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Encapsulation of herbal extract in polymeric beads: A Novel strategy for Antidiabetic Activity

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Abstract

The study aimed for an approach in screening bioactive compounds from botanical drug. The herbal remedies for diabetes treatment are an area of research with a huge potential for the progress in the growth of inexpensive alternative medicine with low or no side effects. This study explores the formulation & evaluation of a novel herbal medicine with a specific emphasis on its anti-diabetic activity. Diabetes is a metabolic pathology with chronic high blood glucose levels that occurs when the pancreas does not produce enough insulin or the body does not properly use the insulin it produces. Therefore, this review aimed to formulate a herbal-based product, Gurmar leaf and Garlic extract, into beads that swell in water and that can be administered orally. Hence, Antidiabetic beads are helpful in improving the high blood glucose level.

Keywords: Diabetes Mellitus, Anti-diabetic activity, Anti-diabetic beads, Botanical drug, Administered orally.

1. Introduction

Diabetes Mellitus (DM):

A chronic condition known as diabetes mellitus (DM) has been brought on by excessive blood glucose, or blood sugar. Your body needs glucose as its primary energy source. Whereas glucose is a substance that your body can produce, it also comes from the food you eat. Increased bile acid absorption and an enlargement of the bile acid pool are two characteristics of diabetes mellitus, a disorder caused by an insulin imbalance. Hypercholesterolemia and dyslipidemia can result from diabetes mellitus. Diabetes mellitus is a condition that is controlled with antidiabetic medications. Drugs or substances classified as "antidiabetic" are those that are used to treat diabetes mellitus. (1)

DM is classified different categories based on etiology of the disease.

- Type I
- Type II

Type I- It occurs in patient with little or no insulin secretory capacity. Insulin dependent DM body does not produce any insulin.

Type II- It is characterized by abnormally in insulin secretion and insulin deficiency eventually result in weight loss in spite of an increasing appetite and food consumption. It is non-insulin dependent DM in which body does not produce enough or there is improper use of secreted insulin. Type-2 DM is due to impaired insulin production or insulin resistance in the targeted organs. (2)

Symptoms and Causes: (2)

(Table No. 1.1 Symptoms and Causes)

Symptoms	Causes
Feeling very thirst	Insulin resistance
Dry mouth	Autoimmune disease
Blurred Vision	Pancreatic damage
Loss Of Weight	Genetic mutation
Fatigue	Blindness
Frequent urination	Kidney failure
Pain or Numbness in the hands or feet	Heart attack

Beads:

Beads are a spherical dosage form containing an active substance. They can enhance the bioavailability and stability of drugs, provide a uniform distribution of drugs, and have an interesting appearance as a dosage form. Hydrogel beads are able to swell when in water because the hydrophilic polymer of the hydrogel is crosslinked with its cross linker. Ionic gelation is the method used to cross-link polymer and its cross linker to produce hydrogel beads. Hydrogel beads can be made from natural and synthetic polymers. Antidiabetic beads can be used to deliver antidiabetic drugs in a way that provides extended release. Antidiabetic beads are used to treat diabetes mellitus by controlling blood glucose levels. Beads can be used for patient compliance. It also enhances the stability and reduce the high blood glucose level. Beads can be used as therapeutic agents in the treatment of diabetes, which can offer a combination of traditional and modern medicinal approaches. It enhances the delivery and effectiveness of antidiabetic medications and release at a specific site. Much research efforts are concentrated on the development of hydrogel beads using natural polymers, as they have good solubility in water, a high swelling ability, a low toxicity level, and high biodegradability and biocompatibility. Pectin is a natural polymer to produce beads that have a bioactive substance that is able to suppress blood glucose through an inhibition mechanism that prevents the absorption of glucose into the blood. Zinc is a cation divalent that is cross linked with the carboxyl group of pectin to create hydrogel beads. (3) The use of sodium alginate (SA) beads can be an excellent solution to ensure adequate and sustained release. Sodium alginate is the sodium salt of alginic acid, which is a linear polymer composed of repeating units of α-L-guluronic acid and β-D-mannuronic acid. The chemical structure of SA consists of these alternating monomers linked together in a chain-like fashion. It is a biocompatible, water-soluble pharmaceutical excipient utilized for its *in-situ* gelling properties.(4) Hydrogel beads deliver drugs for 16 hours or but our main aim to increase rate of drug release for 24 by physical cross linking of polymerization technique.(5)

Herbal drugs used in the antidiabetic activity:

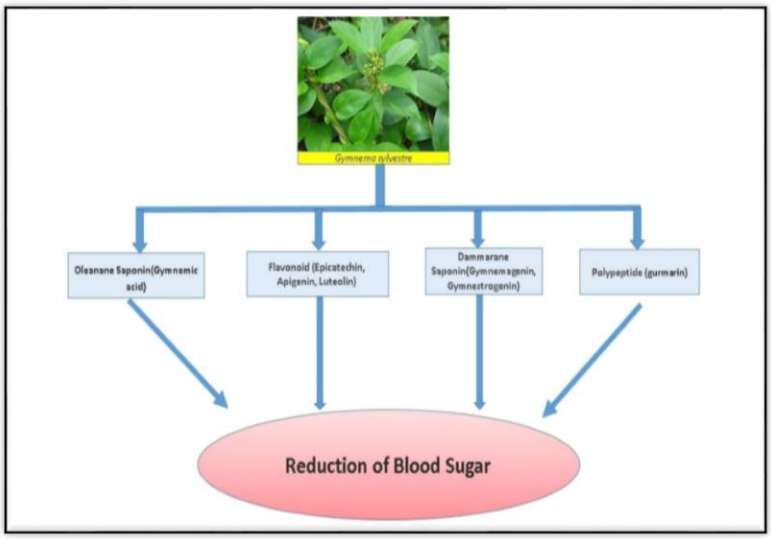
Phyto-medicine or Botanical medicine is popularly called as “Herbal Medicine” because various plant parts like seeds, berries, roots, leaves, bark or flowers, etc. are used for medicine preparation. Use of herbal

medicine is becoming popularized as up-to-date analysis and experimentation show their importance in the treatment and prevention of diseases due to their natural origin and less side effects. The World Health Organization (WHO) has listed 21,000 plants that are used for medicinal purposes throughout the world.(6, 7) It is validated in science due to its active phytochemical ingredients. Before herbal formulation, herbalists must have necessary information about its cultivation, collections, processing, diagnosis, extraction of active phytochemicals, etc. India stands to become a significant and successful exporter of herbal crude extracts. Indian herbal market is providing a good source of income to both farmers and traders. For encouraging the use of herbs in developed countries, some precautions should be followed like well documentation about herbal medicine, single plant medicine free of pesticides, heavy metals, poisons and detrimental side effects. Herbal medicines used friendly and with standardized chemical and activity profile.(8)

Gurmar:

It is commonly known as Gudmar which means "sugar destroying". It is mostly used in Indian ayurvedic medicines for treatment of diabetes. The active constituents in G. Sylvester are alkaloids, flavonoids, saponins and carbohydrates. It is also used for treatment of cancer, treatment of inflammation and treatment of various microbial disease. (8) *Gymnema Sylves*tre is an important herb in the treatment of **Type II DM** due to the presence of oleanane, dammarane types of secondary metabolites and antioxidants like flavonoids, cinnamic acid, folic acid, ascorbic acid etc. along with potential health benefit and with fewer side effects or no effects.(8)

Mechanism of action of Gurmar on antidiabetic activity:



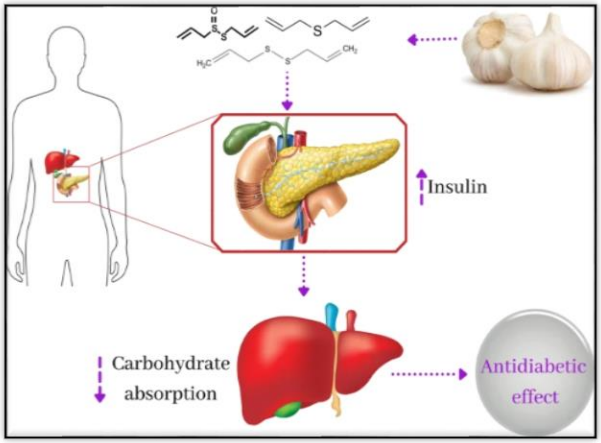
(Fig 1.1 Mechanism of action of Gurmar) (8)

Garlic:

Garlic is an effective way to help manage hyperglycemia, according to a WHO report. A study by Ryan et al. (2001) discovered that one-third of diabetes patients take alternative drugs they believe to be effective, with garlic being the most often utilized. It is demonstrated that garlic and its components, processed in

different ways, have antidiabetic properties. Garlic oil is shown to help diabetic individuals with hyperglycemia. Garlic may have a hypoglycemic effect by increasing the amount of insulin secreted by β-cells in the pancreas, releasing bound insulin, or improving insulin sensitivity. According to earlier research, garlic (allicin) can raise blood insulin levels by working well with substances like cysteine, protecting insulin against -SH group interactions, which are a frequently occurring reason for insulin inactivation. S-allyl cysteine sulfoxide, an isolated garlic component, has an antioxidant activity that may help explain its positive effects on diabetes, according to another explanation put out by researchers. According to research, garlic may have antidiabetic effects by either boosting the release of bound insulin or the pancreatic production of insulin from the β-cells.(9) All over India, this perennial plant is grown. Its strong smell is caused by the sulfur-containing component allicin, which also has strong hypoglycemic effects. Increased hepatic metabolism, increased insulin release from pancreatic beta cells, and the insulin sparing effect are suggested to be the causes of this impact.(10)

Mechanism of action of Garlic on antidiabetic activity:



(Fig 1.2 Mechanism of action of Garlic) (11)

2. Plant and excipients profile

- Gurmar
- Garlic
- Zinc Acetate
- Sodium Alginate

Gurmar:

(Fig 1.3: Gurmar)

(Table No. 1.2 Profile of Gurmar)

Synonym	Kavali, Kalikardori(12)
Biological source	The biological source of Gurmar leaves is the plant *Gymnema Sylvestre.(12)*
Family	*Asclepiadaceae*(13)
Chemical constituent	Constituents include 2 resins (one is alcohol soluble), 6% Gymnemic acid, Stigmasterol, Quercitol, Saponins.(14)
Geographical source	Banda, Konkan, Western Ghats, and Deccan extending to the part of the northern and western India. (12) It is distributed in Asia, Tropical Africa, Malaysia and Srilanka.(12)
Properties	It has a long history of use in herbal medicine and a broad range of therapeutic properties.
Uses	Reduction of sugar intake Weight Loss(8)

Garlic:

(Fig 1.4: Garlic)

(Table No. 1.3 Profile of Garlic)

Synonym	Ail
Biological source	Garlic is obtained from the dried bulbs of *Allium Sativum.*
Family	*Amaryllidaceae*
Chemical constituent	Alliin, Allicin, Alkyl Sulphides, Ajoene (15)
Geographical source	Central Asia(16)
Properties	High nutritional value. Antioxidants.
Uses	Used to treat diabetes Antioxidant Antimicrobial(17)

Zinc aetate:

(Fig 1.5: Zinc Acetate)

(Table No. 1.4 Profile of Zinc Acetate)

Synonym	Zinc acetate
Biological source	Derived from various biological source including food
Family	Carboxylic acid
Properties	Physical Eg.: solubility, appearance Chemical Eg.: pH stability Biological Eg.: toxicity, Bioavailability
Uses	Used to prevent zinc deficiency Cross Linker Wound healing

Sodium Alginate:

(Fig 1.6: Sodium Alginate)

(Table No. 1.5 Profile of Sodium Alginate)

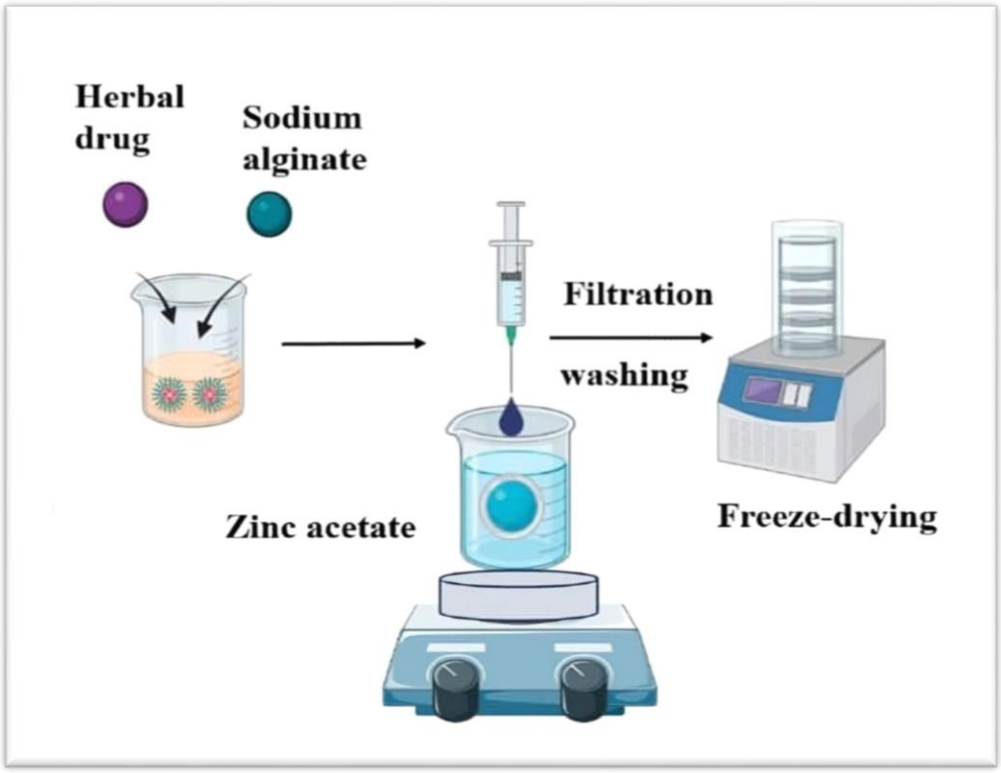
3. Methodology identification

Preparation of beads: Polyherbal drug extract hydrogel beads are prepared by ionic gelation method. Sodium alginate and herbal drug are solubilized in distilled water and then mixed until they become homogenous mixture. Then the mixture of phytoconstituent extract and Sodium alginate is added drop wise with zinc acetate solution by syringe with diameter 2.5 mm. The cross-linking time is 15 min with mechanical stirring. After that the beads formulation is filtered and washed with distilled water. After that the beads are dried using freeze dryer.(3)

Preparation of polymer: A 4% sodium alginate solution will be prepared by completely dissolving 4 grams of sodium alginate into 100 mL of distilled water with proper stirring, and gentle heating will be done using a magnetic stirrer.(3)

Preparation of cross linkage: 2.5 gm of Zinc Acetate will be dissolved in 100 ml of distilled water with proper stirring by using magnetic stirrer.

Synonym	Alginic acid sodium salt, Algin
Biological source	Sodium alginate is a natural polysaccharide that comes from brown algae and bacteria.
Family	*Phaeophyceae*
Properties	Gelling Antibacterial Mucoadhesive
Uses	Thickening agent Gelling agent Emulsifier Stabilizer Texture-improver (18)



(Fig 1.7: Methodology Identification)

4. Phytochemical tests for herbal drug

Gurmar

(Table No. 1.6 Phytochemical tests)(19, 20)

Sr. No.	Test	Observation
1	**Test for Carbohydrates:** **A. Molisch's test:** Take 2ml of sample in test tube + 2 – 3 drops of Molisch's reagent + 1 ml sulfuric acid in test tube without mixing.	Purple or Purplish red ring
2	**Test for Alkaloids** **A. Mayer's test:** Take 2 ml of extract + 2 ml of HCl + boil and cool + 2 drop of Mayer's reagent.	Formation of white or creamy yellow precipitate
	B. Wagner's test: Take 2 ml of extract + 2 ml of HCl + boil and cool + 2 drop of Wagner's reagent.	Reddish brown precipitate
	C. Hager's test: Take 2 ml of extract + 2 ml of HCl + boil and cool + 2 drop of Hager's reagent.	Bright yellow precipitate
	D. Dragendroff's test: Take 2 ml of extract + 2 ml of HCl + boil and cool + 2 drop of Dragendroff's reagent.	Orange or Orange – Red precipitate
3	**Test for Flavonoids:** **A. Ferric chloride test:** Dissolve small amount of sample in the water or ethanol+ few drops of dilute FeCl3 solution	Sample turn into red, green, purple or blue

5. Phytochemical tests for herbal drug

Garlic

(Table No. 1.7 Phytochemical tests)(19, 20)

Sr. No.	Test	Observation
1	**Test for Alkaloids** **A. Mayer's test:** Take 2 ml of extract + 2 ml of HCl + boil and cool + 2 drop of Mayer's reagent.	Formation of white or creamy yellow precipitate
	B. Wagner's test:	Reddish brown precipitate

	Take 2 ml of extract + 2 ml of HCl + boil and cool + 2 drop of Wagner's reagent.	
	C. Hager's test: Take 2 ml of extract + 2 ml of HCl + boil and cool + 2 drop of Hager's reagent.	Bright yellow precipitate
	D. Dragendroff's test: Take 2 ml of extract + 2 ml of HCl + boil and cool + 2 drop of Dragendroff's reagent.	Orange or Orange – Red precipitate
2	**Test for Glycosides:** **A. Keller – Kiliani test:** Take extract of drug + 3 ml of glacial acetic acid + few drops of FeCl3 solution + conc.H2SO4.	Deep blue colour at the junction of two liquids

6. Future prospects

The future prospect of antidiabetic herbal beads quite promising. In research and development, the formulation of antidiabetic beads is being optimized to enhance their efficacy and safety. They can be used not only for type I diabetes but also for patient with type II diabetes. In the upcoming year if the clinical trial of these beads is successful, they could become a new and effective option for diabetes management. Additionally, we will complete evaluation test including Yield, Shape and Morphology, Particle size distribution, swelling ability, swelling time, Moisture content, Packing and Labelling of formulation according to standard requirements. Overall, the future of antidiabetic beads is quite bright and they could provide an innovative solution in the treatment of diabetes.

7. Conclusion

Herbal drug incorporated into beads present a promising approach for antidiabetic treatment. The herbal drug is safer and more effective than synthetic preparation and show less side effect. Encapsulation in beads enhances the stability and bioavailability of the herbal constituents, ensuring better therapeutic efficacy. Beads allow for sustained and targeted release of the herbal active ingredients maintaining the steady blood glucose level. The bead helps to regulate blood sugar levels, promote Faster diabetes management and lower cholesterol levels. The antidiabetic beads highlight the potential of plant-based solutions in enhancing diabetes treatment by boosting bioavailability and improving patients quality of life. Additionally, with a growing consumer interest in natural and sustainable health care options, these herbal antidiabetic beads are well positioned to meet the rising demand for alternatives in diabetes care.

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