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AN ERA OF GREEN SYNTHESIZED NANOPARTICLES FOR DIABETES TREATMENT: A REVIEW

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ABSTRACT

Diabetes mellitus is one of the most common metabolic diseases. The total of 1.5% of the world population suffers from diabetes mellitus. It is rated as one of the most common non-communicable disease globally. Diabetes covers a wide range of heterogenous diseases. Mainly antidiabeteic drugs are used to save life and all the symptoms of disease. The main aim is to prevent the long term diabetic complications. Oral hypoglycemic agents are also used in treatment of diabetes. But sometime, these agents causes many side effects like weight gain, hypoglycemia, gastrointestinal disorders etc. So the need of hour is to prepare some agents or drugs which do not cause any ill effects on human health and also environment friendly. Use of medicinal plants is now a days a new effective method for treating various diaseases. Medicinal plants have a great impact on the health of individuals and communities. Metal compounds in plants play a vital role in living systems and has the potential in controlling pathogenesis and complications of disease. The development of eco-friendly methods for diabetes treatment using nanotechnology is an important and emerging area . Green synthesis of nanoparticles is a cost-effective, safe, non-toxic and eco-friendly process. The present review highlights the potential of plant derived nanoparticles for diabetes treatment. This approach improves the diagnosis, solubility, sustained delivery and protection from physical and chemical degradation. It also contributes to the rising cost of health care. Further clinical trials are needed for proving the therapeutic potential of nanoparticles to check the adverse effects.

Keywords: Diabetes; nanoparticles; green synthesis and eco-friendly

INTRODUCTION

This review highlights the treatment of diabetes. Diabetes mellitus is a metabolic disease which, when not properly cured, causes hyperglycemia and many disorders of carbohydrate, protein and lipid metabolism. This disease is associated with many micro-vascular ramifications like insulin deficiency in diabetes [1]. Deficiency of insulin in the body due to the decline in the activity of ß-cell is the most common symptoms of diabetes. This creates an imbalance between the demand of insulin and supply of insulin in body [2]. If effective strategies for the prevention of diabetes are not implemented, the total number of individuals suffering globally from diabetesis estimated to increase from 171 million to 366 million in 2030 [3]. A variety of approaches are being devised for the treatment and cure of diabetes but each of them has some significant limitations and side effects. When exploring new strategies for the prevention of diabetes, one possibility is the use of nanotechnology. The application of nanotechnology is the plant active compounds and their extracts to enhance stability, sustained delivery and pharmacological activity [4]. Synthesis of nanoparticles from plants and their extracts have been suggested as a valuable alternative to chemical synthesis method [5]. Green synthesis of nanoparticles is an easy, efficient and eco-friendly approach. The application of nanotechnology to the plants could be more advantageous because it do not require any elaborative method like intracellular synthesis and many purification steps or maintenance of the cell culture [6]. Many plants and their parts have been successfully used for the extracellular synthesis of metal nanoparticles.

DIABETES

Diabetes mellitus is a metabolic disease which, when not properly treated or untreated is characterized by chronic hyperglycemia and disordered carbohydrate, lipid and protein metabolism. It is associated with the development of specific microvascular complications and of non-specific macrovascular disease [1]. There is a great relationship between pancreas and diabetes. Pancreatic cells contain beta cells, which produces insulin to check the supply and use of glucose in our body. These cells play a vital role in the glycemic homeostasis. Diabetes is a progressive condition shown by insulin resistance, where muscle and adipose tissue become insensitive to the effects of insulin. There is a decline in beta cell activity results in relative insulin deficiency and as a result blood glucose levels rise above normal

[7]. It is a systemic disease caused by an imbalance between insulin supply and insulin demand in the body by pancreas. There are three main categories of diabetes mainly:

1. Primary diabetes
2. Secondary diabetes
3. Gestational diabetes

Primary diabetes is of two types: Type1 and Type 2. Type 1 is caused by the destruction of insulin producing pancreatic beta cells or may be due to decrease in beta cell number. Type 2 is mainly due to the resistance to insulin. Pancreas secrete more insulin but beta cells fail to sustain this [8]. Secondary diabetes is due to genetic defects of beta cell function, insulin action, malfunctioning in exocrine pancreas. Gestational diabetes develops during pregnancy. The different causes of all type of diabetes are genetic factors, immunologic factors, environmental factors and infectious agents. Age, obesity, stress, depression etc are the main causes of Type 2 diabetes. In every ten and thirty seconds it causes a death and an amputation respectively.

NANOTECHNOLOGY AND DIABETES

Despite oral administration of anti-diabetic drugs and injections of insulin, phytotherapy and nanotechnology (metal based phytomedicines) play an important role in the management of diabetes mellitus. Herbal plants are recognized as a source of lead compounds since they are measured as time tested and safer for both, human and ecosystem. Nanotechnology is an important field of modern research dealing with synthesis and manipulation of nanoparticles. A nanoparticle is used to describe a particle size within the range of 1nm- 100nm. Nanotechnology is the science that usually deals with the size range from a few nanometers (nm) to several hundred nm, depending on their intended use [9]. It has been the area of interest over the last decade for developing precise drug delivery systems as it offers numerous benefits to overcome the limitations of conventional formulations [10,11]. It is very promising both in diabetes diagnosis and treatment since it can enter the tissues at molecular level. Nanotechnology is being enthusiastically evaluated and implemented in diabetes treatment indicating a major advance in detection, diagnosis, and treatment of the disease

Many of the metal compounds play a role in living systems and these have to be found to potential effect in the pathogenesis and complications of the disesase. We know metal in its oxidizing state provides a variety of properties. A metal looses electrons easily to form positively charged ions and they seem to be soluble in biological fluids.

Metals ions are electron deficient and most of the biological fluids are electron rich. The attraction of oppositely charged molecules leads to tendency for metal ions to bind to and interact with biological material and elicit pharmacological activity [12].

Mainly transitional metals are working with proper functioning of enzymes [13]. Diabetes causes alterations in the number of trace elements in the body and thus the essential trace elements like zinc, chromium and manganese are found deficient in case of diabetes. Trace elements play a role in glucose and lipid metabolism [14].

METAL OXIDE NANOPARTICLES IN DIABETES TREATMENT

Metals like silver, gold, iron, zinc and copper have been routinely used for the synthesis of nanoparticles. Nanoparticles have received much attention recently due to their use in diabetes management. Metal based drugs to treat diabetes with metal complex are being reported. Zinc chloride stimulates lipogenesis in rat adipocytes similarly to the action of insulin [15]. The main idea of using the metals in diabetes treatment was first reported in 1899. There are so many metal and metal complexes been synthesized to overcome the problems of painful insulin injections.

Metal nanoparticles are usually synthesized using various chemical methods such as chemical reduction, solvo-thermal reduction, electrochemical techniques [16,17] and photochemical reaction in reverse micelles [18]. Among them, chemical reduction is the most frequently applied

method. Previous studies showed that the use of a chemical reducing agent resulted in generation

of larger particles and consumes more energy. It was also reported that more by-products were formed by chemical approaches which are not eco-friendly. Moreover, the chemically synthesized nanoparticles were reported to show less stability and more agglomeration [19]. Biological methods of nanoparticles synthesis using microorganisms, enzymes, and plant or plant extract have been suggested as possible ecofriendly alternatives to chemical and physical methods [20]. Hence there is a need to develop an eco-friendly protocol that could produce stable and dispersible nanoparticles of controllable size by consuming less energy.

GREEN SYNTHESIS OF NANOPARTICLES

Indian greeneries are the chief and cheap source of medicinal plants and plant products. From centuries till date, these

medicinal plants have been extensively utilized in Ayurveda. Recently, many such plants have been gaining importance due to their unique constituents and their versatile applicability in various developing fields of research and development [21]. Today synthesis of nanoparticles by ecofriendly processes are becoming more popular among the researchers due to its low cost, synthesis in ambient atmosphere, non-toxicity etc and mainly easy application of these synthesized nanoiparticles. These nanoparticles are higly soluble in water, biocompatible and devoid of any toxic substances.Environmentally friendly synthesis based methods are becoming more and more popular in chemistry and chemical technologies. This trend has several origins, including the need for greener methods counteracting the higher costs and higher energy requirements of physical and chemical processes. For this reason, scientists are searching for cheaper methods of synthesis.

The other reason is that conventional methods for nanoparticle synthesis usually require harmful reductants such as sodium borohydride or hydrazine and many steps in the synthesis procedure including heat treatments, often producing hazardous by-products. In order to reduce the environmental impact of nanoparticle synthesis, greener routes have been investigated for over a decade The principles of green chemistry were presented by Anastas and Warner who developed 12 principles that eloquently describe green chemistry [22]. Green chemistry should aim at thwarting waste, minimizing energy use, employing renewable materials, and applying methods that minimize risk. The three main concepts for the preparation of nanoparticles in a green synthesis approach are the choice of the solvent medium (preferably water), an environmentally friendly reducing agent, and a nontoxic material for the stabilization of the nanoparticles [23]. Many approaches were investigated, and microorganisms such as bacteria, yeasts, fungi, and algae were used in the biosynthesis of metal nanoparticles. More recently, the utilization of plants for the production of nanobiotechnology is presently one of the most dynamic disciplines of research in contemporary material science whereby plants and different plant products are finding an imperative use in the synthesis of nanoparticles (NPs) [24]. One of the first approaches of using plants as a source for the synthesis of metallic nanoparticles was with alfalfa sprouts [22], which was the first report on the formation of silver nanoparticles (AgNPs) using a living plant system. Most of the NPs synthesized via

green synthesis are investigated for investigated for biomedicine and more particularly as antibacterial agent.

PLANT BASED NANOPARTICLES

The role of nanoparticles as an antidiabetic agents opens a door of new era of medicines which is safe and less toxic to environment. It is environmental and biosynthetic friendly technology for the synthesis of nanoparticles. Zinc oxide nanoparticles have emerged as novel antimicrobial agents owing to the high surface area to volume ratio. In the recent year, a lot of work has been carried out for microbial resistance against metal ions, antibiotic development of resistant strains. New application of zinc oxide nanoparticles is the recent growth in the field of porous and nanometric materials prepared by non-conventional processes. Zinc oxide nanoparticles act as a semiconductor material due to its application on solar cells, ceramics, catalysts, cosmetic, gas sensors and varistors. The precipitation method was used followed by controlled freezing drying processes and material obtained were thermally treated at various temperature. The influence of temperature or textural, morphological and structural properties of the material studies by the powder SEM, TEM, Thermal analysis .Zinc is an essential trace element, is known to be activator of hundred of enzymes in our body [25]. It plays a role in glucose metabolism. Zinc and diabetes interacts in our body so many times during the metabolism in a cell. It is known to be present in insulin. It is coordinated by three nitrogen atoms from histidines and three water molecules .it is known to keep the structure of insulin [26]. It plays a role in insulin biosynthesis, storage and secretion. This element promotes the hepatic glycogeneis and improves the glucose utilization. Higher intake of zinc is associated with the slightly lower risks of type 2 diabetes in women's [27]. Silver is a metal which is hihly participitate in all metabolic processes. Silver is found to have a disinfectant and also found to applications in traditional medicines to culinary items. This is reported that silver is non toxic for humans and most efficient against harmful organisms even at low concentrations without any side effects [28]. Some of the salts and derivatives of silver also showed the antimicrobial property. Silver is found to be as an antimicrobial agents and in treatments' of many diseases [29].

CONCLUSION

This review encompasses the various treatments of diabetes with nanoparticles and the effectiveness of nanoparticles acting as an excellent antidiabeteic tool. Diabetes is a

leading cause of death and it claims the lives of approximately seven million people worldwide. The research on plant assisted synthesis of nanoparticles is an emerging area in the field of nanotechnology. They can be easily synthesized by biological methods without much need of sophistication. This method is completely safe, economically viable, easy to scale up, less time consuming and environmental friendly. Thus it deserves urgent attention so that biogenically green synthesized nanoparticles will result in a significant payoff in the field of bionanomedicine. Use of plants for the production of nanoparticles has drawn concentration of researchers because of its rapid and effective, economical, eco-friendly protocol and also itprovides a single step technique for the biosynthesis process [30]. With this new era,diabetes treatment and management could bring become an easy task. There will be no need for insulin injections and other treatments. Also it will be cost effective and efficient treatment method fpr diabtetes treatment.

FUTURE PROSPECTS

However, further investigations using animal studies and clinical trials are needed for proving the diabetes with drug and therapeutic potential of nanoparticles in treating diabetes and to check the adverse effects. There is still need for further optimization and characterization of nanaoparticles and to elucidate the molecular mechanism involved in cell production of insulin for full understanding of their whole potential, thereby permitting the employment of synthesized nanoparticles as diabeteic therapeutic agents

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