Addition of moringa in the functional food to make it nutritious & healthy, and how beneficial it is in combating diseases including COVID-19?

*At report and research paper written by '**Terry Exports LLP'** on market potential of moringa & role ofgovernment & food companies to promote.*

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1. Introduction

Since centuries, the world has been consuming plants & herbs in multiple applications such as eating them raw and using them in foods, pharmaceuticals to curing and preventing diseases and other unfathomable uses.

One such versatile plant/herb is *Moringa Oleifera* (MO) with miraculous medicinal and therapeutic values used in alleviating and managing various disease states (Varmani & Garg, 2014). As per (Z.F.Ma, 2018), "it is usually referred as Moringa in the literature, is a cruciferous plant belonging to the genus Moringa under the family Moringaceae". *Moringa Oleifera* is indigenous to Indian subcontinent, however, due to its great benefits, it has now gradually grown in part of Africa, Asia & Europe & Caribbean (Z.F.Ma, 2018). As per study by (Z.F.Ma, 2018), since 150 B.C., moringa has been used for health benefits in diets. As described by Carlos Martin from Cuba in his study with his colleagues, "different application fields of Moringa oleifera are presented in the light of the increasing scientific interest it has generated in recent years" (Martín, et al., 2013).

Among the 13 cultivars of Moringa (M. arborea, M. rivae, Moringa oleifera, M. longituba, M. stenopetala, M. concanensis, M. pygmaea, M. borziana, M. ruspoliana, M. drouhardii, M. hildebrandtii, M. ovalifolia and M. peregrine), Moringa Oleifera has been widely studied and researched plant due to its phytochemical and pharmacological properties (Z.F.Ma, 2018). As corroborated by (Vázquez-León1, et al., 2017), moringa is known as one of the most useful trees in the world as every part of the tree is edible and widely used in food, healthcare and other industrial purposes.

The cultivation of medicinal plants such as moringa is significant, as the phytochemicals and biochemicals in plants would widely vary according to the key parameters like plant species, plant age, harvest seasons, and by other factors that affect tree development, such as soil nutrients, geographical location, and climate conditions (Vázquez-León1, et al., 2017). Moringa tree best grows in semi-arid tropical and sub-tropical regions. The favourable temperatures for moringa growth are between 25 and 35 C as described by (Trees For Life International, 2011). Though, moringa does not require too much water for its cultivation for irrigation facilities, unlike in another crops such as rice, however, its intensive cultivation with adequate irrigation and fertilisation increases biomass yield to as high as 100 tons per hectare asquoted by (Martín, et al., 2013) in a study by (Foidl, et al., 2001). The parts of the plant which are leaves, flowers, roots, bark are not just edible but has potential to uses as construction material, as well. In a research by (Fahey, 2005), quoted in (Martín, et al., 2013),"the plant is also used as living fence or windbreak, while the lignocellulosic biomass ofthe trunk and the branches may be used asconstruction material and to produce cellulosic pulp and ethanol", which is least known among the moringa community.

Moringa is known by multiple names like drumstick, horseradish tree, behn tree, ben tree, multipurpose tree, miracle tree (Ramachandran, et al., 1980). In one of the studies on effect of drying methods on chemical composition of moringa leaves powder, the authors mentioned that moringa is also known as shobhanjana, murungai, soanjna, shajna, sainjna. Sainjna is often known as "mother's best friend" (Mansour, et al., 2016).

Nutritionally, moringa is highly densed with micronutrients and macronutrients, biochemicals. Also, in a study by (Rajendran, et al., 2019), it has been corroborated that moringa possess anti-inflammatory, hepatoprotective, antinociceptive, oxidative DNA damage protective, antiperoxidative, and cardio protective effects. Various functionally bioactive components present in moringa herb helps to attributes these properties. These components are flavonoids, alkaloids, natural sugars. Moringa is rich in protein, vitamins, minerals, amino acids, phenolic acids and phytosterols (Rajendran, et al., 2019). As per the research by (Rajendran, et al., 2019), all the parts of the plant hold several medicinal values, however, leaves are thought to have hold the highest medicinal value in the miracle tree.

2. Nutritional & health benefits of moringa for combating diseases

In India, the Ayurvedic medicine contemplated the use of this plant for cure, prevention and treating "more than 300 diseases" as mentioned in (Martín, et al., 2013). Its therapeutic uses are practiced in several countries, such as Bangladesh, Egypt, the Philippines, Guatemala, India, Malaysia, Myanmar, Puerto Rico, Senegal, Sri Lanka, Thailand and Venezuela, among others. In spite of the deep roots of the moringa use in many remedies and medical treatments in different nations, not all is documented in the scientific literature as noticed by (Martín, et al., 2013).

In a study carried by (Silva, et al., 2014) to understand the benefits of moringa oleifera, it is noted that the moringa plant contains various amino acids, fatty acids, vitamins and nutrients glucosinolates and phenolics (flavonoids, anthocyanins, proanthocyanides and cinnamates).

As various reports states and our practical experience being in moringa business and getting the lab test results for the nutritional profile, it can be easily mentioned that moringa leaves powder contain nutrients, minerals, vitamins, which are not easily seen in other ethnomedicinal plants. The protein content of more than 24% in a plant source is not easy to be found along with the combination of all the amino acids. (Sánchez-Machado, et al., 2009) in their study found that the three most abundant amino acids were glutamic acid, arginine, and aspartic acid. They concluded, in their study, that moringa oleifera is a nonconventional plant with substantial nutritional values.

"As per Indian belief in ayurvedic science, moringa leaves are used in the treatment of diabetes & blood hypertension. Popular anecdotes from African nations also reports several cases of miraculous cure of diabetes & hypertension using remedies prepared from this plant" (Martín, et al., 2013).

Cancer as a disease is known to have second major cause of death, around the globe. Therefore, needed cure of cancer is the worldwide demand among the people and lot of research has been carried out since a while now. Moringa is known to have anti-cancer properties. Several epidemiological studies based on plant extracts have been developed to treat breast, lung, and colon cancer. As per (Z.F.Ma, 2018), in a recent study, ethanol extract of moringa leaves showed strong anticancer activity against diethyl nitrosamine-induced hepatocellular carcinoma in Wistar rats, mainly by inducing apoptosis and improving antioxidant activity. In a study by (Jung, 2014), mentioned in (Z.F.Ma, 2018), treatment with aqueous extract of moringa leaves inhibited tumour cell growth, induced apoptosis and decreased reactive oxygen species (ROS) levels in lung cancer cells and some other types of cancer cells, suggesting that Moringa leaves has the potential to decrease proliferation and invasion of cancer cells. In another study by (Sreelatha, et al., 2011) the antiproliferative and apoptosis properties of moringa leaf extract were determined using human tumor (KB) cell line. The study showed that moringa leaves inhibited cell proliferation of KB cells in a dose- dependent manner. The observed antiproliferative property of Moringa leaves was further demonstrated by induction of apoptosis, morphological changes, and DNA fragmentation. Further research or bioactive compounds in moringa plant especially moringa leaves would open the way to cure the dreaded disease of cancer in humans.

Various studies have shown the hypolipidemic properties of Moringa. For example, the hypolipidemic effect of Moringa leaves was investigated in rabbits fed with high-cholesterol diet for 3 months. Daily consumption of moringa leaf extract (100 mg/kg bw) significantly decreased cholesterol levels by 50% and atherosclerotic plaque formation in internal carotid by 86.52% in the rats compared to control group. These observed effects were like simvastatin (reference drug) treated group (5 mg/kg bw) (Chumark, et al., 2008).

In a study carried by (Ahmad, et al., 2018) in which the effects of moringa leaf powder in cookies (5% w/w) in 20 healthy subjects was examined. Moringa-containing cookies decreased blood glucose compared to isocaloric control cookies made from 100%

wheat flour. In addition, the consumption of moringa containing cookies caused no adverse effects on gastrointestinal symptoms of the study subjects. The study provided evidence of hypoglycemic effect of Moringa leaf powder when incorporated into cookies in healthy subjects, and suggested that more research is required to understand the benefits of long-term consumption of Moringa containing foods for reducing the risk of diabetes and other chronic diseases (Ahmad, et al., 2018). These studies were conducted on animals and very few studies have been conducted on humans, therefore, more studies needs to be conducted on humans to understand the impact of moringa on humans and efficacious nature of moringa leaves, seeds, flowers, roots, bark on humans.

Cardiovascular disease is caused by tension, stress and our food consumption habit and lack of exercise regime, which happens to be part of the modern lifestyle adopted by the mankind. As per World Health Organisation's statistics, "cardiovascular diseases (CVDs) are the number 1 cause of death globally, taking an estimated 17.9 million lives each year. CVDs are a group of disorders of the heart and blood vessels and include coronary heart disease, cerebrovascular disease, rheumatic heart disease and other conditions" (World Health Organisation, 2020)[1]. Various studies have shown the hypolipidemic properties (cholesterol lowering drugs) of Moringa.

(Chumark, et al., 2008) studied the hypolipidemic effect of moringa leaves on rabbits fed with high cholesterol diet for 3 months. Daily consumption of Moringa leaf extract (100 mg/kg bw) significantly decreased cholesterol levels by 50% and atherosclerotic plaque formation in internal carotid by 86.52% in the rats compared to control group. These observed effects were similar to simvastatin (reference drug) treated group (5 mg/kg bw). In another study, daily consumption of aqueous extract of Moringa leaves (1 g/kg bw) for 30 days by rats fed with high-fat diet significantly decreased serum cholesterol by 14.35% compared to control group. Moringa leaves treatment also decreased the levels of cholesterol in the liver and kidney by 6.40% and 11.09%, respectively (Ghasi, et al., 2000). In another study, daily consumption of Moringa leaf powder (8 g) for 40 days by type-2 diabetic subjects decreased total cholesterol (by 14%), triglycerides (by 14%), LDL cholesterol (by 29%), and VLDL cholesterol (by 15%) compared to control group (Kumari, 2010).

Moringa has been used since centuries in Indian subcontinents for treatment and prevention of diseases including cancer, constipation, diabetes, chronic headaches, thyroid disorders, inflammation, heart disease, anaemia, arthritis, epilepsy, respiratory, skin, and digestive disorders (Blends, 2017)[2]. Moringa is considered to be a great immune booster due to the availability of 40 powerful antioxidants. "These compounds help protect the body against disease and free radicals, stopping them in their tracks before they cause cellular damage and disease" (Blends, 2017).

Future studies should explore the possible mechanisms of actions of the phytochemicals present in the moringa which makes the plant miraculous to treating the diseases and the potential of considering moringa oleifera plant as a functional food for the prevention and management of chronic diseases (Z.F.Ma, 2018).

3. Moringa & COVID-19

At the time of writing this section of this paper (19th April 2020), *COVID-19* has been named & declared a pandemic disease by World Health Organisation (World Health Organisation, 2020)[3]. Intensive research is carried out by healthcare and scientist community. As per the preliminary research for this paper, (R., et al., 2010) debated in the research paper while studying the antiviral properties of phytochemicals. In the key points the research found that "a wide variety of active phytochemicals have been found to have

[1] https://www.who.int/health-topics/cardiovascular-diseases/#tab=tab_1

[2] https://restorativeblends.com/blogs/articles/top-7-health-benefits-of-moringa

[3] https://www.who.int/emergencies/diseases/novel-coronavirus-2019

therapeutic applications against genetically and functionally diverse viruses. The antiviral mechanism of these agents may be explained on the basis of their •antioxidant activities, scavenging capacities, the inhibition of DNA, RNA synthesis, or the blocking of viral reproduction, etc" (R., et al., 2010).

Myricetin is a bioflavonoid which "*showed excellent antiviral effect against hepatitis B virus, influenza virus, and/or coronavirus*" as quoted by (Q & X, 2005) in (R., et al., 2010). While attempting to connect the antiviral properties of myricetin with other studies, (Semwal, et al., 2016) corroborated that "*the compound was reported to display activity against the SARS-coronavirus, a causative agent for severe acute respiratory syndrome, and inhibited the coronavirus helicase protein* by affecting the ATPase activity in vitro at an IC50 value of 2.71 μM". Further, a toxicity study suggested that myricetin does not exert cytotoxicity towards normal breast epithelial MCF10A cells, hence, researchers concluded that the compound is safe for further in vivo studies as researched by (Yu, et al., 2012). To find the source of myricetin, research by (Shervington, et al., 2018) states that "the flavonoids found in moringa oleifera arepresent as flavonols, a subgroup within the flavonoid family derived from the amino acid phenylalanine at several stages of the phenylpropanoid pathway. The key flavonols present in moringa are *Myricetin*, Quercetin and Kaempferol. The paper further corroborates that the antioxidant properties of moringa leaves exhibits antibacterial, antiviral, anti-inflammatory and anti-carcinogenic properties. Moringa oleifera leaf extract has also been found to decrease high blood pressure as quoted by (Shervington, et al., 2018) through study by (Aekthammarat, et al., 2018). Study by(Yu, et al., 2012) further demonstrates that "naturally-occurring flavonoids, including myricetin and scultellarein might serve as SARS-CoV chemical inhibitors". Scultellareinis abundantly available in moringa flowers & roots as found in the recent experiment by (Al-Taweel & Al-Anbari, 2019). This strongly opens the gateway for the further research to develop the drug for COVID-19 and moringa needs to be studied thoroughly.

4. Moringa in functional foods & grassy taste

Having researched the nutritional benefits and the chemical compositions of parts of moringa especially, moringa leaves. This section of the paper is to debate on the addition/usage of moringa leaf powder in the food human eat in general to make it healthier and nutritious so that the benefits of the miracle tree can be had from the diets. The taste of moringa leaf powder is grassy as per our primary experiment to taste it by mixing one tablespoon of USDA certified organic moringa leaf powder in one glass of water. One of the potential clients of 'Terry Exports LLP' discussed on the altering the taste of moringa leaf powder by addition of natural sugars like stevia leaf powder, coconut milk powder and mango extracts to lessen the effect of grassy taste. However, it needs to be researched if the nutritional composition stays the same as before for moringa. Other client in the USA intend to make a ready to go energy beverage toreach out to the natural beverages target audience. There has been no major evidence that changing the taste of moringa to make it sweeter shall be accepted by the wider consumer base and therefore primary market research needs to be conducted for the retail brands. However, (Badejo, et al., 2014) attempted to discuss on the taste of moringa leafextract when mixed with Cyperus esculentus (tigernut). The tigernut extract was mixed withmoringa leaf extract and spiced with ginger to produce functional drinks. The drinks were evaluated for physicochemical characteristics, sensory parameters, and antioxidant potentials.The study suggested that there was little impactof adding tiger nut in moringa as per the experiment conducted on people to know how it tasted. Having said that, multiple reports andresearch suggested that due to high amount of nutrition in moringa, it should be incorporated in food products like, wheat, maize, cookies etc.

5. Moringa for infants, breast-feeding & lactating mothers

Moringa leaves & powder are known to have significant impact on the lactating mothers and infants of the age 0-6 months as studied in

(Zakaria, et al., 2018). In the study conducted, "a total of 70 nursing mothers and infants were sampled, 35 intervention and 35 controls. purposive sampling based on the inclusion criteria". Material of intervention in the form of Moringa leaf extract through spray drying and control in the form of Moringa leaf powder, encapsulated in the same color and weight. The data were analyzed statistically with T test. Nutrition to infants of 0-6 months is exclusively met through the breastfeeding.[4] Moringa oleifera, that has the potential to be developed in culinary breastfeeding mothers, because it contains phytosterol compounds that function to improve and facilitate the production of breast milk (lactagogum effect) (K., 2011) as mentioned in (Zakaria, et al., 2018).

Leaf extracts containing various micronutrients such as iron, vitamin C and E and other phytochemical compounds directly affect the increase in the volume of breast milk, so as not to have iron deficiency, zinc, calcium, vitamin C, vitamin E, vitamin A, and B vitamins (Zakaria, et al., 2018). In addition to micronutrients in moringa leaf extract, it also contains macro nutrients such as protein & energy that potentially impacts on the weight gain of the infant. As a conclusion of the study by (Zakaria, et al., 2018), the consumption of moringa leaf extracts by breastfeeding mothers may contribute to the nutritional status of the infants at 4 months of age based on the body weight index of the infants and not as much to the infants of 6 months of age.

6. Role of governments & food companies to promote moringa

Due to the aforementioned benefits of moringa which have been reported by the researchers and in practical by people who consume moringa regularly in their diets, moringa should be highly encouraged and promoted by government and food companies to incorporate moringa in different food products. Back in 2014, as per report by (Burwood-Taylor, 2019)[5] published in (AgFunderNews, 2019), moringa was never heard of commercially among the people and households and retail consumers, in the USA especially. "Driving the US market for the plant is Kuli Kuli, a startup out of Oakland, California that was founded by Lisa Curtis, an ex-Peace Corps volunteer who discovered the benefits of moringa leaves, while in a small village in Niger". As Lisa Curtis mentioned in her interview published in (AgFunderNews, 2019), she started from scratch with her childhood friend Jordan Moncharmont out of Stanford to out the moringa products to pitching to investors and asking the feedback of the consumers by offering them the moringasample for taste to eventually grow 300% with their moringa products sale, down the line afterfew years of her successful launch of her moringa brand, through constant hustle. However, there have been no global food brands which have adopted moringa in their food products widely. Nestle, Kraft Heinz Company, Mondelez International, Danone, Heineken, Archer Daniels Midland, Diageo,PepsiCo, Coca-Cola and others have very greatpotential to introduce moringa to their foodproducts and their brands to promote nutrition which the food companies strive for.

The role of government & NGOs in promoting moringa can greatly attributed to their hunger programs and global institutions like United Nations, World HealthOrganisation among others can also be involved in. As per (Briel & Webb, 2003), "the UN World Food Program helps fight global hunger through emergency relief and development programs, including milling and fortification activities". Moringa having great micro and macro nutrients can help ameliorate the hunger and poverty across the world. World Food Programme, food assistance branch of the United Nations, which is committed to end hunger and provide food security and nutrition by 2030. Moringa should be part of such programmes. As a great example and initiative taken by government of Republic of Cuba, revolutionary leader Fidel Castro played very significant role in promoting moringa across Cuba (Cuba Debate, 2012). When he was ill

[4] http://www.who.int/iris/handle/10665/42859

[5] https://agfundernews.com/breaking-kuli-kuli-launches-moringa-products-into-2500-walmarts.html

back in 2015, he credited moringa for his recovery (Deccan Herald, 2016)[6]. Castro took it up as his pet farming activity. “He once called up the founder of Cuba’s Finlay Instituto, Concepcion Campa Huergo, suggesting that Cubans should go to India, study moringa cultivation, and bring its seeds back” (Deccan Herald, 2016). Pharmacist, biochemist, and lead scientist Concepcion Campa Huergo is the moringa director in Cuba and heading moringa programmes through research and cultivation. Concepción Campa has been recognized internationally for her scientific contributions to children's health. As part of the Cuban team, she developed the vaccine of meningitis B. “This vaccine, patented as VA-MENGOC-BC®, was awarded the World Intellectual Property Organization's Gold Medal in 1989” (C, 2008).

7. Quality of moringa for sourcing

Genetic variation, environmental factors, post-harvest handling and different means of food preparation influence the nutritional and functional qualities of moringa (Yang, et al., 2006). From our experience and as multiple reports suggest while seeing the quality of moringa leaf powder. Broadly, there are two major parameters that should be analysed one is microbiological report which tells the health of moringa including the heavy metals and the life process of developing the moringa powder from sowing the seeds to cultivating the moringa to plucking and drying the leaves after washing with herbal water at normal room temperature to processing the powder, and second is nutritional report which describes how nutritionally dense the moringa is.

Drying method of moringa leaves is very essential as it would determine the nutrition in the moringa which would vary from different vendor to vendor and therefore adequate training and knowledge is critical to understand on how nutrition changes with the temperature while being dried. (Mansour, et al., 2016) debated that shadow drying of the moringa leaves gives the best result, however in practical scenario chances increases that dirt and other toxic composition may enter in the leaves while being dried as per our experience especially when dried in bulk to process the orders for clients. Second challenge is that temperature cannot be controlled in shadow drying and therefore the results might not come the same as always. To overcome this challenge, solar drying method is considered the best option so that leaves get dried in controlled manner to get the desired results every time and it is considered as second best method in the research by (Mansour, et al., 2016) over oven drying or other cabinet drying method. In oven drying, leaves may getexposed to too much heat which shall reduce the protein content of the leaves but may increase the crude fiber content. However, the colour of leaves turned brown when dried in oven drying the chlorophyll of the leaves. As aforementioned in the paper, there are lot other parameters like geography, soil, climate, location of farms, handling and packaging which would impact the quality of moringa. Ascorroborated by an experiment in the research by (Compaore, et al., 2011) and mentioned in (Mansour, et al., 2016).

8. Potential market size of moringa

Based on the application of moringa, the moringa market has been segmented functional food & beverage, nutraceuticals, pharmaceuticals, personal care, and others as seen by a market research report (Market Research Future, 2019). As per the report, market is expected to register a CAGR 9.3% to reach USD 7.9 billion by 2025. The reportstates that the market shall grow at a considerable rate than the last few years, due tothe much benefits of the miracle tree on humanhealth. Moreover, the findings of the report suggest that the demand of organic certified moringa products is rising, especially in Europe, which has created the opportunities forthe growth of the market. This is in contrary to our business experience as we have been seeing

6 https://www.deccanherald.com/content/583335/castro-loved-miracle-plant-india.html

significant surge in the interest of moringa products from the USA, Australia, Brazil, Qatar, South Korea, Philippines and other countries besides Europe.

As per (Grand View research, 2019), market size for moringa products in 2018 stood at USD 5.5 billion. The report also suggests that "production of moringa is majorly concentrated only in India and some parts of Africa. Due to its geographical limitations in production, demand across the world can only be fulfilled by export, which is an offline process". "In 2018, U.S. was the largest market for moringa with more than 75.0% of market share in North America. The rising awareness of organic health supplements is the major factor for the growth of moringa products. The culture of calorie reduction and weight loss is also driving the market since moringa also helps in reducing weight gains. Majority of the Americans prefer supplements over to their daily diets. Moringa can be an additional source of multivitamins, antioxidants, amino acids, and other nutrients". The same is corroborated by our business experience while speaking to our current and potential clients in the USA & other western countries.

9. Conclusion

As a conclusion which can be easily be said that, after carrying out the secondary research by going through previous research of scientists and primary research by speaking to current and potential clients of 'Terry Exports LLP', moringa should be encouraged more by the food companies and governments around the globe. Moringa as an ingredient should be further researched for pharmaceutical research. Addition of moringa in food shall be greateffort to reach out to wider audience and this shall definitely create new source of revenue forthe corporates and investors as this would create new food product development and value addition to current food products for different segments. Moringa community, healthcare professionals and scientist should share more research which would be beneficial for every stakeholder.

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