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THE POTENTIALS OF MORINGA OLEIFERA IN CONTRIBUTING TO FOOD AND NUTRITION SECURITY IN THE DEVELOPING COUNTRIES

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Food security at the aggregate, household levels and access to adequate basic health services are essential perquisites for good nutrition. Unfortunately, despite the sustainable development goals, global food security is worsening and 815 million people in the world are still undernourished. Poverty has been identified as the major driver of malnutrition. This paper argues that the promotion of the utilization and consumption of neglected crops would provide an affordable and sustainable alternative to improving food and nutrition security because most of these plants are rich in essential nutrients and are easily available, especially to the poor. It contends that *Moringa oleifera*, an underutilized plant, possesses a great potential for improving the nutritional and health status of poor households thereby enhancing food and nutrition security. Moringa is able to achieve this because it can contribute to the four fundamental elements of food security-food availability, food access, food utilization and food stability. This paper concludes with a call for action on the part of governments, in collaboration with food researchers to formulate policies that will promote the cultivation, utilization and consumption of moringa in areas where hunger and malnutrition are more prevalent.

Keywords: Moringa, Food and nutrition security, Developing countries

INTRODUCTION

From all indications, global food insecurity is worsening by the day with countries in the developing regions being the worst hit.The absolute number of people in the world affected by undernourishment, or chronic food deprivation, is now estimated to have increased from around 804 million in 2016 to nearly 821 million in 2017. The situation is worsening in South America and most regions of Africa[1]and sub Saharan Africa home to some of the most nutritionally insure people in the world. According to FAO sub Saharan region remains the region with the highest population of undernourished people affecting an alarming 22.7% of the population in 2016[1].

The prevalence of stunting among children in Africa is estimated at 39%, in fact Africa is the only region where the number of stunted children has risen[2]. This high prevalence of malnutrition is majorly caused by the high rate of poverty in those regions.

This situation has made household food security and nutrition issues at the top of the planning agenda in many countries in sub-Saharan Africa. Poor infrastructure and limited resources compounded with conflict, HIV, and poor access to health services are factors that contribute to the staggering levels of malnutrition and food insecurity on the continent[3] (Fanzo, 2012). This situation is further threatened by the global food crisis which has sent the prices of staples out of the reach of majority of the people. This means that meeting the ambitious Sustainable Development Goals (SDGs) set by world leaders to end hunger and malnutrition by the years 2030 would be quite a challenging one.

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Compounding this adverse health situation is the issue of micronutrient malnutrition from such micronutrients as iron, zinc, iodine and vitamin A. Due to lack of sustainable solutions, 2 billion people, about one third of the world's population, are iron deficient, and 250 million school aged children are vitamin A deficient[4] (WHO, 2018). It is likely that other micronutrient deficiencies are also highly prevalent, at least seasonally. The health consequences of these leading micronutrient deficiencies include mental retardation, cretinism, goitre in adults and children due to iodine deficiency; physical growth retardation, damaged immune mechanism and impaired reproductive functions due to iron deficiency; impaired immune function, cognitive dysfunction and anorexia due to zinc deficiency and childhood blindness due to Vitamin A deficiency[5]. Micronutrient deficiencies can be greatly alleviated by ensuring adequate food supplies and varied diets that provide essential vitamins and minerals. FAO[6] reported that in many developing countries, as much as 50% of the population may be affected by such deficiencies. About 20% of maternal deaths are caused by anaemia and with this anaemia is additional risk factor in contribution of 50% of all maternal deaths[7].

There is also an emerging face of malnutrition: childhood overweight and obesity: Childhood obesity is one of the most serious public health challenges of the 21st century. Childhood obesity has reached epidemic levels in developed as well as in developing countries[8]. This problem is global and is steadily affecting many low- and middle-income countries, particularly in urban settings. The prevalence has increased at an alarming rate. Globally, in 2016 the number of overweight children under the age of five is estimated to be over 41 million. Almost half of all overweight children under five lived in Asia and one quarter lived in Africa[9]. Overweight and obesity in childhood are known to have significant impact on both physical and psychological health. Overweight and obesed children are likely to stay obese into adulthood and more likely to develop non-communicable diseases like diabetes and cardiovascular diseases at a younger age[8].

Considerable investments have been made by governments and aid agencies in programs designed to prevent malnutrition. Approaches have included school lunch programs, nutrition education, introducing exotic vegetables, and even campaigns to periodically give children massive doses of vitamin A. A major drawback to these approaches is the dependence on imported solutions and outside personnel, and progress can quickly dissipate once the program funding dries up. This unfortunate scenario calls for an urgent need to look for alternative sources of both micro and macro nutrients. The World Declaration and the Plan of Action on Nutrition, adopted by 159 countries, at the International Conference on Nutrition organized by the UN's Food and Agriculture Organization (FAO) and WHO in 1992, states that strategies to combat micronutrient malnutrition should: '*Ensure that sustainable food-based strategies are given first priority particularly for populations deficient in vitamin A and iron, favouring locally available foods and taking into account local food habits.*'[10]Africa's diverse agricultural ecosystems provide a wide array of indigenous and traditional foods which if effectively mobilized and managed can increase food availability, expand household food choices and ensure dietary diversity and better nutrition[11].

Identification and utilization of locally available, cheap and nutritious foods is the call of the hour. More so, the greatest biodiversity is found in developing countries and poor communities rely greatly upon agricultural biodiversity for their foods andlivelihood[12]. Thus maintaining the viability of developing countries' local food systems which contain immense agricultural biodiversity remains one sustainable way of ensuring food and nutrition security for resource-poor populations. This could be the logical and sustainable strategy to avoid both nutritional deficiencies as well as diseases due to macro-nutrient excess thus enhancing food security. Food-based strategies favouring local multi-nutrient food materials have also been identified as the best suitable and sustainable strategies for combating micronutrients malnutrition[13].

Moringa has been reported to be one of the most useful tropical trees[14] (Foidl *et al.,* 2001) but it is unfortunately grossly underutilized. *Moringa oleifera* is a plant which grows in the tropical region of the world. In Nigeria for example Moringa leaves serves as a source of vegetable during the scarcity of the conventional vegetables.

Food and Nutrition Security Concept

According to the Committee on world food security (2012), food and nutrition security refers to a situation "when all people, at all times, have physical, social and economic access to food which is consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and cared allowing for a healthy and active

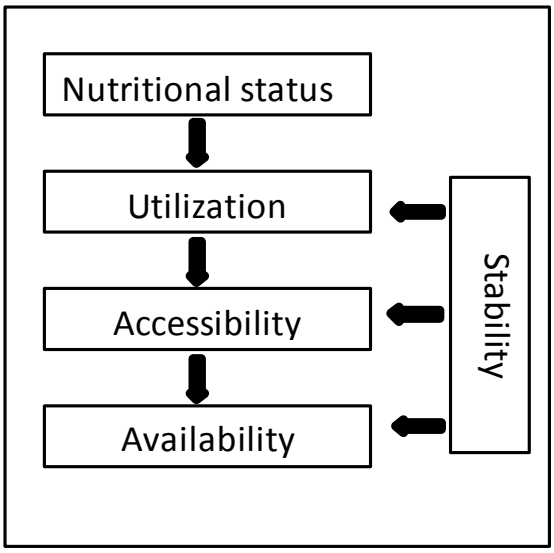
life".[15] Household food and nutrition security however is the application of this concept to the family level, with individuals within households as the focus of concern.

Almost 240 million people, or better put, one out of every four persons in the sub-Saharan Africa, lack access to adequate food. Hike in prices of food items and drought are forcing the population into hunger and starvation[16].

The concept of food and nutrition security is complex but can be simplified by focusing on four distinct, but inter-related dimensions of the concept: food availability, food access, and food utilization and food stability. Figure 1 shows the four dimensions of food security.

- Food availability is achieved when sufficient food, in quantity, quality and diversity are consistently available to all individuals within a country. Such food can be supplied through household production, other domestic output, or commercial imports of food assistance[18]. Constraints to food availability include: inappropriate agricultural knowledge, technologies, and practices; inappropriate economic policies, including pricing, marketing, tax and tariff policies; lack of foreign exchange; inadequate agricultural inputs; non-existent or ineffective private sector; population growth rates that offset increased production or imports; marketing and transportation systems which inhibit the cost-effective movement of food from source to need; inability to predict, assess and cope with emergency situations which interrupt food supplies; natural resource, climatic, and (especially in Africa) disease constraints; donor disinterest or fatigue; and political choice on the part of the host government at any level[19].

Figure 1: The Four Dimensions of Food and Nutrition Security



Source: Gross et al. (2000)

- Food access is ensured when households and all individuals within them have adequate resources to obtain appropriate foods for a nutritious diet. Access depends on income available to the household, on the distribution of income within the household, and on the price of food [20]. There is both physical and economic access to food and these have continuously posed challenges to the Sub-Saharan Africa in terms of achieving food security. Constraints to physical access to food include: weak or inappropriate infrastructures such as poor roads, ports, communication, food storage facilities and other installations that facilitate the functioning of markets, particularly in rural areas[21]. Food has become economically inaccessible in Africa due to relative increase in food prices. It is reported that from 1990 to 2013, food prices have increased by 19.1% in Sub-Saharan Africa as compared to 15.3% in developing countries[18]. These high relative prices of food as well the rapid rate of food prices increase in Africa indicate high level of market inefficiency.

  The factors that contribute to reduced food access to food in the developing countries include, high poverty level, high basic food price, poor physical access, low human development, high level of inequalities, inefficient preventive social protection mechanisms, ineffective and inefficient harvesting, storage, processing and handling have strongly affected production and/or purchase of food at household level, therefore contributing to reduce access to food.

- Food utilization/consumption is the proper biological use of food, requiring a diet providing sufficient energy and essential nutrients, potable water and adequate sanitation. Effective food utilization depends in large measure on knowledge within the household of food storage and processing and preservation techniques, basic principles of nutrition, and proper childcare and illness management.

  Constraints to food utilization include: nutrient losses associated with food preparation; inadequate knowledge and practice of health techniques, including those related

to nutrition, child care, and sanitation; and cultural practices that limit consumption of a nutritionally adequate diet by certain groups or family members[19].

- Food stability refers to the stability of food availability, accessibility and utilization over time. All three components must be present simultaneously at all times. A person who has adequate access to quality food today is still considered food insecure if he has periodic inadequate access to food which may cause his nutritional level to deteriorate. Variation in weather conditions, political and economic instability, and price fluctuation are some factor that may impact on food security status[16].

The Moringa Tree

Moringa oleifera Lam is one of the best known and most widely distributed and naturalized species of a monogeneric family *Moringaceae*[21]. *Moringa oleifera* is native of the western and sub-Himalayan tracts, India, Pakistan, Asia Minor, Africa and Arabia[22].

The moringa tree is perennial, erect, and slender and medium sized, with many arching branches. It has drumstick like fruits, small white flowers and tear drop shaped round leaves[23]. The tree ranges in height from 5 to 10 m[24], is found wild and cultivated throughout the plains, especially in hedges and in house yards, thrives best under the tropical insular climate, and is plentiful near the sandy beds of rivers and streams[25]. It can grow well in the humid tropics or hot dry lands, can survive destitute soils, and is little affected by drought[24]. Altitudes below 600 m is known to be best for moringa however, growth of up to 1200 m in some tropical areas has been recorded. It can yield 3.0 t seed/ha compared to average yields of sunflower (2.0 t/ha) and groundnut (0.5 t/ha). The plant starts bearing pods 6-8 months after planting but regular bearing commences after the second year. The tree bears for 30-40 years. The drought tolerant nature of the tree makes it particularly suited to the marginal areas where the costs associated with the cultivation and harvest of other commercial crops are high. This tree can be propagated by both sexual and asexual means. The moringa tree is known by different names like "mothers best friend", "miracle tree", "miracle tree of hope" and "natures pharmacy" to name but a few. It is considered as one of the World's most useful trees, which can be attributed to its nutritional components as seen in Table 1 and almost every part of the moringa tree can be used for food, medication and industrial purposes[26].

Table 1: Nutrient Composition of Moringa

	Pods	Fresh Leaves	Dry Leaves
Moisture (%)	86.9	75	7.5
Calories	26	92	205
Protein (g)	2.5	6.7	27.1
Fat (g)	0.1	1.7	2.3
Carbohydrate (g)	3.7	13.4	38.2
Minerals (g)	2	2.3	
Ca (mg)	30	440	2,003
Mg (mg)	24	24	368
P (mg)	110	0.7	0.204
K (mg)	259	259	1.324
Fe (mg)	5.3	7	28.2
Vitamin A (β-carotene (mg)	0.11	6.8	16.3
Vitamin B1- thiamin (mg)	0.05	0.21	2.64
Vitamin B2- riboflavin (mg)	0.07	0.05	20.5
Vitamin B3- nicotinic acid (mg)	0.2	0.8	8.2
Vitamin C-ascorbic acid (mg)	120	220	17.3
Arginine (g/16gN)	3.6	6.01	1.33%
Histidine (g/16gN)	1.1	2.1	0.61%
Lysine (g/16gN)	1.54	4.3	1.32%
Tryptophan (g/16gN)	0.8	1.9	0.43%
Methionine (g/16gN)	1.4	2	0.35%
Threonine (g/16gN)	3.9	4.9	1.19
Leucine (g/16gN)	6.5	9.3	1.95%
Isoleucine (g/16gN)	4.4	6.3	0.83%
Valine (g/16gN)	5.4	7.1	1.06%

Source: Fuglie (1999)

Moringa: It's Contribution in Food and Nutrition Security

Food and nutrition security is a broad and complex concept which is determined by the interaction of a range of agro-physical, socioeconomic, and biological factors. Like the

concepts of health or social welfare, there is no single, direct measure of food security. However, the complexity of the food security problem can be simplified by focusing on four distinct, but inter-related dimensions of the concept as mentioned above: food availability, food access, and food utilization and food stability. The role of moringa to food and nutrition security is discussed below.

Moringa and Food Availability

Moringa's potential contribution to food/nutrient availability is enormous. The leaves, fruit, flowers and immature pods of this tree are edible and used as a highly nutritive vegetable in many countries, particularly in Asia and many parts of Africa. The leaves can be incorporated into any dish and used as spinach for example in the northern part of the country the leaves are used in preparing soups. These leaves appear at the end of the dry season, when there are few other sources of leafy green vegetables[27], therefore contributing to all year availability of vegetables. It produces so much leaves for so many years that one tree can serve a family for 30 years.

The flowers can be cooked and mixed with other foods or fried in batter. They can also be placed in hot water for five minutes to make a kind of tea. The pods can be eaten from when they first appear to when they become too woody to snap easily (up to 30 cm long). They are cooked like other green beans and have a similar flavour to asparagus. The seeds can be boiled and eaten as any other green pea when still green. They can be used from the time they appear until they turn yellow and their shells begin to harden[28]. The dry seeds are apparently not used for human consumption, perhaps because the bitter coating becomes hardened. The mature seed is about 40% oil. Moringa oil contains about 73% oleic acid, (other vegetable oils normally contain only about 40% oleic acid), and this makes it of excellent quality for cooking similar to olive oil. The oil is slow to become rancid and so could be used over a long time by households.

Moringa leaves can be easily dried (in the shade to reduce loss of vitamins) and rubbed over a wire screen to make a powder, which can be stored and conveniently added to soups, sauces, food, etc., they are not changing their taste. The brittle dried leaves can also be pounded and sifted to remove leaf stems. The powder should be stored in a sealed dark container.

Apart from directly contributing to food availability, moringa indirectly plays significant roles in food availability in a myriad of ways such as outlined below.

The extract obtained from the leaves of moringa in 80% ethanol contains growth enhancing principles (i.e., hormones of the cytokinine type). The extract can be used in the form of a foliar spray to accelerate the growth of young plants. Use of the growth hormone spray will also cause the plants to be firmer and more resistant to pests and disease. Plants that are treated with this growth hormone spray will also produce more and larger fruit and will consequently have a higher yield at harvest time. Spraying the leaves of plants with the moringa extract prepared in 80% ethanol and then diluted with water produced some notable effects such as a longer, more vigorous life-span, heavier roots stems and leaves, bigger fruits and higher sugar levels, etc. The extract produces an overall increase in yield of between 20-35% based on data such as the stem diameter, number of nodules, number of axels, number of flower buds, and number of fruits per flower bud[14].

The residue obtained after extraction of coagulants from the defatted moringa kernels (meal) could form a good source of protein supplement for animals because of high crude protein content (approximately 70%), all of which is in the form of true protein. This may be a good source of sulphur amino acids for fibre-producing animals (i.e., Angora rabbits, sheep and goats) in a mixed diet containing sufficient levels of other essential amino acids. This could replace the high cost conventional seed meals[14]. Moringa shoots can be used as green manure. Incorporating Moringa leaves into the soil before planting can prevent damping off disease (*Pythium debaryanum*) among seedlings thereby improving yield. In addition, the relative ease with which it propagates through both sexual and asexual means and its low demand for soil nutrients and water after being planted makes its production and management easy.

Moringa and Food Accessibility

Moringa could increase food accessibility by improving household income. Almost all the parts of the moringa tree could be sold for money which will be used to purchase other essential food items. The leaves especially are consumed in some parts of the country. Large scale moringa farming could be a source of employment to people who will be involved in planting, weeding and harvesting. As stated earlier the dry seeds contain about 40% oil. Moringa oil sold for many years as "ben oil", is of excellent quality (73% oleic acid, similar to olive oil) that could be used for cooking and making perfumes. *M. oleifera* seed oil is highly resistant to oxidative rancidity, which can explain its several industrial uses such as in the production of cosmetics,

machinery lubricants, cooking oil and fuel for lamps, being quite appreciated in the perfume industry due to its high odour retention capacity[28]. More recently the oil has also been shown to be particularly effective in the manufacture of soap producing a stable lather with high washing efficiency and is also excellent to burn for light. This oil and/or soap produced from it can equally be sold to improve household income. The cosmetic, lubricating oil, cooking oil and soap industries which are moringa based would further serve as sources of employments for many people thereby empowering such people financially to meet essential needs of life.

Moringa serves as a cheap source of rich nutrients like protein, vitamin A, iron, vitamin C thereby saving money that could be used for the purchase of other needs of the house hold. In Malawi, a study carried out to evaluate the cost of three major nutrients from different food sources. The cost ratios for vitamin A show that moringa is the cheapest source of vitamin A of all commonly used foods in Malawi. The cost of vitamin A from beans is about 150 times higher than that of moringa. Even among leafy vegetables, the cost of nutrients is the lowest when they are consumed in the form of moringa. For instance, costs of vitamins A, C and calcium from Amaranthus leaves is about 8, 12 and 3 times higher than that of moringa leaves respectively[29].

Moringa and Food Utilization

Nutritionally, the dried moringa leaves are about 30% protein[30] with all of the nine essential amino acids present in various amounts. Moringa is considered to have the highest protein ratio of any plant so far studied on earth. The leaves are sources of the sulphur containing amino acid such as methionine and cystine which are often in short supply in most legumes[31]. The leaves of the moringa tree are excellent sources of vitamin A (four times the amount in carrots), the raw leaves are rich in vitamin C (seven times the amount in carrots) and they are also good sources of vitamin B and other minerals. The leaves are outstanding source of calcium (four times the amount in milk), protein (twice the amount in milk), and potassium (three times the amount in bananas). The content of iron is very good as well and the leaves have purportedly been used for treating aneamia in the Philippines. Moringa contains low levels of carbohydrates and fats which makes it nutritionally good.

According to Rweyemamu[13], 100 g of *Moringa oleifera* leaves can meet the daily requirements of vitamin A for 17 children at the age of 1-3 years, ten pregnant women and seven lactating mothers. The same amount of *Moringa oleifera* leaves are sufficient to supply the kid with vitamin C for 7 days, the pregnant woman for 4 days and lactating mother for 3 days. It has been reported that Moringa possess similar protein quality and quantity with soybeans. In Africa, more often than not, the porridges given to babies are of poor nutritional value usually cereal flour with sugar added, sometimes small fish and rarely (when the mothers have the means) powdered milk. These baby cereals do not cover children's protein, lipid and micronutrient (vitamins and minerals) needs. Baby foods enriched with moringa has been formulated.

Yang *et al*. (2002)[32] reported that *in vitro* Iron Bioavailability (IB) of vegetables is increased by 2-10 times by cooking. The cooking enhancing effect can be achieved with different heating processes including boiling, stir-frying and hot-air drying. In the case of moringa, boiling in water enhanced the *in vitro* IB of fresh leaves and dried powder by 3.5 and 3 times, respectively. Bioavailability trials using fresh as well as blanched and sulphited shade dehydrated drumstick leaves were conducted on vitamin A deficient rats. The results revealed that the dehydrated drumstick leaves produced a marked increase in food intake, weight gain and liver vitamin A, compared to fresh drumstick leaves or synthetic vitamin A.

The utilization of many plant foods is limited by the presence of relatively high concentration of a number of anti-nutritional factors which interfere with the assimilation of nutrients contained in such foods. For instance phytates serve as chelating agents, which bind such important minerals as calcium, iron, zinc, copper, etc. Trypsin inhibitors decrease the digestibility of dietary proteins by forming a complex with trypsin. Moringa leaves however; contain low levels of tannins (12 g/kg dry matter), phytates (21 g/kg) and absence of trypsin and amylase inhibitors, lectins, cyanogenic glucosides and glucosinolates. Pods and stem contain irrelevant amounts of tannins but saponins and alkaloids are present in amounts biologically important in leaves (80 g/kg) and stem, respectively, although in levels considered nontoxic to ruminants[16,31]. Asogwa *et al*.[33] demonstrated the growth promoting potential of dried moringa leaves in rats. They reported that normal rats fed dried moringa leaves exhibited significantly ($p<0.05$) higher gain weight than either normal rat chow fed rats and soy flour based diet fed rats.

Another issue in food utilization is health and disease impede on food/nutritional utilization. In most of the developing countries the non-communicable diseases (NCDs) which had been regarded as diseases of the industrialized societies are fast raising serious health concerns in these countries. The rapid change in disease pattern has occurred as a result of shifts in diet and physical activity patterns, termed the "nutrition transition", and the adoption of a more westernized lifestyle, due to economic development and market globalization[34]. In Nigeria for instance, more than 29% of the disease burden is attributable to non-communicable diseases[35].

Moringa is a good source of natural antioxidants; such as ascorbic acid, flavonoids, phenolics and carotenoids, which have abilities to prevent or mitigate numerous chronic diseases which are associated with anti-oxidative stress such diseases include cardiovascular diseases (CVDs), cancer, obesity and type 2 diabetes mellitus etc. In a study with the aqueous extract of moringa leaves on alloxan induced diabetic rats, it was observed that the extracts reduced hyperglycemia, malondialdehyde levels in hepatic tissues[36]. The anti-obesity properties of moringa leaves has been demonstrated in animals[37,38]. Moringa leaf extracts has also shown potential anticancer effects[39,40].

Moringa has been used in folk medicine for the treatment and prevention of myriad of other diseases. It has been reported to possess antibiotic, antitrypanosomal, hypotensive, antispasmodic, antiulcer, anti-inflammatory, hypo-cholesterolemic, and hypoglycemic activities. Moringa has also been said to act as lactation enhancer and has been used to treat aneamia. This diverse health benefits from moringa has led to it being referred to as "Nature Pharmacy".

In addition to food, shelter and clothing, water is one of our basic human needs and lack of potable water is a major cause of death and disease in our world. Leaves and seeds of *Moringa oleifera* are also widely used in water treatment exhibiting no significant side effect and are non-toxic and biodegradable[41]. It is known that the seeds possess strong antimicrobial properties reducing as much as 99.9% of the bacteria suspended in water after a 1-to-2-hour treatment[42]. The advantage of using moringa as a natural coagulant is that it comes with practically no cost sincethe seed cake used is a by-product other advantages include that they are non-toxic, biodegradable[41] and availability.

The aqueous seed extract or the seed cake after oil extraction has been traditionally used to purify water in Africa and, in South Asian countries, and other parts of the world as a natural coagulant since it has high levels of active cationic proteins[43] with a coagulation efficiency similar to that of alum.

Soil may become contaminated by the accumulation of heavy metals and metalloids through emission from the rapidly expanding industrial areas, mine tailing, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, waste water irrigation, coal combustion residues, spillage of petrochemical, chemicals and atmospheric deposition[44]. Heavy metal contamination of soil may pose risk and hazard to humans and the ecosystem through: direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human), drinking of contaminated ground water, reduction in food quality (safety and marketability) via phyto-toxicity, reduction in land usability for agricultural production causing food insecurity and land tenure problems[45,46]. Heavy metals are a threat to human life and the environment because of their non-biodegradable nature and thus persistence; hence they are toxic and bio-accumulative. The removal of such metals from the environment is necessary. Studies carried out have proved that moringa seed extracts is able to act as a bio-absorber of such heavy metals as nickel, iron, copper, lead, chromium, etc. The removal percentage of Iron, copper and chromium reached 69.99%, 88.86% and 93.73%, respectively. *Moringa oleifera* seed powder biosorbent also has a great potential for the removal of Pb and Cr from contaminated water. The biosorption of all metals on the adsorbent was rapid, as over 80 % of the metals were removed within the first 20 minutes of interaction[47].

All these findings suggest that the crude extract of. *M. oleifera* seeds can be an alternative for water treatment, at least at the household level especially in developing countries thus enhancing food security.

Moringa and Food Stability

Global changing climate is another important driver of food insecurity that cannot be underestimated. Amongst other impacts, climate change is responsible for biodiversity loss in the ecosystem. Agriculture, forestry and fisheries are all sensitive to climate. In the tropical regions of the world (where most developing countries are located) climate change will have a negative effect on food production. This implies that in many low-income countries with limited financial capacity to trade and high dependence on their

own production to cover food requirements, it may not be possible to offset declines in local supply without increasing reliance on food aid.

For climate variables such as rainfall, soil moisture, temperature and radiation, crops have thresholds beyond which growth and yield are compromised[48]. Wild foods are particularly important to households that struggle to produce food or secure an income. A change in the geographic distribution of wild foods resulting from changing rainfall and temperatures could therefore have an impact on the availability of food. Changes in climatic conditions have led to significant declines in the provision of wild foods by a variety of ecosystems, and further impacts can be expected as the world climate continues to change. For the 5000 plant species examined in a sub-Saharan African study, it is predicted that 81 to 97% of the suitable habitats will decrease in size or shift due to climate change. By 2085, between 25 and 42% of the species' habitats are expected to be lost altogether[49]. The implications of these changes are expected to be particularly great among communities that use the plants as food or medicine.

Adaptation to climate change involves deliberate adjustments in natural or human systems and behaviours to reduce the risks to people's lives and livelihoods. Mitigation of climate change involves actions to reduce greenhouse gas emissions and sequester or store carbon in the short term, and development choices that will lead to low emissions in the long-term. Planting moringa tree could help mitigate against climate change. It has been reported that the rate of absorption of carbon dioxide by the moringa tree is twenty times higher than that of general vegetation[50]. Moreover, moringa tree is draught resistant and is well adapted to growing in adverse climate conditions. Moringa is a multipurpose tree with a great potentials of improving the food security of poor small holder farmers, thus, planting of this tree will go a long way to reducing the adverse effect of climate change in a variety of ways.

CONCLUSION

In Sub-Saharan Africa (SSA), the agricultural biodiversity within traditional food systems contributes to food and livelihood security in very profound ways. Communities traditionally employ a wide range of locally available food resources in daily diets.The cultivation, utilization and consumption of moringa may therefore be a key strategy to ensure food and nutrition security in the developing countries especially in sub Saharan Africa.

Moringa is able to do this by contributing to food security through myriad of ways. Moringa trees are draught resistant and the leaves are available all year round. Moringa is very rich in both macro and micronutrients for human and animals thus enhancing food/nutrient availability. These nutrients will provide a cost effective means of reducing the alarming incidence of malnutrition in sub Saharan Africa. Sales of different parts of this plant are a source of extra income to the family which will enhance food accessibility. It is loaded with antioxidant phytochemicals that help to promote health, Moringa seeds contain coagulants that are very useful for water purification, thereby reducing incidence of water borne diseases that impede on food utilization. Moringa is also a very important agent in climate change mitigation having the capacity to absorb more carbon dioxide that most other trees.

There is therefore an urgent need for the promotion of the utilization of moringa especially among the rural dwellers and the urban poor. Government must begin to formulate agricultural, food/nutrition policies that will promote the cultivation, utilization and consumption of moringa. People must be educated on importance of moringa. This can be done by carrying out food/nutrition education for the rural women and those in the low income group. This programme will be aimed at enlightening the women on the various benefits of moringa, teaching them simple method of preservation and cooking and teaching them new recipes for moringa based diet preparation. Governmental and non-governmental organizations should also encourage the cultivation of moringa by providing technical and managerial support to farmers, for example provision of moringa seeds at little or no cost to farmers. They should encourage and sponsor research works on moringa utilization.

Food/nutrition researchers should focus more on community targeted studies that will promote the consumption of our local foods. Research works based on enhancing the food value and finding novels ways of moringa utilization is pertinent at this hour.

REFERENCES

1. FAO, IFAD, UNICEF, WFP and WHO (2018), "The State of Food Security and Nutrition in the World 2018", Building Climate Resilience for Food Security and Nutrition.
2. UNICEF/WHO/World Bank Group (2018), "Joint Child Malnutrition Estimates", 2018 Edition.

3. Fanzo J (2012), "The Nutritional Challenge in Sub-Saharan Africa", Working Paper United Nations Development Programme (UNDP), p. 3, Regional Bureau for Africa.
4. WHO (2018), http://www.who.int/nutrition/topics/micronutrients/en/
5. Prasad A S (1991), "Discovery of Human Zinc Deficiency and Studies in an Experimental Human Model", *Amer. J. of Clin. Nutri*., Vol. 53, pp. 403-412.
6. FAO (2006), "The State of Food Insecurity in the World", Food and Agricultural Organization, Rome, Italy.
7. Sanghvi T G H (2010), "Maternal Iron-Folic Acid Supplementation Program: Evidence of Impact and Implementation", *Food Nutr Bull*., Vol. 31, pp. 100-107.
8. Sahoo K, Sahoo B, Choudhury A K *et al*. (2015), "Childhood Obesity: Causes and Consequences', *J Family Med Prim Care*, Vol. 4, pp. 187-192.
9. WHO (2018), "Childhood Overweight and Obesity", www.who.int/dietphysicalactivity/childhood/
10. FAO/WHO (1992), "The World Declaration and the Plan of Action on Nutrition", Food and Agricultural Organization, Rome, Italy.
11. Smith I F (2013), "Sustained and Integrated Promotion of Local, Traditional Food Systems for Nutrition Security", in Fanzo J, Hunter D and Borelli T (Eds.), *Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health*, pp. 123-139, Routledge, Abingdon, Oxon.
12. Hobblink H (2004), "'Biodiversity. What's at Stake?", *Currents*, Vols. 35/36, pp. 18-21.
13. Rweyemamu L M P (2006), "Challenges in the Development of Micronutrient-Rich Food Ingredients from Soya Beans and *Moringa Oleifera* Leaves", Conf. Proceedings Moringa and Other Highly Nutritious Plant Resources: Strategies, Standards and Markets for a Better Impact on Nutrition in Africa, Accra, Ghana.
14. Foidl N, Makkar H P S and Becker K (2001), "The Potential of *Moringa oleifera* for Agricultural and Industrial", *In The Miracle Tree*, pp. 45-76, Dakkar, Senegal.
15. Committee on World Food Security (2012), "Thirty-Ninth Session", Rome, Italy (CFS 2012/39/4) 15-20 October.
16. Matemilola S and Elegbede I (2017), "The Challenges of Food Security in Nigeria", *Open Access Library Journal*.
17. Gross R, Schoeneberger H, Pfeifer H and Preuss H A (2000), "Food and Nutrition Security: Definitions and Concepts", *SCN News,* Vol. 20, pp. 20-25.
18. ECA (2015), "Status of Food Security in Africa", Ninth Session of the Committee on Regional Cooperation and Integration, Addis Ababa, Ethiopia, United Nations Economic and Social Council, Economic Commission for Africa.
19. USAID (1992), "Policy Determination: Definition of Food Security", *United States Agency for International Development*, Washington DC.
20. USAID (2015), "USAID Office of Food for Peace Food Security Country Framework for Bangladesh FY 2015-2019", *United States Agency for International Development*, Washington DC.
21. Ramachandran C, Peter K V and Gopalakrishnan P K (1980), "Drumstick (*Moringa oleifera*): A Multipurpose Indian Vegetable", *Econ Bot,* Vol. 34, pp. 276-283.
22. Mughal M H, Ali G, Srivastava P S and Iqbal M (1999), "Improvement of Drumstick (*Moringapterygosperma* Gaertn.)—A Unique Source of Food and Medicine Through Tissue Culture", *Hamdard Med,* Vol. 42, pp. 37-42.
23. Nambiar V S (2006), "Nutritional Potential of Drumstick Leaves: An Indian Perspective", Conference Proceedings on Moringa and Other Highly Nutritious Plant Resources: Strategies, Standards and Markets for a Better Impact on Nutrition in Africa, Accra, Ghana.
24. Morton J F (1991), "The Horseradish Tree, *Moringapterigosperma* (Moringaceae)—A Boon to Arid Lands", *Econ Bot,* Vol. 45, pp. 318-333.
25. Qaiser M (1973), "Moringaceae", in Nasir E and Ali S I (Eds.), *Flora of West Pakistan. No.38*, pp. 1-4, University of Karachi Press, Karachi.
26. Khalafalla M M, Abdellatef E, Dafalla H M *et al.* (2010), "Active Principle from *Moringaoleifera* Lam Leaves

Effective Against Two Leukemias and Hepatocarcinoma", *African Journal of Biotechnology*, Vol. 9, pp. 8467-8471.

27. Price M L (2000), "The Moringa Tree", *ECHO Technical Note*, 12 p, ECHO, Florida, USA, http://www.echonet.org/tropicalag/moringa3.htm

28. Ferrao A M B and Ferrao M J E (1970), "Fatty Acids in Moringa (*Moringaoleifera* Lam.)", *AgronAngolana*, Vol. 30, No. 8, pp. 3-16.

29. Babu S C (2000), "Rural Nutrition Interventions with Indigenous Plant Foods—A Case Study of Vitamin A Deficiency in Malawi", *Biotechnol. Agron. Soc. Environ.*, Vol. 4, pp. 169-179.

30. Asogwa I S, Onweluzo J C and Omah E (2018), "Effect of Boiling Time and Sun Drying on the Nutrient Composition of *Moringa oleifera* Leaf Powder", *Int. J of Food and Nutri. Sci.*, Vol. 7, pp. 37-44.

31. Makkar H P S and Becker K (1997), "Nutrients and Anti-Quality Factors in Different Morphological Parts of the *Moringa oleifera* Tree", *J Agric. Sci.*, Vol. 128, pp. 311-322.

32. Yang R Y, Tsou S C S and Lee T C (2002), "Effect of Cooking on *in vitro* Iron Bioavailability of Various Vegetables", in: Lee T C and Ho C T (Eds.), *Bioactive Compounds in Foods: Effect of Processing and Storage*, pp. 130-142, American Chemical Society, Washington DC.

33. Asogwa I S, Ani J C and Omah E C (2017), "Effect of Moringa Leaf Powder Supplementation on Some Biochemical Indices of Rats", *Inter. J. of Res. Stud. in Biosci.*, Vol. 5, pp. 48-58.

34. WHO/FAO (2003), "Diet, Nutrition and the Prevention of Chronic Disease", A Report of a Joint WHO/FAO Expert Consultation, Geneva, 28 January-1 February 2002, WHO Technical Report Series 916, WHO, Geneva.

35. WHO (2018), "Non Communicable Diseases Country Profile", www.who.int

36. Abd Eldaim M A, Elrasould A S and Abd Elaziz (2017), "An Aqueous Extract from *Moringaoleifera* Leaves Ameliorates Hepatotocicity in Alloxan Induced Diabetic Rats", *Biochemistry and Cell Biology*, Vol. 95, pp. 524-530.

37. Ghasi V C, Nwobodo E and Ofili J O (2000), "Hypocholesterolemic Effects of Crude Extract of Leaf of *Moringaoleifera*", *Journal of Ethnopharmacology*, Vol. 69, pp. 21-25.

38. Ahmed H H, Metwally F M, Rashad H M *et al.* (2014), "*Moringa oleifera* Offers a Multi-Mechanistic Approach for Management of Obesity in Rats", *International Journal of Pharmaceutical Sciences Review and Research*, Vol. 29, pp. 98-106.

39. Jung I L, Lee J H and Kang S C (2015), "A Potential Oral Anticancer Drug Candidate, Moringaoleifera Leaf Extract, Induces the Apoptosis of Human Hepatocellular Carcinoma Cells", *Oncol. Let.*, Vol. 10, pp. 1597-1604.

40. Adebayo I A, Arsad H and Samian M R (2017), "Antiproliferative Effect on Breast Cancer (MCF7) of *Moringaoleifera* Seed Extracts", *African Journal of Traditional Complementary and Alternative Medicine,* Vol. 14, pp. 282-287.

41. Ali E N, Tan C S and Makky E A (2014), "Impact of *Moringa oleifera* Cake Residue Application on Waste Water Treatment", *Journal of Water Resource and Protection,* Vol. 6, pp. 677-687.

42. Madsen M, Schlundt J and Omer E F (1987), "Effect of Water Coagulation by Seeds of *Moringa oleifera* on Bacterial Concentrations", *J Trop Med Hyg.*, Vol. 90, pp. 101-109.

43. Muyibi S A and Evison L M (1995), "*Moringa oleifera* Seeds for Softening Hard Water", *Water Res,* Vol. 29, pp. 1099-1104.

44. Zhang M K, Liu Z Y and Wang H (2010), "Use of Single Extraction Method to Predict Bioavailability of Heavy Metals in Polluted Soils to Rice", *Communications in Soil Science and Plant Analysis,* Vol. 41, pp. 820-831.

45. McLaughlin M J, Hamon R E, McLaren R G, Speir T W *et al.* (2000), "Review: A Bioavailability-Based Rationale for Controlling Metal and Metalloid Contamination of Agricultural Land in Australia and New Zealand", *Australian Journal of Soil Research,* Vol. 38, pp. 1037-1083.

46. Ling W, Shen Q, Gao Y, Gu X and Yang Z (2000), "Use of Bentonite to Control the Release of Copper from Contaminated Soils", *Australian Journal of Soil Research,* Vol. 45, pp. 618-623.

47. Adhiambo O R, Lusweti K J and Moranga G Z (2015), "Biosorption of Pb2+ and Cr2+ Using *Moringa Oleifera* and Their Adsorption Isotherms", *Science Journal of Analytical Chemistry,* Vol. 3, pp. 100-108.

48. Porter J R and Semenov M A (2005), "Crop Responses to Climatic Variation", *Philosophical Transactions B,* Vol. 360, pp. 2021-2035.

49. Levin K and Pershing J, "Climate Science 2005: Major New Discovering", WRI Issue Brief, WRI, Washington DC.

50. Villafuerte L R and Villafurte-Abonai L (2009), "Data Taken from the Forestry Agency of Japan in Moringa", *Malnggay Philippines*, p. 240, Apples of Gold Publishing, Singapore.

51. Fuglie L J (1999), "The Miracle Tree: *Moringa oleifera*: Natural Nutrition for the Tropics", p. 68, Church World Service, Dakar, http://www.echotech.org/bookstore/advanced_search_result.php?keywords=Miracle+Tree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