke et al., 2022). Considering of their potential for nourishment and restorative benefits, there has been an increase in the demand for foods enriched with natural substances. Stress, illnesses, pollutants and other conditions all lead to a reduction in the body's nutritional stores, making people more likely to contract diseases like Covid-19(Aguilar et al.,2021).

2. MORINGA OLEIFERA TREE PARTS

2.1 Seeds, fruits (pods) and oils

Because they include both proteins strong in sulfated amino acids, a rich saturated/monounsaturated fatty acids (SFA/MUFA) ratio, sterols, and tocopherols, *Moringa oleifera* seeds (shown in Figure 1) are a viable source for food and non-food uses because of monounsaturated fatty acid. Although Moringa seeds may sprout and develop devoid of water when sown during the rainy season, commercial use necessitates drip irrigation, which also allows for generation of seeds during the dry weather. The fruit is a 20–60 cm long trilobite capsule known as a pod (shown in Figure 2) and matures approximately 30 days following blossoming. The pods split lengthwise into three pieces as they reach maturity, turning brown and dry. Each pod normally contains 12 to 35 spherical seeds with a size of one cm (Leone et al.,2016).

Figure 1. Moringa seeds

(Source: www.islandherbsandspices.com)

Figure 2. Moringa pods

(Source: healthcautions.com)

Diarrhea, issues with the liver and spleen, joint pain and other conditions can all be treated with moringa pods (Sujatha and Patel,2017). Moringa oleifera oil (MOO), in contrast to soybean, sunflower, canola, corn, and cottonseed oils, is extremely resistant to auto-oxidation. The oil's composition in fatty acids and triglycerides suggests that MOO is excellent for both edible and non-edible applications. The oil content of the seeds ranges from 35 to 40 percent, and employing enzyme technology can further enhance oil extraction from seeds using conventional methods. The delightfully nutty flavour and bright golden colour of moringa oleifera oil are very appealing (Nadeem et al., 2016).

2.2 Leaves

That's because the leaves of the tree provide high quantities of calcium, protein, and vitamin A as well as balanced levels of key amino acids, they are frequently employed as a low-cost source of nourishment. In the leaves, mineral concentrations and protein content varied significantly between species. LMA offers a measure of the proportion of cell wall material the amount of cell lumen per square foot of leaf surface area in a leaf. Given that higher LMA, expressed as dry mass per fresh leaf area, suggests a bigger cell wall fraction compared to the cell lumen accessible for vital fraction components like protein, we anticipated that LMA would adversely predict protein content(Olson et al., 2016). Additionally, it has been reported that the leaf of *Moringa oleifera* contains between 19 and 16 amino acids, of which 10 are essential amino acids—threonine, tyrosine, valine, phenylalanine, methionine, isoleucine, tryptophan, lysine, leucine, and histidine—among others.

Compared to other plant sources like *Manihot esculenta*, *Amaranthus spinosus*, *Talinum triangulare*, *Vernomia anydalira*, and *Teiferia occidentalis*, it has been observed that the calcium, potassium, magnesium, and iron content of *Moringa oleifera* leaves is higher (Falowo et al., 2017).

Figure 3. Moringa leaves

Moringa oleifera leaves (shown in Figure 3) are known as "the miracle tree" leaves because they have been used for centuries as a classical source of drugs and for curing a variety of diseases. Through CYP 450 isoenzyme inhibition and claimed reduction in NAPQI creation, the MO leaves extract, which is rich in bioactive components, effectively safeguards the liver against APAP toxicity; controls the ROS environment by elevating the amounts of antioxidant enzymes via the Nrf2/ARE system; and the control of inflammatory cytokines, which prevents the hepatic-necrotic damage from getting worse (Karthivashan et al., 2015).

2.3 Roots

Due to its long taproot, Moringa oleifera is drought resistant and available throughout the year. It thrives between 25 and 35 degrees Celsius and can withstand a wide range of soil and rainfall conditions (Igwilo et al., 2014). It was discovered that the root extract has anti-inflammation, anti-lithic, and anti-fertility properties. From the roots, 67 distinct proteins were identified. The catalytic activity is related to approximately 57.35% of proteins. Moringa oleifera roots were used to extract the first polysaccharide component, MRP-1. We determined that MRP-1 was an unadulterated polysaccharide with the typical sugar designs based on the depictions by three specialised approaches, including FT-Infra Red, Nuclear magnetic resonance , and Roman inspection. (Cui et al., 2019).

Figure 4. Moringa root

(*Source: www.ahealthyleaf.com)*

Roots (shown in Figure 4) were able to produce analgesia and enhance the analgesic effects of morphine, which allowed them to depress the central nervous system. Significant anti-inflammatory, anti-arthritic, and analgesic efficacy was demonstrated by aurantiamide acetate and 1,3 dibenzyl urea extracted from roots, which was mediated via the suppression of TNF-alpha, interleukin-2, and cytokines (Sana et al., 2015). The antioxidant potential of the root powder was greater than that of the leaf powder. The different proportions of the bioactive compounds that are already present in the leaves and roots could be the cause of these slight variations in the antioxidant activities of the plants (Lungu et al., 2021). In the reaction with $AgNO_3$, which resulted in the formation of Ag NPs, root extract of Moringa oleifera was used as the reducing agent. The shifting color of the silver nanoparticles served as a visual cue for their formation. Using the reduced property of the *Moringa oliefera* root and without the use of harsh chemicals or surfactants, silver nanoparticles were produced in an environmentally friendly manner (Danbature et al., 2021).

2.4 Stem and bark

It has fragile branches, a whitish-grey bark, and a brittle stem (shown in Figure 5, 6) (Mohanty et al., 2020). The extracts of *Moringa oleifera*'s wood and stem bark had total phenolic content of 112, 5.38 and 5.21 1.20 g GAE mL-1, respectively. This indicates that the total phenolic content of the leaf portion of the M. oleifera plant is significantly higher than that of the twig portion and significantly higher than that of the stem bark or wood portion.

Figure 5. Moringa stem

Figure 6. Moringa tree bark

The extracts of *Moringa oleifera*'s wood and stem bark contained 38.4 ± 5.43 and 8.92 ± 3.98 g CE mL-1, respectively, of flavonoids. The results of the total phenolic content indicate that the aqueous extract of the leaf portion of the M. oleifera plant has the highest total flavonoid content of all the parts, while the wood portion has the lowest total flavonoid content. This is consistent with the findings of the total phenolic content (Fatiqin et al., 2021). Procyanidins, which were found in the barks of the stem and root, are known to play a significant role in the antioxidant properties of a number of foods. These compounds are powerful scavengers of reactive oxygen and nitrogen species due to their propensity for nitration as well as their capacity to donate hydrogen (Atawodi et al., 2009).

2.5 Flowers

The flowers are creamy white or white (shown in Figure 7) (Sujatha and Patel ,2017). Flowers that are fragrant, bisexual, and surrounded by five different, thinly viened, yellowish-white petals that are thinly divided. The width and length of the flowers range from 2.0 cm to 1.0 cm (Raja et al., 2016).

Figure 7. Moringa flower

Flowers are useful as an aphrodisiac, stimulant, cholagogue, and abortifacient because they contain sucrose, glucose, nine amino acids and a trace amount of alkaloids; used to treat hysteria, muscle diseases, inflammations, tumors, and spleen enlargements; and useful in lowering the atherogenic index, serum cholesterol, phospholipids, triglycerides, and ratio of

LDL to phospholipids; lowering the lipid composition of the liver, aorta and heart (Sujatha et al., 2017). Linear and lanceolate are the five reflexed sepals. The five petals are spatulate and slender (Mohanty et al., 2020).

3. NUTRITIONAL VALUE

Despite its low carbohydrate and fat content, *Moringa oleifera* leaf is considered a complete dietary supplement due to its high protein and essential amino acid content. Additionally, a substantial nutritional profile of *M. oleifera* ranges from 205–350 calories per gram and is high in dietary fibre and protein. Minerals such as sodium, zinc, magnesium, copper, potassium, calcium, and iron are all found in it. *Moringa oleifera* has a lot of crucial antioxidants, amino acids, flavonoids, and isothiocyanates, as well as proteins, vitamins A, E, C, and D, pyridoxine, nicotinic acid, and folic acid (Patil et al., 2022). Many of the phytoconstituents observed in Moringa species include alkaloids, saponins, steroids, glucosinolates, phenolic acids, flavonoids, terpenes and tannins and 110 or so chemicals were found to be part of the genus as shown in table 1 (Abd Rani et al., 2018).

3.1 Protein

Being high in protein due to the necessary amino acids, which account for around 30% of the leaf's weight, is one of its characteristics. This makes the leaf's protein content comparable to that of milk powder, which is always accessible and comprises 35%, whereas other plants only have essential amino acids in their seeds. The protein content of the leaf is 100 g of dry mass: 29.4 g protein. Therefore, Moringa oleifera, can be regarded as a novel source of protein to be added to diet, identical to chia seeds, which provide 24 g of protein per 100 g of dry mass. (Milla et al., 2021).

There is a constant search for novel protein sources in legumes. This is why *Moringa oleifera*, an intriguing but underappreciated legume used to prepare traditional foods, deserves our attention. Many pulses have been researched and advocated for, especially in impoverished countries, as a source of human-friendly protein. The seeds and leaves of M. oleifera are a vital source of protein, and the nutritional quality of legumes is largely determined by their bioavailability and content of essential amino acids. Because they contain fewer sulphur amino acids and have a more compact structure than animal proteins, vegetable proteins have been shown to be less sensitive to in vivo decomposition and presence of anti-physiological proteins (lectins, protease inhibitors) and non-protein components (dietary fibre, tannins, and phytic acid) (Mune et al., 2016).

3.2 Amino acids

The amount of each type of *Moringa oleifera*'s amino acids (AA). The most prevalent Amino Acid in their groupings, glutamic acid, is an acidic AA. While arginine was just the second highest concentration of Amino Acid in the leaves, aspartic acid was the second highest Amino Acid in the stem and root. While arginine is a basic amino acid that is required and non-essential, aspartic acid is an acidic amino acid. Leucine (5.12 g/100 g, stem), arginine (8.22 g/100 g, leaves), and leucine (5.33 g/100 g, root) were the three essential amino acids with the greatest concentrations in each sample. In contrast to isoleucine and arginine 5.33, whose respective Coefficient of variation% values were 46.8 and 92.7, the Coefficient of variation% of the Amino Acid values were generally low (Olaofe et al., 2013).

3.3 Carbohydrates and Dietary fibre

Carbohydrate are gotten normally from plant sources. Starch, resistant starch, sucrose, raffinose, stachyose, pectin, cellulose, and other important carbohydrates are found in plants. Because of their useful properties as stabilizers, sweeteners, thickeners, emulsifiers, gelling agents, and so on, these carbohydrates are isolated and added to foods. Moringa seeds contained 33.5% total dietary fibre, according to a dietary fibre analysis. Arabinogalactan, xylan-type polysaccharides, and cellulose make up the polysaccharide fraction of defatted moringa seed flour (DMSF).

This investigation has demonstrated that DMSF may be a potential source of dietary fibre with a variety of applications due to its abundance of complex carbohydrates (Anudeep and Radha,2018). It is common knowledge that polysaccharides have antioxidant, immunomodulatory, and anti-inflammatory properties. Anti-tumor and immunomodulatory properties of Panax ginseng polysaccharides have been reported. It has been demonstrated that Turbinaria ornata's sulfated polysaccharides have anti-inflammatory properties.

There aren't many studies on the bioactivity and composition of Moringa oleifera root polysaccharides as a traditional medicinal plant. To isolate and filter the polysaccharides from the Moringa oleifera root and study their structure and function, water extraction and DEAE sepharose chromatography were utilised.MRP-1, a single purified polysaccharide fraction, was found and analyzed using “FT-IR, Roman spectroscopy and NMR spectroscopy (Cui et al., 2019). As can be seen, its level of carbohydrates is lower than that of the other parts of the plant (8.1%) in leaves (Milla et al., 2021).

3.4 Fats

Relative concentrations of PUFA indicated their importance in the diet. The eicosanoids assist in controlling a variety of bodily activities, including the immune system, inflammation in response to injury and illness, blood pressure, blood lipid concentration, and many others is 86. In terms of nutrition and health, the proportion of PUFA and SFA in oils is significant. Therefore, it's crucial to consider the PUFA ratio (also known as the P/S ratio) when assessing the negative consequences of dietary fats. The oil is more nutrient-dense the greater the P/S ratio. This is so because the amount of saturated and polyunsaturated fats in a person's diet has a direct correlation with how severe their atherosclerosis is 87. The current PUFA/SFA was exceptionally low in leaves (0.65), but just fair overall (Olaofe et al., 2013). The total fat content of Moringa oleifera is 6.50 – 20.00 g/100g (Falowo et al., 2017).

3.5 Vitamins

Using moringa leaves for human consumption for centuries in African nations. These leaves make a great source. They are regarded as among the best plant sources of vitamins A, B, and C (Roni et al., 2021). The amounts of total carotenoids, including vitamin B1 (326 mg/100 g) and vitamin C (15.2 mg/100 g). Moringa leaves are higher in vitamin C than oranges and higher in vitamin A than carrots (Burgos et al.,2021). The amount of vitamin B2 ,B3 and E are (20.5, 8.2 and 113mg/100g) respectively (Gopalakrishnan et al., 2016).The amount of vitamin A are 6.80 mg /100g (Patil et al., 2022).

3.6 Minerals

Magnesium, potassium, calcium, sodium, and many minerals can be found in M. oleifera seed. 2,357.71 mg/kg is the highest potassium concentration recorded, while The lowest level of calcium is 121.14 mg/kg. K > Na > Mg > Ca are the four macro elements in sequence, with which the sequence is different in which leaves contain them (K, Mg, Ca:17,638.41 mg/kg, 3,813.44, and 3,562.19 mg/kg, respectively). At the same period, tiny amounts of the elements copper, zinc, and iron being discovered. The highest concentration of iron in ratio of 36.2 mg and kg. Fe, Zn, and Cu are arranged in a different sequence in the three microelements than the three elements in leaves. Tin, cadmium, lead, and arsenic are also present in M. oleifera seeds at quantities of 0.007, 0.018, 0.015, 0.01 mg/kg, or 8.41, 29.51, and 1,274.12 mg/kg, respectively. Due to their low concentration (arsenic is permitted to 0.5 mg/kilogram in grains and their products), they are in compliance under GB2762-2017, (The National Food Safety Standard, Food Contaminants Limit.); 'Cadmium and lead' can only be found in amounts of 0.2 and 0.5 mg/kilogram, respectively, there is a 250 mg/kg tin restriction in seeds and nuts (Liang et al., 2019).

3.7 Ash content

The total ash content of Moringa oleifera is between 3.60 -5.00g /100g (Falowo et al., 2017).

Table 1. Nutrition composition of *Moringa oleifera* leaves.

Nutrients	Amount
Protein	29.4g/100g
Amino acid	(in g/100g)
Alanine	3.29
Serine	4.33
Glycine	5.09
Valine	3.15
Threonine	3.28
Isoleucine	4.44
Aspartic acid	6.27
Leucine	5.38
Lysine	3.31
Glutamic acid	15.1

Phenylalanine	4.62
Histidine	2.05
Methionine	0.99
Arginine	8.22
Cystine	2.06
Tyrosine	2.38
Proline	2.45
Carbohydrates	36±9.2g/100g
Vitamin A	6.80mg/100g
Vitamin B1	326mg/100g
Vitamin B2	20.5mg/100g
Vitamin B3	8.2mg/100g
Vitamin C	15.2mg/100g
Vitamin E	113mg/100g
Minerals	(in mg/kg)
Phosphorus	112.1
Potassium	3,562.19
Magnesium	3,813.44
Calcium	17,638.41
Sodium	224.1
Manganese	8.37

Copper	0.95
Sulphur	137
Chromium	< 0.5
Molybdenum	0.75
Nickel	< 0.5
Selenium	2.71
Iron	27.8–38
Fats	6.50-20g/100g
Bioactive molecules	(in mg)
Chlorogenic Acid	1.8–6.97
Glucosinolates	21.84–59.50
Tannins	132–1200
Oxalates	430–1600
Phytates	250–2100
β-carotene	6.6–17.6
α-Tocopherol	74.5–122.1
Thiamine	2.85
Polyphenols	2.10 –12.2
Flavonoids	5.1–12.2
Myricetin	5.8

Quercetin	0.21–7.6
Kaempferol	4.6
Gallic Acid	1.03–1.34
Ash content	3.6-5g/100g

(Sources: Milla et al., 2021; Olaofe et al., 2013; Hedhili et al., 2021; (Patil et al., 2022; Burgos et al., 2021; Gopalakrishnan et al., 2016; Liang et al.,2019; Falowo et al., 2017)

4. NUTRACEUTICAL PROPERTIES

Different parts of the *Moringa oleifera* were used as traditional cures by healers. The Ayurvedic and Unani medication systems have long recognized its numerous therapeutics applications. Almost all of the plant's components: Stem, roots, gum, leaf, fruit (pods), blossoms, seeds, and seed oil have all been used in the indigenous medical system to treat a variety of ailments, such as skin infections, swelling, anaemia, asthma, chest infections, diarrhoea, headache, joint pain, arthritis, gout, diarrhoea, heart trouble, fevers, digestive disorders, wounds, conjunctivitis and diabetes. (Milla et al.,2021).

4.1 Antibacterial

Food-borne illnesses pose a threat to consumers' health, particularly in developing countries. Numerous bacterial strains have developed drug resistance and are recognized as pathogens for numerous diseases. Using the reduced property of the Moringa oleifera root and without the use of harsh chemicals or surfactants, silver nanoparticles were produced in an environmentally friendly manner. The nanoparticles were examined using a variety of spectroscopic methods, including UV-visible, FT-IR, SEM, XRD, and EDX. Based on the review, the NPs arrangement was affirmed what's more, were viewed as round, hexagonal in shapes and translucent in nature. This preliminary result suggested that the Silver Nanoparticles had significant antibacterial activity against the pathogens tested, particularly Salmonella typhi (Danbature et al., 2021).

4.2 Anti-nephropathy

With age, kidney function deteriorates, and aging-related kidney complications rise in proportion. Natural compounds that don't have as many side effects are being looked at because how well existing medications work to treat kidney disorders is limited by their side effects.

Moringa oleifera may alleviate a number of pathological factors that are tied to kidney illnesses, such as oxidative stress and inflammation. Scientists from Nigeria demonstrated that, the herbs *Moringa* oleifera is good for you and won't hurt your organ or kidneys. Nigerian researchers demonstrated that *Moringa oleifera* are the gainful spice or makes not mischief kidneys and an organ of body, moringa root extricate specifically restrained SMAD4 and ERK phosphorylation was induced by TGF-beta. As a result of These data imply that moringa root extract may lessen renal fibrosis due to its antifibrotic effect in mice kidney fibroblast cells. Rats' liver fibrosis was lessened when *Moringa oleifera* seed extract was taken orally. Ethanol extract of M. oleifera decreased when MDA, ROS, Low - density lipoprotein, and CHOL are produced, all of that elevate the liability of chronic kidney disease, to reduce oxidative urgency in male Streptozotocin induced mice. By decreasing levels of urea, bilirubin (direct or indirect), and other bilirubin, ethanolic extract detoxified plasma, in male Sprague Dawley rats induced by melamine (Akter et al., 2021).

4.3 Anti-obesity and Anti hyper lipidemic

Around the world, obesity is seen as a serious health issue and is rising quickly. By inhibiting adipogenesis and inducing apoptosis. In particular, it has been shown that an extract of *Moringa oleifera* leaves has anti-adipogenic activity. Derivates of iso-quercetin (quercetin 3-Omalonylglucoside and iso-quercetin) were shown to be a bioactive component in 70% ethanolic extract of Moringa leaf extract. Docking experiments were performed to determine the association of iso-quercetin with markers of apoptosis (BCL-XL) and adipogenicity (FABP4 and PPAR) subsequently, in order to determine with relation to anti-obesity qualities, the likely effect of iso-quercetin. The out -turns demonstrated that all of the important proteins under study interacted significantly with iso-quercetin. Later, they conducted in vitro analysis to further the study's promotion. In light of this, they conducted a cell viability analysis on affecting 3T3-L1 cells' responses to iso-quercetin and Moringa leaf extract. According to the findings, Moringa leaf extract and iso-quercetin significantly reduced activity of cell or exhibited non-proliferative action. Then became interested in evaluating the triglyceride level, and to our surprise, we found that the triglyceride content decreased in a dose-dependent manner. In attempt to identify the molecular pathways behind the extract's anti-obesity properties, a number of genes involved in fatty acid metabolism, development of preadipocytes into adipocytes, PPAR CEBP, adiponectin and FABP4, and were selected. They discovered that Moringa leaf extract therapy dramatically reduced the expression of adipogenesis markers (Balusamy et al., 2019).

In the extracellular fluid, lipoproteins aid in the movement of lipids throughout the body. LDL is produced in the liver by lipolytic enzymes; higher quantities cause CHOL to accumulate in the arteries. If compared to nondiabetic rats, diabetic rats have higher levels of LDL. It's interesting to note that both diabetic and non-diabetic rats treated with *Moringa oleifera* had much lower LDL levels than the control group. Numerous previous research has hinted at the hypolipidemic effects of *Moringa oleifera*, which are consistent with the results of this investigation. However, LDL and CHOL levels in non-diabetic and diabetic rats treated with MO decreased dramatically in comparison with diabetic rats (negative control). Compared to non-treated non-diabetic rats (positive control), HDL level increased considerably (Omodanisi et al., 2017).

4.4 Anti-cancer

Uncontrolled and aberrant cell proliferation is a recognised symptom of the condition known as cancer. Numerous variables, including smoking, radiation exposure, and insufficient exercise, contribute to the occurrence of cancer. One in seven fatalities may be caused by cancer, which is linked to unchecked cell proliferation. Treatments including surgery, chemotherapy, and radiation are very expensive and have negative effects (Iqbal et al.,2021). By enhancing lipid peroxidation, DNA breakage, and the activation of apoptosis in oesophageal malignant cell line cells, Moringa oleifera extract has antiproliferative effects. Antioxidants are produced in cells to combat reactive oxygen species, but excessive production of these species causes oxidative stress. Protein, lipid, and DNA deterioration have been linked to a prolonged rise in oxidative stress. Polyunsaturated fatty acids and free radicals interact, resulting in lipid peroxidation and harm to cellular membranes. Lipid peroxidation in malignant oesophagus cell line cells showed that a Moringa oleifera extract dramatically enhanced Reactive oxygen species levels. Given that cancer cells have a greater metabolic rate, exposure to substances like the polyphenol-rich Moringa oleifera extract might elevate levels of reactive oxygen species. The polyphenols in Moringa oleifera extract, including as gallic acid, have been proven to cause cell death in cancer cell types and possess pro-oxidant characteristics.

Chlorogenic acid, another polyphenol contained in Moringa oleifera extract, triggered apoptosis in human oral squamous cell carcinoma and K562 leukaemia cells in response to reactive oxygen species. According to studies, Moringa oleifera extract induces apoptosis in a number of cancer cell lines and has anticancer potential (Tiloke et al., 2016).

4.5 Anti-diabetic

Type 2 diabetes, often known as type 2 diabetes mellitus, is a serious public health issue. The primary pathophysiology of Type-2 diabetes is insulin resistance and reduction of pancreatic insulin production. Type 2 diabetes and its consequences are typically difficult and expensive to treat. Type 2 diabetes has traditionally been treated alternatively using herbal medications. A long-used traditional herb is Moringa oleifera (MO) drumstick tree (Taweerutchana et al.,2017). Numerous important bodily systems, including the cardiovascular and nervous systems, are harmed by this uncontrolled, elevated sugar state. According to the WHO, the rate has been continuously rising over time. For example, in 2014, 8.5% of people aged 18 and older had diabetes, but 1.5 million people died directly from diabetes in 2019. It's alarming that 48% of fatalities take place before the age of 70 (Patil et al.,2022). Despite no differences in mean Plasma Glucose (77±6, 78±5, and 79±5 mg/dl, respectively), mean plasma insulin increased after doses of 0, 1, 2, and 4 g *Moringa Oleifera* (2.3±0.9, 2.7±1.0, 3.3±1.4, and 4.1±1.7, respectively). While there was no difference in Area Under the Curve of glucose, Area Under the Curve of insulin was higher after high-dose *Moringa Oleifera* (4 g) than after baseline or low-dose *Moringa Oleifera* capsule (1 g) (24.0±3.5 ,14.5±1.8 or 16.1±2.0, respectively; p = 0.03). As a result, the Area Under the Curve of the insulin/glucose ratio following high-dose *Moringa Oleifera* was significantly higher by 74% (p = 0.041) than it was at baseline.

In healthy subjects, the result is that high-dose (4 g) capsules of *Moringa Oleifera* leaves powder capsules gradually improved insulin secretion. These findings imply that *Moringa Oleifera* leaves could have potential as a type 2 diabetes treatment (Anthanont et al., 2016).

4.6 Anti- inflammatory

The body's physiological response to protect the host is inflammation from harm brought on by biotic and abiotic elements like bacterial infection, among others noxious stimuli. This safeguarding procedure involves series Tumor necrosis factor (TNF) and interleukin-6 are examples of cytokines. (IL-6) is induced, released in response to the inflammatory process, and mediates it in various ways. Apoptosis of the immune system can prevent immune disorders while unchecked and excessive inflammation even persistent degenerative conditions like cancer. Polysaccharides have been shown to have anti-inflammatory, immunomodulatory, and antioxidant properties. The build-up of pro-inflammatory mediators will indeed result in the commencement of several chronic inflammatory diseases. MRP-1 demonstrated anti-inflammatory activity by suppressing LPS-induced NO production along with TNF-secretion. RT-PCR also revealed that there was a decrease in the release of iNOS mRNA, which could influence the transcription process or mRNA stability. This study presents a novel macromolecular of root with all of anti-inflammatory properties (Cui et al.,2019).

4.7 Immunomodulatory

Moringa can combat oxidation reactions by stimulating neurotransmitters in the brain such as serotonin, dopamine, and noradrenaline. These serve as stimuli for stress and pleasure, memory, personal mode, and emotions, particularly in depressive and psychotic patients. Moringa's neuroenhancer potential on actions and thoughts changes in the cerebellum of mice was studied in order to consider Moringa for brain function modulation. Four groups of male Wistar mice were formed. M. oleifera was given orally and ordinary saline for 28 days in two groups, A and B, nicotine has been given to C group, and *Moringa oleifera* was given orally & within peritoneal cavity along with nicotine to D group. On the first day of the investigation, animals were allowed to acclimate to their new surroundings before being slaughtered for field trials to provide a baseline reading for the study. The animals were nourished in accordance with the plan in order to assess the impact of each group on brain functioning. On the final day, the animals were sedated for 24 hours before being subjected to perfusion obsession. Moringa has been shown to have the ability to inhibit chromatolysis, which causes the twisting of cerebellar cortex cells and leads in neuropsychiatric abnormalities. The cerebellum (purkinje cells) in a research animals was also shown to be degraded, as seen to linked analytical pathology. As a result, Moringa may protect against nicotine-induced cell damage (Iqbal et al.,2021).

5. MALNUTRITION

Malnutrition causes growth restriction and negatively affects a person's physical, intellectual, and social development, sometimes with permanent lifetime consequences. The prevalence of chronic malnutrition is among the highest in Sub-Saharan Africa. Micronutrient supplementation is the quickest and simplest short-term fix for nutrient deficiencies, however in the event of chronic undernutrition, this approach is probably insufficient. Combining some foods with readily available, inexpensive native plants would be a better approach to improving diet in developing nations (Barichella et al., 2018).

Moringa oleifera leaf powder is quite useful in reducing stunting. The intake of Moringa oleifera leaf powder like an enrichment in supplemental meals has the potential due to nutrigenomic and biology molecular features (D. Putra et al., 2021). Because of its leaf protein content, Moringa is of basic relevance for tropical deficiency reduction efforts, and our findings assist determine the species with the greatest and lowest protein contents. Our findings corroborate the presence of high protein levels in *Moringa oleifera, Moringa concanensis, and Moringa stenopetala* (Olson et al., 2016).

Different Strategies for African Development and the Church World Service conducted a study in southern Senegal in 1997-98 to see if Moringa leaf powder may prevent or treat malnourished in pregnant or breast-feeding mothers and their children. Malnutrition was a serious issue in this region, with over 600 malnourished new born treated each year. During the trial, doctors, nurses, and midwives were taught how to prepare and use Moringa leaf powder to treat malnutrition. The production and usage of Moringa leaves powder in meals was also taught to village women. Children's weight was either maintained or increased, and their general health improved. Pregnant women recovered from anaemia and had babies who weighed more at delivery, while nursing mothers produced more milk. Pesticides, pollution, and various other particles are all around us all the time. These are only a few of the free radicals that are so harmful, as we now know. Antioxidants are the only defence against free radical damage. Moringa is a fairly straightforward and widely accessible remedy for the malnutrition issue (Dhakar et al., 2011).

6. BAKERY PRODUCTS

6.1 Bread

The main ingredients for making bread, a fermented confectionery, are yeast, wheat flour, water, and salt. Other steps in the making process include combining, rising, kneading, shaping, and baking. Defatted moringa seed powder has been added to the enriched bread, increasing its carbohydrate, mineral, and vitamin A content. This study discovered that adding moringa seed powder to wheat bread significantly increased the bread's protein content. This finding may have substantial nutritional significance for underdeveloped countries where several elevated protein foods are prohibitively expensive (Eke et al.,2022). The sensory evaluation of the loaves revealed a general decline in product similarity as the amount of powdered *Moringa oleifera* leaves substituted raised. Despite a comparable increase in the amount of vitamin C of the dough, loaf height, volume, and specific loaf volume were all reduced when dried Moringa oleifera leaves were added to wheat flour to make bread. This may be connected to the leaves of the Moringa oleifera plant's antibacterial characteristics (Sengev et al.,2021). After six days of storage, the quantity of fungal colonies was decreased by 99% compared to the control bread lacking of moringa, indicating that the sanitary condition of bread combined with 2.5% of moringa is considerably higher than those achieved for other concentrations. Therefore, moringa at a concentration of 2.5% might enhance the hygienic integrity of wheat bread (Aguilar et al., 2021).

6.2 Muffins

In the composition of muffin dough, moringa seed residue was included. Protein concentration varied significantly across the board for all formulations, and for the 7% and 9% formulations, iron levels varied significantly. While the amount of fat stayed constant, the amounts of sodium and calcium both saw large changes. As a result, the muffins' nutritious content is altered by the inclusion of moringa seed residue. The viscosity behaviour of these formulations was also assessed, and it was discovered that all of them were pseudo-plastic and thixotropic, the latter of which indicates that the fluid needs some time to reach viscosity equilibrium when subjected to a fast change in shear rate (D. Paz et al.,2020).

6.3 Biscuits

Due to a variety of qualities, including taste, convenience, being ready to eat, affordability, and a longer shelf-life than other bakery items, biscuits are among the most consumed confectionery products around the world. It is also generally recognised and eaten in many nations, making it an effective supplemental method for improving the nutritional quality of essential nutrients including protein, dietary fibres, and functional components. The current study shown that adding MDL to food goods like biscuits will provide a number of challenges for consumer acceptability and have an impact on physical characteristics, particularly in terms of colour (green) as well as texture (hardness). Its fortification can improve nutritional qualities like iron and protein compounds for health advantages, however various restrictions and adverse consequences accompany this inclusion. These biscuits' protein content wasn't entirely absorbed. Additionally, important Moringa components, like vitamin A, may be lost during baking operations. Therefore, as previously mentioned, there are several restrictions on how much Moringa Dried Leaves may be added to biscuits (Hedhili et al.,2021).

Even at the lowest *Moringa oleifera* Leaf Powder -substitution level, the inclusion of *Moringa oleifera* Leaf Powder helped the samples' protein as well as dietary fibre contents rise while their overall starch content fell. The characteristics of biscuits' starch pasting are altered by the addition of *Moringa oleifera* Leaf Powder. In particular, reduced viscosity values following heating and chilling were found, showing that the control and *Moringa oleifera* Leaf Powder-substituted biscuits had lower retrogradation tendencies and starch swelling powers, respectively (Giuberti et al., 2020).

6.4 Cookies

Global consumption of cookies totals 10 million tonnes annually. Notably, the majority of bread-like cookies are produced with sugar, fat, and refined wheat flour, making them high-calorie and low-protein foods. Due to this, it is imperative to create functional cookies that will satisfy dietary needs and offer health advantages. The protein, fat, and ash levels of cookies were enhanced when wheat four was partially replaced with MOLP. Additionally, the enriched cookies had improved bioactive, antioxidant, and inhibitory activities against the enzymes -amylase and -glucosidase (Fapetu et al.,2022). Greater breaking strength suggests harder cookies, which may be the result of many circumstances during baking and storage, whereas substantial variance was seen for crispness and consumer acceptance across all treatments and overall values for sensory profiling (Shahbaz et al., 2021).

As determined by the sensory panel members, cookies with 2.5% MOLP received the highest rating. Due to their sensory qualities, 2.5% MOLP-fortified cookies are especially advised for diabetics and pre-diabetic patients (Fapetu et al.,2022).

6.5 Cake

Cake that has been enriched with MOLP and RBF combined to have higher nutritional, minerals, and vitamin A contents. The cake having 1.5% MOLP+ 2% RBF were virtually as satisfactory as the control, however sensory analysis of the study showed that the desirability of the snacks reduced when MOLP concentration was raised. The study also discovered that adding MOLP to cake significantly increased its protein concentration, which may be advantageous in poor countries where many people are unable to afford meals high in animal protein because they are expensive. The high amounts of vitamin A content of RBF and the MOLP- enriched cake may also aid in the fight against vitamin A deficiency in poor nations.

Overall, the research shows that adding 1.5% MOLP and 2% RBF to cakes can increase their nutritious content and bequeath to good food (Roni et al.,2021).

7. CONCLUSION

Various studies are done on the *Moringa oleifera* to identify their benefits and that research shows that they have many beneficial nutritional and nutraceutical characteristics that prevent and cure many diseases and their all parts are consumed by people. Various superfoods are found on the market that are fortified with *Moringa oleifera*. The fortification of bakery products with moringa leaves will increase their nutritional and physiological quality, but if MO leaves are used in high concentrations, it will also affect their acceptability among people. It can also extend the shelf life of fortified products due to their antimicrobial properties.

For future prospects, MO parts can be used to fortify various products like chips, kurkure, noodles, candies, and gummies. It can also be used for the enrichment of breakfast cereals and other products.

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