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Biosynthesis, Characterization and Biological Applications of BaO Nanoparticles Using *Linum usitatissimum*

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Abstract: Nanotechnology is extremely important in the world of science. It serves as a link between bulk substance and the atomic scale. Nanoparticles (Ns) are materials having a diameter ranging from 1 to 100 nm. Nanospheres can be created using three different methods: chemical, biological, and physical. Chemicals and solvents used in chemical procedures are toxic to the biological system and the atmosphere. Advancements in the molecular based study of matter at the nanoscale will assist to comprehend, analyze, estimate, and develop novel materials. Biological synthesis is comparable to reducing agents in that it is a bottom-up process. Biological synthesis, on the other hand, uses a natural byproduct to obtain a costly chemical that is used as a reducing agent in the production of metal and its oxide nanostructures. Plant components (such as carbohydrates, proteins, and coenzyme) have a remarkable ability to transform metal salts into nanoparticles. *Linum usitatissimum* was used to make barium oxide nanoparticles in this study because its polyphenols have strong antioxidant activity and other therapeutic properties. *Linum usitatissimum* has steroids, alkaloids phenolic compounds, flavonoids carbohydrates, in its phytochemical makeup. *Linum usitatissimum* prepare barium nanoparticles have improved antioxidant, anti-inflammatory, and antibacterial activities.

Keywords: Nano-technology, Co-precipitation, Phytochemicals, Pharmacological Activity

1. Introduction

The term nanotechnology is defined as the process to control the amount of material in the state of atom or molecule. In nanotechnology, the size of the structure ranges from 1-1000 nanometers in any of its dimension and the materials modify and evolve in this size. It improves the properties by becoming lighter, stronger, faster and long lasting. Products with high performance are made by using tools and different technique [1]. It is the type of technology that has significant effect on all societies and industries at its latest form. There are different types of nanotechnology. One of them is green nanotechnology. It is a branch that increases the sustainability of environment by producing green nano products [2]. Its function is to eradicate the environmental and health risks and increases the process of replacement between original to nano products [3].

In the domains of nanoscience and nanotechnology, the critical and crucial leading role of molecular-based approaches for the analysis of matter is well understood. Improvements in these techniques will play a large role in any future developments in this subject. Quantum and statistical mechanics, intermolecular interaction, molecular simulation, and molecular modeling are all used in this research. Advancements in the molecular based study of matter at the nanoscale will assist to comprehend, analyze, estimate, and develop novel materials. Nanotechnology and nanoscience are becoming critical components of industrial and medical equipment such as diagnostic biosensors [4], medication delivery mechanisms, and imaging devices in just these few years. In the food sector, nanomaterials have been used to dramatically improve manufacturing, packing, shelf life, and nutritional bioavailability [5]. Nanostructures, on the other hand, have antibacterial activity against food-borne microorganisms, and a variety of nanoparticles are now being employed as food sensors are used to monitor food quality and safety [5].

Natural Nanoparticles play an essential role in solid/water

partitioning due to a high surface to mass ratio. Pollutants can be incorporated to the nanoparticle surface, co-precipitated during the production of natural nanoparticles, or confined by collection of NPs with contaminants adhered to their surface. Its length, structure, shape, permeability, accumulation and collective configuration of nanoparticles all have an impact on how pollutants respond with them. When luminophores are treated within the silicate layers, they are protected from ambient O_2 and are non-toxic. There are different ways to synthesize nanoparticles [6]. One of them is the eco-friendly green synthesis method, from a plant extract. This method has an advantage because the plants are easily accessible and less hazardous. The nanoparticles produced by this method is stable and present in various size and shapes. There are different levels of phytochemicals in the plants that differentiate them in their bioreduction capacity and it affects the morphology and physiochemical properties of manufactured nanoparticles [7].

The co-precipitation method has gain interest than above all methods because of its synthesizing way. It is cost-effective and has low temperature and energy that makes it inexpensive and produces at large scale with good yield. The barium oxide nanoparticles have unique optical and structural properties. The dependence of physical properties is on microstructure of nanoparticles. These can be grain boundaries, crystal defects, and surface morphology. Therefore, the information about microstructure is necessary to gain the understanding of properties of barium oxide nanoparticles [8].

Linum usitatissimum contains important fatty acids that aid in the passage of nerve impulses. *Linum usitatissimum* oil is therefore beneficial for numbness and tingling, and avoiding catastrophic nerve diseases such as parkinson's and alzheimer's disease. It's a powerful resource for researching intelligence-related diseases like Menopausal signs, bipolar disorder, and anxiety. *Linum usitatissimum* oil is a laxative, however when they are roasted and converted into Kashaya, they function as an absorbent and are used to treat inflammatory bowel syndrome (IBS) with diarrhoea. *Linum usitatissimum* is a well-known cardio tonic that helps to keep the heart in good working order and regulates blood flow [9].

Table 1. *Taxonomical Classification of Linum usitatissimum.*

Kingdom	**Plantae**
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Malpighiales
Family:	Linaceae
Genus:	Linum
Species:	*L. usitatissimum*
Binomial Name:	*Linum usitatissimum L*

2. Review of Literature

2.1. Nanotechnology

Richard Feynman was the first person who introduced the concept of modern nanotechnology. He got noble prize in 1965 in physics. He presented a lecture in a meeting at Caltech and gave the concept of about manipulation of matter at atomic level. He is considered the father of modern nanotechnology because his hypotheses were proven correct. After his work, a scientist named Norio Taniguchi used his concept and explained the processes of semiconductor. There are other scientists named as Kroto, Smalley, and Curl who also uses the concept of Richard Feynman and discover fullerenes [10]. There is a scientist named Eric Drexler who wrote a book in 1986. Its title was ―Engines of Creation: The Coming Era of Nanotechnology‖. He called it molecular nanotechnology. Advancement in nanotechnology made carbon nanotubes by Japanese scientist Iijima (Iijima, 1991).

There is everyday impact of nanotechnology on human life and has diverse potential benefits. Constant exposure of nanoparticles to human leads to environmental risks and potential health. It introduces scientific disciplines like nanotoxicology and nanomedicine. The adverse health effects of nanoparticles is studied in nanotoxicology. Nanomedicine includes health risks due to nanomaterials that are present in medicines and medical devices. Nanotechnology, which uses nanoparticles, is a fast - growing field. Nanotechnology has use in safety ranging from food production to contamination checking. Contaminants have been removed using nanomaterials. Nanotechnology is also employed in extraction methods to adsorbed trace amounts of pesticides, chemicals, heavy metals, foodborne diseases, and toxins, in relation to sensors for detection of pesticides, chemical products and heavy metals [11].

Nanotechnology-based detecting systems have the ability to offer a number of benefits over traditional laboratory techniques. Nanoparticles in combination with electrochemical or optical monitoring modalities provide fast, accurate and cost-effective approaches for point-of-care testing that allow for miniaturization and automating. Several significant milestones toward the development and implementation of new nanotechnology have been taken in the recent decade. Nanodevices and nanomaterials, in combination with suitable ligands, provide unique prospects for developing ultrasensitive detection methods. Nanoparticles, quantum dots, nanotubes, nanowires, and spin valves are among them. Infectious diseases, protein biomarkers, chemicals, and heavy metals have all been detected using Nano sensors like the Giant Magneto Resistor [12].

Nanoparticles have a long and distinguished history. They are not just the result of modern study, nor are they limited to man-made materials. Weathering, volcano eruptions, wildfires, and microbiological activities all contain naturally nanoparticles, which comprise both organic and inorganic substances [13]. Nanoparticles are not always created in advanced synthesis laboratories, but they have clearly been in nature for many years and hence have a lengthy history of use [14]. While the use of clay particles as organic

nanomaterials does not appear to be very advanced, the 4500-year-old controlled strengthening of a ceramic matrix with organic asbestos Nano fibers is more significant. Metal nanoparticles have the ability to tint glass in a unique way. For a long period, gold has been used to give glass a vibrant red tint [15]. The Lycurgus Cup in the British Museum is one of the finest examples of ruby glass. The Romans created it in the fourth century, and it looks green in daylight but turns red when lighted from within [16].

2.1.1. Barium Metal

It is a silvery metal with a soft look. It oxidizes in air and readily reacts with water. It's all compounds are toxic but barium sulfate is insoluble so, it can be swallowed. Its suspension is prescribed to persons suffering from digestive disorders. It is distinguished on an X-ray by passing through the body. Its properties include the optical bandgap energy. Its applications are catalytic, photocatalytic, and RH humidity sensing characteristics [17].

2.1.2. History of BaO Nanoparticles

The word ―nano is derived from a word that is in Greek and that word is ―dwarf or ―very little‖. It has meter of one thousand millionths that is 9-10 meter. Its study is called Nanoscience that has structure and molecules in the range between 1 and 100nm and the technology that uses it is called nanotechnology. The use of nanoparticles was used in fourth century by Romans. They gave importance due to their unique characteristics like catalytic activity, melting point, wettability, electrical and thermal conductivity. Barium oxide nanoparticles are of importance because of its high conductance and has wide band-gap semi-conductor [18].

2.2. Classification of Nanoparticles

2.2.1. Composition

The purity and function of nanoparticle depends on the elemental and chemical composition of it. The contamination and reduction of efficiency in the nanoparticle is due to the presence of undesired elements. The process of compositional analysis is carried out by x-ray photoelectron spectroscopy [19].

2.2.2. Morphology

There are different shapes and surface structures of nanoparticles that determine its properties. There are various shapes like flat, spherical, cylindrical, conical, and irregular shape. The surface is crystalline and amorphous in nature. There are different methods like SEM, TEM, and electron microscopy for its analysis [20].

2.2.3. Dimensionality

It is divided into three kinds that is 1D, 2D, and 3D [21]. When there is one billionth of any unit so one dimension nanoparticle will be formed such as thin films. It is used in chemistry [23], pharmaceutics [24], engineering and electronics [25]. Two dimension nanoparticles comes out the size range of nanometrics and act as building blocks for nanodevices. Its example is carbon nanotube. They found its applications in nanoreactors, nanocontainers, and sensorphotocatalysts [26]. The major use of three dimensional nanoparticles is in medical science and research. It further finds its importance in the field of batteries, magnetic materials, and catalysis. Its examples are dendrimers, fullerenes, and quantum dots. The performance of nanostructures depends on basic parameters [27].

2.3. Properties of Nanoparticles

Some of the necessary properties are the following.

2.3.1. Optical and Electronic Properties

Noble metals of great worth have optical characteristics of NPs are size dependent, and they feature a prominent UV–visible extinction band that is absent from the bulk metal's spectrum. This activation band is known as the localized surface plasma resonance and occurs when the higher photon frequency is constant with the overall excitation of the conduction electrons [28].

2.3.2. Mechanical Properties

Investigators can use NPs' unique mechanical characteristics to find new applications in a variety of domains, including tribology, surface engineering, nanofabrication, and nanomanufacturing. To determine the actual mechanical properties of NPs, many mechanical metrics like as elastic modulus, toughness, tensile stress, adherence, and resistance can be examined. Surface treatment, coagulation, and lubrication, in addition to these characteristics [29], help to improve the mechanical characteristics of NPs. In order to provide useful results in these sectors, a thorough understanding of the fundamentals of nanoparticle mechanical characteristics, such as elastic modulus and hardness, movement law, resistance, and interfacial bonding, as well as their size-dependent features, is required [30].

2.3.3. Magnetic Properties

Researchers in a range of sectors, includes heterogeneous and homogeneous catalysts, pharmacology, magnetic fluids, storage systems, magnetic resonance tomography, and pollution control, such as wastewater purification, are interested in magnetic nanoparticles. According to the research, NPs operate best when their size is between 10 and 20 nm [31].

2.3.4. Thermal Properties

A well-known characteristic is that nanoparticles have higher thermal efficiency than solutions in a steady condition. At room temperature, copper, for example, has a thermal property 700 percent larger than liquid and 3000 times higher than motor oil. Oxides, such as alumina, have a good thermal stability than water. As a conclusion, liquids with scattered granular particles are expected to have substantially greater thermal conductivities than ordinary heat exchanger solvents. Nano fluids are supposed to formerly improve the properties; heat transfer liquids and fluids containing particulate were utilized [32].

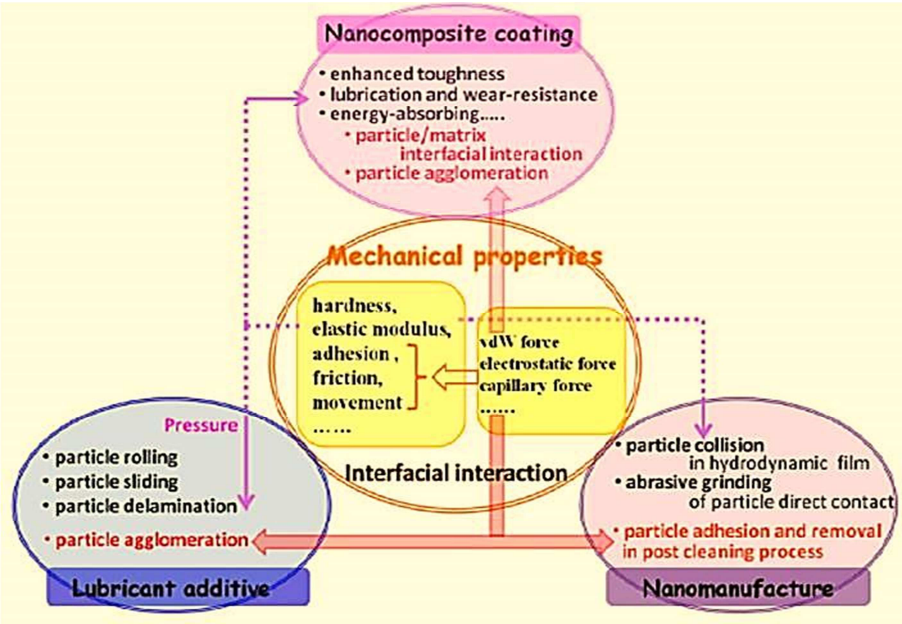

Figure 1. *Applications of Mechanical Properties.*

2.4. Techniques for Nanoparticle Synthesis

There are different synthesis methods for nanoparticles that are stable. The mutual existence and creation of nanoparticles is enhanced by its connection with organic molecules. It forms different dimensional mesostructures like 1D, 2D, and 3D [33].

The synthesis methods of nanoparticles are divided into two main kinds. They are top down and bottom up [34].

Basic Approaches for Nanoparticles

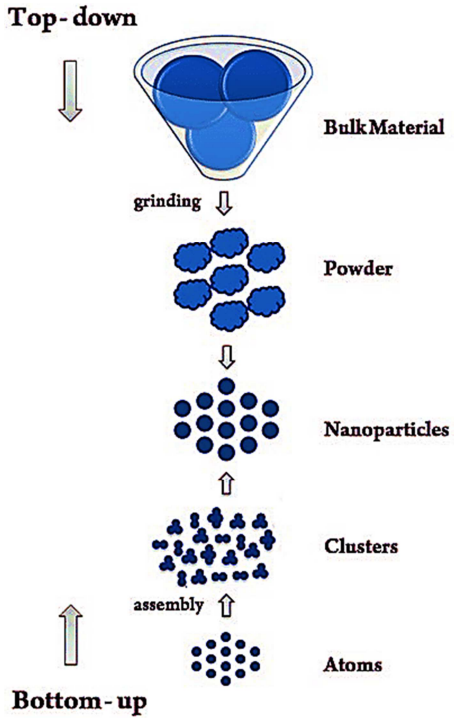

Figure 2. *Different methods to synthesize nanoparticles.*

2.4.1. Top Down Method

It is the breakdown of the bulk material into nanosize scale particles. It has different types like laser ablation, nanolithography, mechanical milling and thermal decomposition [35].

(i). Laser Ablation

It is the method to produce nanoparticles from solvents. There is an irradiation of a laser beam on a metal that is dipped in the liquid solution. This process produces nanoaprticles [36].

(ii). Mechanical Milling Method

It is mostly used method to produce nanoparticles. There is an inert atmosphere where different elements are milled and this method requires the post annealing of the nanoparticles [37].

(iii). Thermal Decomposition Method

It is an endothermic reaction in which heat causes chemical degradation. This heat breaks the chemical bonding in the molecule. The decomposing temperature can be defined as the rate at which a chemical reaction takes place. The nanoparticles are the result of meta breakdown at a certain temperature [38].

(iv). Sputtering

Sputtering is a phenomenon in which nanoparticles are deposited by ejecting electrons from it. The formation of a thin layer of nanoparticles is made much easier with annealing. Heating, film thickness, annealing time, and substrate all play a role in determining the size and shape of nanoparticles [39].

2.4.2. Bottom up Method

It is a constructive method that combines atoms to form

clusters and then to nanoparticles. It includes method like sol-gel, chemical vapor deposition, pyrolysis, and biosynthesis [40].

(i). Sol-Gel Method

It is preferred method because it is simple and majority of nanoparticles are synthesized from it. There is a precursor of a chemical solution that is for discrete particles. The precursors that are used are metal oxides and chlorides. There is shaking stirring and sonication of the precursor into the liquid solution that results in phase separation. It helps in recovering of nanoparticles by filtration, centrifugation and sedimentation and at last drying method is used [41].

(ii). Chemical Vapor Deposition

It is the method to deposit the thin film that is of gaseous reactant and it is deposited on a substrate. There is a reaction chamber that has medium temperature in which the deposition process occurs. There are gas molecules in that chamber that combines with the substrate and chemical reaction occurs. There is production of thin film on the substrate that is recovered later. The nanoparticles formed during CVD are hard, uniform and strong. The disadvantages of CVD include the toxicity of byproducts and the requirement for the equipment [42].

(iii). Pyrolysis

The most commonly employed approach for producing nanoparticles is pyrolysis. The precursor is heated and burnt in this technique. A solvent or a vapour could be used as a precursor. To generate nanoparticles, the precursor is placed in a high-pressure furnace. When an extreme heat is needed, a laser or plasma, rather than a blaze, may be used. The maximum temperature encourages evaporation [43].

2.4.3. Green Method

It is a biological synthesis that protects it from harmful features. It is carried out at low temperature, pressure and pH. It is lower of cost. There are different sources like fungi, bacteria, algae and plant extract. There is bottom up approach required in green synthesis method. In it the nanoparticles are produced due to oxidation and reduction method. There is secretion of biomolecules like proteins, sugars, carbohydrates and enzymes [44].

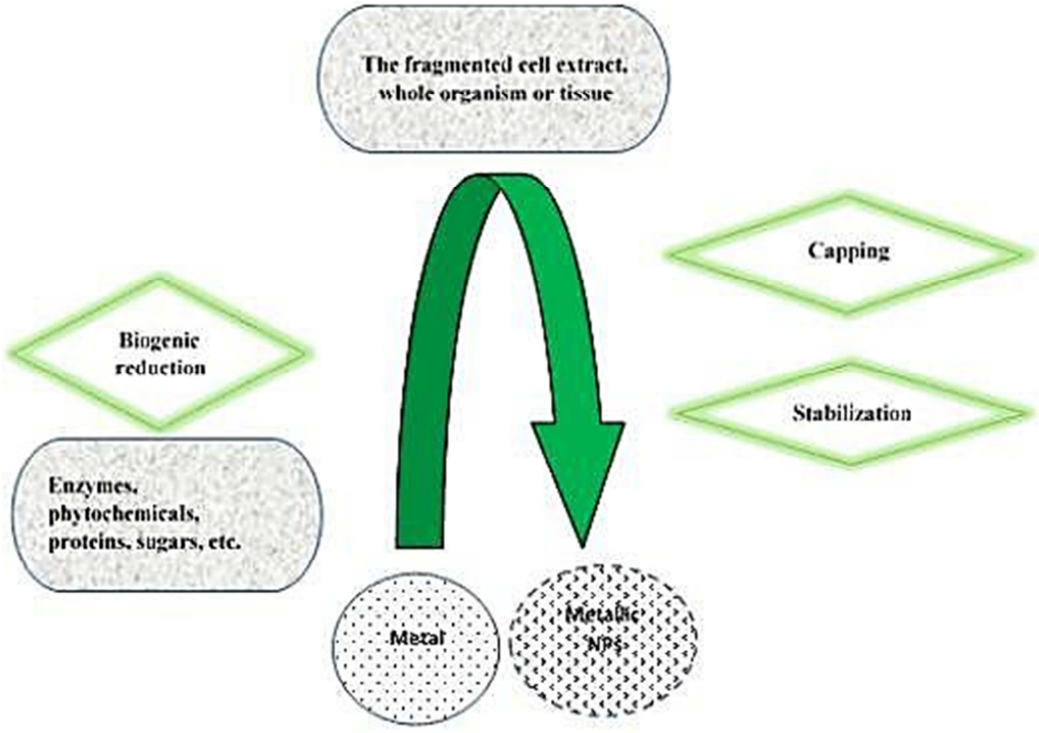

Figure 3. *Synthesis of Nanoparticles by Biological Method.*

(i). Green Synthesis by Plant Extracts

Numerous synthesized pathways have been used to make nanoparticles, with physical, chemical, and biosynthetic methods being the most common. Chemical procedures are generally excessively expensive and involve the use of dangerous and poisonous chemicals that pose a variety of environmental hazard. The biosynthetic pathway is a secure, biocompatible, and environmentally sustainable green method of synthesizing nanoparticles for medicinal applications utilizing plants and microbes. Fungi, algae, bacteria, and plants, among other things, can be used to carry out this process. Plant components like leaves, fruits, roots, stems, and seeds have been utilized to synthesize different nanoparticles owing to the existence of phytochemicals in their extract, which function as a stabilizing and reducing compound. There are various advantages of synthesizing nanoparticles by plant extracts. There is a single step required in this method. It is nonpathogenic and economic. It is cost

effective and eco-friendly and produces a large amount of metabolites [45].

(ii). Plant Role in Nanoparticle Green Synthesis

The widely approved ―green chemistry‖ approach is applicable to the nanoparticle synthesis for the production of clean and sustainable nanoparticles, which involves bacteria, fungi, plants, actinomycetes, and other organisms, and is referred to as green synthesis. Synthesizing nanoparticles employing the organisms mentioned above illustrates a green alternative for the creation of nanoparticles with novel features. Unicellular and multicellular organisms are acceptable in these syntheses to respond. Plants are considered as nature's industrial plants since they are low-cost and low-maintenance [46]. Because extremely little amounts of these heavy metals are harmful at quite small concentrations, plants have shown immense potential in heavy metal detoxification as well as storage, through which environmental pollution can be addressed. Biosynthesis of nanoparticles with plant extract has benefits over other biological synthesis methods, such as microorganisms, because it can be accomplished through complex operations such as keeping microbial colonies [47].

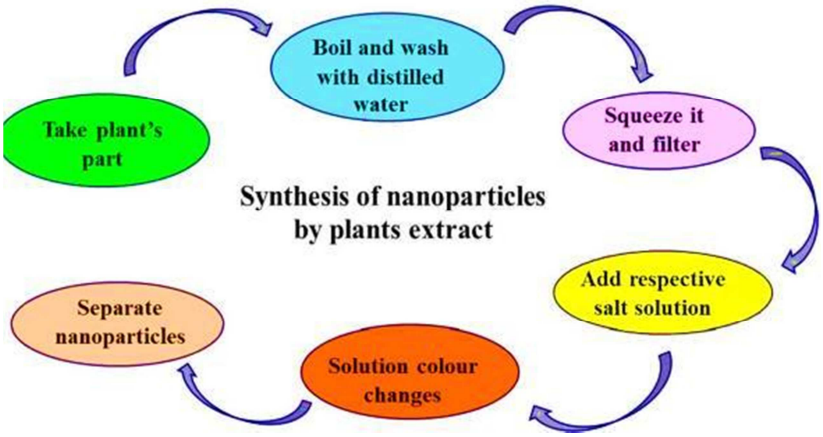

Figure 4. *Synthesis of nanoparticles by plant extract.*

2.5. Studies on Nanoparticle Green Synthesis

The biologically synthesized silver nanoparticles made from Clitoria ternatea and Solanum nigrum leaf extract were found to be effective against nosocomial infections, with Clitoria ternatea silver nanoparticles obtaining increased activity than Solanum nigrum silver nanoparticles. The antibacterial activity of the disc diffusion approach is well documented. The current study demonstrated a straightforward, quick, and cost-effective method for producing silver nanoparticles. Because of these uses, prepared nanoparticles can be employed as antibacterial and in healing process, water filtration, and healthcare [48].

Under reasonable circumstances, one-pot biogenic production of palladium and platinum nanoparticles from herbal extracts, algae, and fungi is possible. It is possible to produce and maintain a number of harmless nanoparticles with various shapes and structural patterns (spheres, rods, and rings). Varying the pH, temperature, incubation period, and quantities of plant extract and metal salts can all help to improve their performance. These biologically active nanoparticles can be used as nanocatalysts in environmental cleanup to remove dye from textile factories, as well as in Suzuki coupling reactions to produce a variety of organic substances [49].

Acorus calamus was used to successfully generate Barium ferrite nanoparticles. The magnetoplumbite structure is created without any contaminants, according to XRD results. Barium ferrite nanoparticles are between 32 and 35 nm. The hexagonal particles are clean and have a grain size distribution of 70 nm. The efficacy of Barium ferrite NPs against four phytopathogenic plant fungus was verified, including Fusarium oxysporum, Alternaria alternata, Colletotrichum gloeosporioides, and Marssonina rosae. The development of mycelium of harmful plant fungi was inhibited at all concentrations of Barium ferrite NPs.

Glycyrrhiza glabra extract was used as a controlling agent in the green production of Barium chromate nanoparticles with homogeneous size and shape. $BaCrO_4$ nanoparticles have the space group Pnma and are orthorhombic. This simple, room-temperature, solution-phase method could be helpful for the creation of intriguing superstructures of other inorganic materials, though it needs more research into the formation process of $BaCrO_4$ nanoparticles [50].

2.6. Factors That Affect the Nanoparticles Biological Synthesis

Different parameters, such as time of reaction, concentrations of reactant, temperature and pH can be used to alter the morphological properties of nanoparticles.

2.6.1. Effect of PH

The pH of a fluid has an impact on how environmentally friendly technologies create nanoparticles. The pH level affects the diameter and appearance of produced nanoparticles, according to researchers. As a result, changing

the pH of the solution media can affect nanoparticle size.

2.6.2. Effect of Temperature

It is another significant factor that influences nanoparticle production in all three approaches. The physical procedure necessitates the maximum temperature (>350°C), whereas chemical methods necessitate a lower temperature (below 350°C). Green technology nanoparticle production usually demands temperatures of less than 100°C or ambient temperature. The kind of nanoparticle generated is on the reaction temperature of the medium.

2.6.3. Effect of Pressure

The creation of nanoparticles necessitates the use of pressure. The diameter and shape of the synthesized nanoparticles are changed with the pressure applied to the reaction medium. The rates of metal ion reductions using natural compounds was proven to be significantly quicker at normal pressure [51].

2.6.4. Effect of Time

The time that reaction medium is incubated has a significant impact on the quality and kind of nanoparticles created utilizing green technology. Changes in time can occur in a variety of ways, including particle aggregation when there is storage of long term and they may shrink; they may have a shelf life, and so on, all of which affect their potential.

2.6.5. Effect of Pore Size

The permeability of nanoparticles generated has a considerable influence on the quality and use. Molecules have been fixed on nanoparticle, providing for delivery of drug and practical diagnostics

2.6.6. Effect of Environment

The kind of the manufactured nanoparticles is affected by the nearby environment. In many situations, a single nanoparticle quickly transforms into core-shell nanoparticles by absorbing components from the environment or reacting with other materials through oxidation or corrosion. In a biological process, the created nanoparticles acquire a coating, trying to make them denser and larger [52].

2.7. Introduction to Linum usitatissimum

Linum usitassimum, a blue flowered common herb in the Lineaceae family, produces flat seedlings that come in many different colors from golden yellow to reddish brown. It has a pleasing appearance and a nutty flavour. Linseed is another name for flaxseed, and the two names are interchangeable. Flaxseed is a term describing flax when it is taken into the body, whereas linseed is used to represent flax when it is utilized for industrial uses. India, China, the United States, and Ethiopia are all major flaxseed producers. India is the largest flaxseed producer in terms of area, responsible for 23.8 percent of the entire, and third in terms of quantity. It is producing 10.2 percent of the total supply. On commercial scale, every component of the linseed plant is utilized, either instantly or afterwards preparation. There is production of better quality fibres that has strength and is durable. *Linum usitatissimum* is getting popular as a food products in the global food system. It is defined as food or its ingredients that have the potential to give health benefits and supports in disease prevention [53].

2.7.1. Taxonomy

Linum usitatissimum is a tall, annual herb with corymbose branching over the stem. As comparison to the type of flax, which is fiber grown derived from the stem and is longer and has less branches, the linseed type, which is cultivated for the oil compounds production of the seed, is a comparatively plant that is short with many lateral branches. In light soils, *Linum usitatissimum* has a small root that is tap like with threadlike branches that can reach 90-120 cm. Simple, non-motile, linear- pointed with overall margins, and grown on stems and branches, fronds are small, sessile, linear-lanceolate with complete edges. The seed is brown to golden in appearance, elliptical, convex, 4-6 mm long, and has a clean, good appearance. Seeds have 35-45 percent oil content and a 20-25 percent protein content [54].

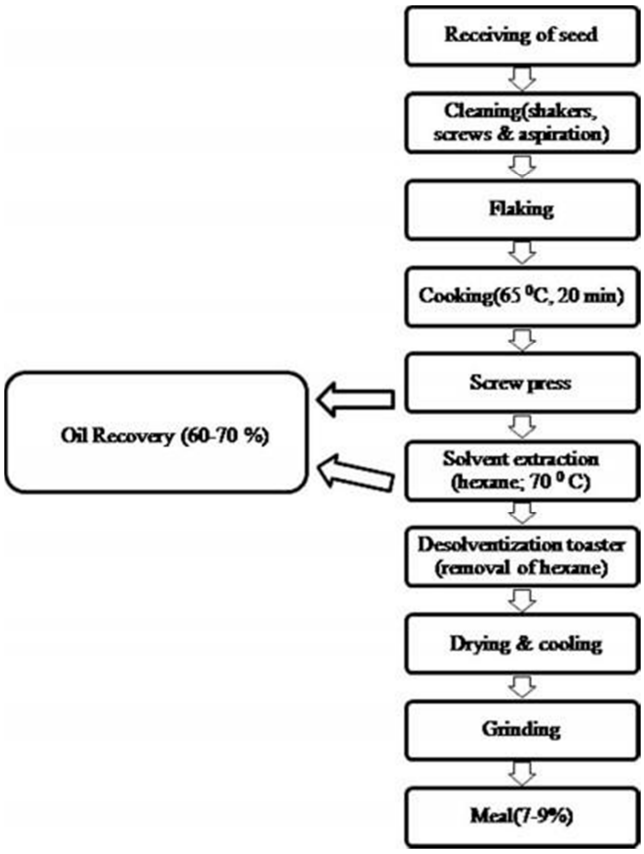

Figure 5. *Linum usitatissimum Preparation.*

2.7.2. Nutrients Composition of Linum Usitatissimum and Its Health Benefits

Linum usitatissimum is renowned for its high concentration of chemical constituents with unique biological activity and functional features, such as omega-3 polyunsaturated fatty acids, dissolved dietary fibres, lignans,

proteins, and carbs. It does, however, include a small amount of harmful health components such as Cadmium, protease inhibitors, and cyanogenic substances.

(i). Fatty Acids in Linum usitatissimum and Health Benefits

Lipids are of 53 percent in flaxseed (about thirty percent) are -linolenic acid, 17 percent linoleic acid, 19 percent oleic acid, three percent stearic acid, and five percent palmitic acid, resulting in an outstanding n-6: n-3 ratio of fatty acid around 0.3:1. Flaxseed omega-3 fatty acids are being studied to see if they can help prevent infectious diseases and treat illnesses like ulcers, chronic headaches, mental retardation, eating disorders, premature delivery, emphysema, psoriasis, glaucoma, Lyme disease, lupus, and anxiety disorders.

(ii). Linum usitatissimum Proteins and Health Benefits

Linum usitatissimum proteins, as all plants, have qualities which influence their conduct in a food system by interacting with different nutrients. For solubility and water oil retention capacity, these qualities are primarily reliant on their hydration processes. Flax protein has an amino acid sequence comparable to soybean protein, which is considered one of the most nutrient-dense foods. The protein content of flaxseed grain and flaxseed paste varies depending on hereditary and environmental factors. The enzyme needed to convert the decapeptide angiotensin I to the octapeptide angiotensin II, a vasoconstrictor hormone that causes blood pressure to rise, was blocked by flaxseed protein hydrolysate [55].

(iii). Dietary Fibers in Linum usitatissimum and Health Benefits

Fiber content ranges from 22 to 26 percent, more than double that of high fiber beans. Your daily fiber need is 20 percent to 25 percent are met by a dry whole flax seed that is half ounce in weight. *Linum usitatissimum* has a mixture of soluble and insoluble dietary fibres in a ratio of 20:80 to 40:60. The main insoluble fiber components are cellulose and lignin, while the soluble fiber portions are mucilage and cellulose. *Linum usitatissimum* dietary fibres were discovered to have a direct link to health, particularly in terms of body weight regulation via both hunger suppression and reduced nutritional absorption. With no effect on hunger, a flax dietary fiber extract rich in viscous dietary fibres dramatically enhanced fat excretion and decreased total and LDL-cholesterol.

(iv). Carbohydrates in Linum usitatissimum and Health Benefits

Flax has only 1 g of carbs (sugars and starches) per 100 grams. As a result, flax has a minor impact on overall carbohydrate consumption. It's only for persons who have specified diseases. The arabinoxylan is mostly made up of arabinose, xylose and galactose, whereas D-galactose, L-rhamnose, L-fucose acid and D-galacturonic acid makes rhamnogalacturonan,. There are substantial differences in monosaccharide composition, carbohydrate yield, and value between flaxseed accessions from throughout the globe.

(v). Linum usitatissimum Lignans and Health Benefits

Linum usitatissimum in general the main way of lignan precursors in the food. Bacteria that ordinarily populate the human intestine turn lignan precursors to enterolignans, enterodiol, and enterolactone. Secoisolariciresinol diglucoside is the primary lignan precursor identified in flaxseed. Lignans play an essential role in the protection of hormone-related malignancies, osteoporosis, and cardiovascular problems, and they are found in a variety of foods [56].

2.7.3. Phytochemical Analysis of Linum usitatissimum

The typical textual technique was followed to conduct preliminary phytochemical assays of diverse extracts.

2.7.4. Pharmacological Activities of Linum usitatissimum

Linum usitatissimum has been the subject of a number of researches in recent years, all of which it has a broad spectrum of pharmacological properties, according to research. The following are some of the significant pharmacological effects:

(i). Anticancer

It is a term used to describe a category of conditions characterized by uncontrolled tumor growth that has the ability to infiltrate or travel to other areas of the system. Malignant cysts, on the other hand, do not grow. A bump, unusual blood, a chest infection, decreased appetite, and an alteration in stool processes are all significant indications and concerns. While these signs and behaviors may suggest malignancy, they could also signal something else. People are affected by about 100 kinds of cancer [57].

(ii). Antidiabetic

Diabetes Mellitus is a disorder of metabolism illustrated by high blood sugar due to fault in insulin action, insulin secretion, or both. The persistent high sugar of diabetes leads to malfunction of special organs of body, particularly the nerves, kidneys, blood vessels, eyes and heart. Diabetes Mellitus is a heterogenous syndrome. It is classified into four types. It is classified due to clinical presentation and cytology of the disease. The diagnosis of this type of diabetes is associated with accidentally through a urine glucose test and an abnormal blood. This type of diabetes takes place subsequent to the age of 40 years. Gestational diabetes occurs about the carbohydrate intolerance during pregnancy.

The effects of ethanolic extracts of flaxseed on reactive hypoglycemia oxygen reacting species formation in peripheral blood mononuclear cells and pancreatic cells, as well as pancreatic antioxidant, were investigated in alloxan-induced rats treated. In both acute and subacute studies, the serum glucose level was dramatically lowered [58].

(iii). Antimicrobial

An antimicrobial is a substance that suppresses the activity of bacteria. Anti - microbial drugs are classified by the bacteria over which they are most effective. Antibiotic and

antifungals are utilized to treat microbes and fungi, respectively. They can also be categorized based on their activity. Microbicides are those that destroy microorganisms, while bactericidal treatments are those that simply restrict their development.

The antibacterial effect of ethanol and chloroform extracts of flaxseeds against five pathogens, including Enterococcus, Salmonella typhii, Bacillus subtilis, Staphylococcus aureus, and Escherichia coli, was tested in an experiment conducted. The results show that extract of chloroform is more efficient against bacteria than extract of ethanol. Antimicrobial activity was shown in chloroform extracts against all five bacteria. Despite the fact that ethanol extract has no antibacterial action against Escherichia coli [59].

(iv). Anti-Ulcer

An ulcer is a rupture or irregularity in a skin barrier that prevents the damaged area from functioning normally. It is a rupture in the integrity of dermis, epithelial, or mucosal layer created by peeling off of inflammatory dead cells, related to biology.

Linum usitatissimum oil and mucilage were discovered to have strong preventive action against ethanol-induced stomach ulcers in a study. The researchers discovered that pre-treating rats with flaxseed oil and flaxseed mucilage lowered the frequency and duration of stomach ulcers caused by ethanol [60].

3. Conclusion

Linum usitatissimum was used as a reducing agent in the biological production of barium oxide nanoparticles, according to the study findings. Because of *Linum usitatissimum* antioxidant, anti- inflammatory, and anti-diabetic capabilities, barium nanoparticles made from it have improved pharmacological effects. Because of their low cost, low toxicity, and high magnetic properties, these nanoparticles can be employed in biomedical applications. However, the synthesizing methodology adopted is both environmentally friendly and cost effective. As a result, employing biological material to synthesize barium oxide nanoparticles shows to be advantageous in the production of nanoparticles.

References

[1] Adachi, M., Tsukui, S., & Okuyama, K. (2003). Nanoparticle synthesis by ionizing source gas in chemical vapor deposition. *Japanese journal of applied physics, 42* (1A), L77.

[2] Adlercreutz, H. (2007). Lignans and human health. *Critical reviews in clinical laboratory sciences, 44* (5-6), 483-525.

[3] Ahab, A., Rohman, F., Iskandar, F., Haryanto, F., & Arif, I. (2016). A simple straightforward thermal decomposition synthesis of PEG-covered Gd_2O_3 (Gd_2O_3@ PEG) nanoparticles. *Advanced Powder Technology, 27* (4), 1800-1805.

[4] Ahn, E.-Y., Jin, H., & Park, Y. (2019). Assessing the antioxidant, cytotoxic, apoptotic and wound healing properties of silver nanoparticles green-synthesized by plant extracts. *Materials Science and Engineering: C, 101*, 204-216.

[5] Al-Okbi, S. Y. (2005). Highlights on functional foods, with special reference to flaxseed. *Journal of Natural Fibers, 2* (3), 63-68.

[6] Amendola, V., & Meneghetti, M. (2009). Laser ablation synthesis in solution and size manipulation of noble metal nanoparticles. *Physical chemistry chemical physics, 11* (20), 3805-3821.

[7] Amin, T., & Thakur, M. (2014). A comparative study on proximate composition, phytochemical screening, antioxidant and antimicrobial activities of Linum usitatisimum L. (flaxseeds). *Int. J. Curr. Microbiol. App. Sci, 3* (4), 465-481.

[8] Ansari, M. A., & Jahan, N. (2021). Structural and Optical Properties of BaO Nanoparticles Synthesized by Facile Co-precipitation Method. *Materials Highlights, 2* (1-2), 23-28.

[9] Baer, D. R. (2011). Surface Characterization of Nanoparticles: critical needs and significant challenges. *J of Surface Anal, 17*, 163-169.

[10] Beach, E. S., Cui, Z., & Anastas, P. T. (2009). Green Chemistry: A design framework for sustainability. *Energy & Environmental Science, 2* (10), 1038-1049.

[11] Chen, X., & Schluesener, H. J. (2008). Nanosilver: a nanoproduct in medical application. *Toxicology letters, 176* (1), 1-12.

[12] Chung, M., Lei, B., & Li-Chan, E. (2005). Isolation and structural characterization of the major protein fraction from NorMan flaxseed (*Linum usitatissimum* L.). *Food chemistry, 90* (1-2), 271-279.

[13] Colomban, P., & Gouadec, G. (2005). The ideal ceramic fiber/oxide matrix composite: How to conciliate antagonist physical and chemical requirements. *Ann. Chim. Sci. Matériaux, 30*, 673-688.

[14] D'Amato, R., Falconieri, M., Gagliardi, S., Popovici, E., Serra, E., Terranova, G., & Borsella, E. (2013). Synthesis of ceramic nanoparticles by laser pyrolysis: From research to applications. *Journal of analytical and applied pyrolysis, 104*, 461-469.

[15] Dugani, A., Auzzi, A., Naas, F., & Megwez, S. (2008). Effects of the oil and mucilage from flaxseed (*linum usitatissimum*) on gastric lesions induced by ethanol in rats. *Libyan Journal of Medicine, 3* (4), 1-5.

[16] Eustis, S., & El-Sayed, M. A. (2006). Why gold nanoparticles are more precious than pretty gold: noble metal surface plasmon resonance and its enhancement of the radiative and nonradiative properties of nanocrystals of different shapes. *Chemical Society Reviews, 35* (3), 209-217.

[17] Ghule, A. E., Jadhav, S. S., & Bodhankar, S. L. (2012). Effect of ethanolic extract of seeds of *Linum usitatissimum* (Linn.) in hyperglycaemia associated ROS production in PBMNCs and pancreatic tissue of alloxan induced diabetic rats. *Asian Pacific Journal of Tropical Disease, 2* (5), 405-410.

[18] Gnanasangeetha, D., & SaralaThambavani, D. (2013). One pot synthesis of zinc oxide nanoparticles via chemical and green method. *Res J Mater Sci, 2320*, 6055.

[19] Grigsby, L. L. (2007). *Electric power generation, transmission, and distribution*: CRC press.

[20] Guo, D., Xie, G., & Luo, J. (2013). Mechanical properties of nanoparticles: basics and applications. *Journal of physics D: applied physics, 47* (1), 013001.

[21] Sarfraz, S., Javed, A., Mughal, S. S., Bashir, M., Rehman, A., Parveen, S.,... & Khan, M. K. (2020). Copper Oxide Nanoparticles: Reactive Oxygen Species Generation and Biomedical Applications. *Int. J. Comput. Theor. Chem*, *8*, 40-46.

[22] Rafique, S., Hassan, S. M., Mughal, S. S., Hassan, S. K., Shabbir, N., Perveiz, S.,... & Farman, M. (2020). Biological attributes of lemon: a review. *Journal of Addiction Medicine and Therapeutic Science*, *6* (1), 030-034.

[23] Hanif, M. A., Hassan, S. M., Mughal, S. S., Rehman, A., Hassan, S. K., Ibrahim, A., & Hassan, H. (2021). An overview on ajwain (Trachyspermum Ammi) pharmacological effects: current and conventional. *Technology*, *5* (1), 1-6.

[24] Khalid, Z., Hassan, S. M., Mughal, S. S., Hassan, S. K., & Hassan, H. (2021). Phenolic Profile and Biological Properties of Momordica charantia'. *Chemical and Biomolecular Engineering*, *6* (1), 17.

[25] Hassan, S. M., Mughal, S. S., Hassan, S. K., Ibrahim, A., Hassan, H., Shabbir, N.,... & Shafiq, S. (2020). Cellular interactions, metabolism, assessment and control of aflatoxins: an update. *Comput Biol Bioinform*, *8*, 62-71.

[26] Khattak, A. K., Syeda, M. H., & Shahzad, S. M. (2020). General overview of phytochemistry and pharmacological potential of Rheum palmatum (Chinese rhubarb). *Innovare Journal of Ayurvedic Sciences*, *8* (6), 1-5.

[27] Latif, M. J., Hassan, S. M., Mughal, S. S., Aslam, A., Munir, M., Shabbir, N.,... & Perveiz, S. (2020). Therapeutic potential of Azadirachta indica (neem) and their active phytoconstituents against diseases prevention. *J. Chem Cheml Sci.*, *10* (3), 98-110.

[28] Khalid, Z., Hassan, S., Shahzad, S., & Khurram, H. (2021). A review on biological attributes of Momordica charantia. *Adv Biosci Bioeng*, *9* (1), 8-12.

[29] Hafeez, M., Hassan, S. M., Mughal, S. S., Munir, M., & Khan, M. K. (2020). Antioxidant, Antimicrobial and Cytotoxic Potential of Abelmoschus esculentus. *Chemical and Biomolecular Engineering*, *5* (4), 69.

[30] Afzal, N., Hassan, S. M., Mughal, S. S., Pando, A., & Rafiq, A. (2022). Control of Aflatoxins in Poultry Feed by Using Yeast. *American Journal of Chemical and Biochemical Engineering*, *6* (1), 21-26.

[31] Shabbir, N., Hassan, S. M., Mughal, S. S., Pando, A., & Rafiq, A. (2022). Eletteria cardamomum and Greenly Synthesized MgO NPs: A Detailed Review of Their Properties and Applications. *Engineering Science*, *7* (1), 15-22.

[32] Mubeen, N., Hassan, S. M., & Mughal, S. S. (2020). A Biological Approach to Control Aflatoxins by Moringa Oleifera. *International Journal of Bioorganic Chemistry*, *5* (2), 21.

[33] Mubeen, N., Hassan, S. M., Mughal, S. S., Hassan, S. K., Ibrahim, A., Hassan, H., & Mushtaq, M. (2020). Vitality and Implication of Natural Products from Moringa oleifera: An Eco-Friendly Approach. *Computational Biology and Bioinformatics*, *8* (2), 72.

[34] Aslam, A., Hassan, S. M., Mughal, S. S., Hassan, S. K., Ibrahim, A., Hassan, H.,... & Shafiq, S. (2020). Comprehensive Review of Structural Components of Salvia hispanica & Its Biological Applications. *International Journal of Biochemistry, Biophysics & Molecular Biology*, *5* (1), 1.

[35] Mughal, S. S., & Hassan, S. M. (2022). Comparative Study of AgO Nanoparticles Synthesize Via Biological, Chemical and Physical Methods: A Review. *American Journal of Materials Synthesis and Processing*, *7* (2), 15-28.

[36] Rafique, S., Hassan, S. M., Mughal, S. S., & Afzal, N. (2020). Asma Shafi 2, Sehrish Kamran 3 Department of Chemistry, Lahore Garrison University, Lahore, Punjab, Pakistan 2 Deparment of polymer, Punjab University Lahore, Pakistan 3 Department of Allied sciences, FMH College of medicine and dentistry. *GSJ*, *8* (9).

[37] Abbas, F., Tahir, M. U., Farman, M., Mumtaz, M., Aslam, M. R., Mughal, S. S.,... & Khan, A. R. Synthesis and Characterization of Silver Nanoparticles Against Two Stored Commodity Insect Pests.

[38] Aslam, A., Hassan, S. M., Mughal, S. S., Perveiz, S., Mushtaq, M., Munir, M.,... & Ayub, A. R. Investigation of Biological Activity of Salvia hispanica.

[39] Tahir, M. U., Abbas, F., Tahira, M., Shahzad, H. M., Sharif, S., Raza, A.,... & Ziad, M. SYNTHESIS OF MANGANESE-TIN BIMETALLIC MATERIALS AND STUDY OF ITS CATALYTIC APPLICATIONS.

[40] ul Mustafa, Z., ullah Khan, A., Mudasar, A. S., & Mughal, S. S. Edge Functionalization of Phosphorene with different Chemical Functional Groups.

[41] Muneer, M., Mughal, S. S., Pervez, S., Mushtaq, M., Shabbir, N., Aslam, A.,... & Abbas, F. DIAGNOSIS AND TREATMENT OF DISEASES BY USING METALLIC NANOPARTICLES-A REVIEW.

[42] Mughal, S., Abbas, F., Tahir, M., Ayub, A., Javed, H., Mamtaz, M., & Iram, H. (2019). Role of Silver Nanoparticles in Colorimetric Detection of Biomolecules. doi: 10.7537/marsbnj050419.04.

[43] Perveiz, S., Hassan, S. M., Mughal, S. S., Pando, A., Rafiq, A., & Shabbir, N. Structural, Morphological and Biotoxicity Studies of Biosynthesized CaO Nanoparticles Via Cuminum Cyminum.

[44] SHABBIR, N., HASSAN, S. M., MUGHAL, S. S., PERVEIZ, S., MUNIR, M., MUSHTAQ, M., & KHAN, M. K. PEPPERMINT OIL, ITS USEFUL, AND ADVERSE EFFECTS ON HUMAN HEALTH: A REVIEW.

[45] Perveiz, S., Hassan, S. M., Mughal, S. S., Ullah, H., Shabbir, N., Munir, M.,... & Farman, M. A Review on Heavy metal contamination in water and the Strategies for the Reduction of Pollution Load of Commercial and Industrial Areas of Pakistan.

[46] Hafeez, M., Hassan, S. M., Mughal, S. S., & Mushtaq, M. Evaluation of Biological Characteristics of Abelmoschus esculentus.

[47] Hassan, S. M., Mubeen, N., Hassan, S. K., Ibrahim, A., Hassan, H., Mughal, S. S.,... & Haider, G. MORINGA Oleifera, A MULTIFUNCTIONAL PLANT: A REVIEW STUDY.

[48] Gupta, D., Mann, S., Sood, A., & Gupta, R. K. (2011). Phytochemical, nutritional and antioxidant activity evaluation of seeds of jackfruit (Artocarpus heterophyllus Lam.). *International Journal of Pharma and Bio Sciences, 2* (4), 336-345.

[49] Harper, C. R., Edwards, M. J., DeFilipis, A. P., & Jacobson, T. A. (2006). Flaxseed oil increases the plasma concentrations of cardioprotective (n-3) fatty acids in humans. *The Journal of nutrition, 136* (1), 83-87.

[50] Ho, C. H., Cacace, J. E., & Mazza, G. (2007). Extraction of lignans, proteins and carbohydrates from flaxseed meal with pressurized low polarity water. *LWT-Food Science and Technology, 40* (9), 1637-1647.

[51] Ho, V. A., Le, P. T., Nguyen, T. P., Nguyen, C. K., Nguyen, V. T., & Tran, N. Q. (2015). Silver core-shell nanoclusters exhibiting strong growth inhibition of plant-pathogenic fungi. *Journal of Nanomaterials, 2015*.

[52] Hodoroaba, V. D., Rades, S., & Unger, W. E. (2014). Inspection of morphology and elemental imaging of single nanoparticles by high-resolution SEM/EDX in transmission mode. *Surface and interface analysis, 46* (10-11), 945-948.

[53] Lee, S., Choi, S.-S., Li, S., and, & Eastman, J. (1999). Measuring thermal conductivity of fluids containing oxide nanoparticles.

[54] Leonhardt, U. (2007). Invisibility cup. *Nature photonics, 1* (4), 207-208.

[55] Lugscheider, E., Bärwulf, S., Barimani, C., Riester, M., & Hilgers, H. (1998). Magnetron-sputtered hard material coatings on thermoplastic polymers for clean room applications. *Surface and Coatings Technology, 108*, 398-402.

[56] Lynch, I., Cedervall, T., Lundqvist, M., Cabaleiro-Lago, C., Linse, S., & Dawson, K. A. (2007). The nanoparticle–protein complex as a biological entity; a complex fluids and surface science challenge for the 21st century. *Advances in colloid and interface science, 134*, 167-174.

[57] Marambe, P., Shand, P., & Wanasundara, J. (2008). An in-vitro investigation of selected biological activities of hydrolysed flaxseed (*Linum usitatissimum* L.) proteins. *Journal of the American Oil Chemists' Society, 85* (12), 1155-1164.

[58] Mohanpuria, P., Rana, N. K., & Yadav, S. K. (2008). Biosynthesis of nanoparticles: technological concepts and future applications. *Journal of nanoparticle research, 10* (3), 507-517.

[59] Nazrul, M. (2017). On-Farm Verification of Linseed and Sesame Variety for Fallow-Fallow-T Aman Rice Cropping System in Sylhet Region of Bangladesh. *Bangladesh Agronomy Journal, 20* (1), 7-12.

[60] Oberdörster, G., Maynard, A., Donaldson, K., Castranova, V., Fitzpatrick, J., Ausman, K., Carter, J., Karn, B., Kreyling, W., & Lai, D. (2005). Principles for characterizing the potential human health effects from exposure to nanomaterials: elements of a screening strategy. *Particle and fibre toxicology, 2* (1), 1-35.