

1.1 ORAL DOSAGE FORM

For many years, oral drug delivery has been considered the most preferred method for systemic administration of medications across various pharmaceutical products with different dosage forms. The oral route is widely regarded as the most traditional and user-friendly method for delivering medications, primarily due to its affordability and simplicity, which in turn enhances patient adherence. Around half of all marketed drug products are taken orally, with tablets being the predominant dosage form ^[1]. The key objective in creating any dosage form is to guarantee that the drug is released correctly at the intended site to achieve the desired therapeutic effect. Factors such as the design of the dosage form, the tablet production process, and the overall chemical composition of the solid unit dosage play a crucial role in determining the drug's effectiveness. A total dosage form includes various excipients, and they most vital among all excipients is the active pharmaceutical ingredient. Their main additives are important to form a suitable dosage form, as single API cannot produce good formulation. During the process of mixing the excipients with the drug, the main active ingredient may mix with other ingredients in the blending process, so according to that, it is important to choose a specific procedure for the designing of the unit dosage form.^[2]

1.2 HERBAL MEDICINE: A GROWING FIELD WITH A LONG TRADITION:

The World Health Organization defines traditional medicine as the collective knowledge, abilities, and practices rooted in the cultural theories, beliefs, and experiences of various societies. These approaches are employed to uphold health and to prevent, diagnose, alleviate, or manage physical and mental health conditions. The approaches in traditional medicine differ significantly, influenced by the local culture, environment, and historical background of each system (WHO, 2005). Despite this, these systems share a common philosophy that emphasizes health over disease and takes a holistic approach to life. Usually, the focus is on the patient's overall health rather than the specific illness or condition they are suffering from, and all conventional medical practices include the use of herbs.^[3]

The primary justifications for the use of traditional medicine include its cost-effectiveness, better alignment with patients' cultural perspectives, reduced concerns about the side effects associated with synthetic medicines, the fulfillment of a desire for

personalized health care, and the dissemination of health information to the general public. Herbal medications are predominantly utilized for chronic diseases and health promotion rather than immediately life-threatening conditions. However, traditional medicines are more frequently resorted to when conventional treatments are ineffective, such as in cases of advanced diabetes and emerging infectious diseases. These remedies are frequently seen as safe and natural, but this belief can be deceptive. Negative interactions can occur when herbs are used alongside prescription drugs, over-the-counter treatments, or other herbs. To ensure safety and effectiveness, it is crucial for individuals to seek advice from healthcare professionals before adding herbal medications to their treatment plans. Mixing different types of treatments without proper guidance can lead to unforeseen complications and adverse reactions ^[4].

Herbs are commonly used to treat a variety of conditions, including inflammation, cardiovascular disease, prostate issues, depression, and to support the immune system. They are effective for both acute and chronic illnesses. For instance, traditional herbal remedies played a significant role in China's response to severe acute respiratory syndrome (SARS) in 2003, and the Africa flower has been traditionally used in Africa to alleviate symptoms associated with HIV-related wasting. Moreover, in many developed countries, pharmacies commonly stock herbal teas, essential oils, and extracts along with conventional medications. Herbal medicines are particularly popular in Europe, with Germany and France leading in over-the-counter sales among European nations ^[5].

Diabetes mellitus symptoms include hyperglycemia, hypertriglyceridemia, and hypercholesterolemia. Synthetic hypoglycemic medicines can cause significant adverse effects, such as hematological issues, liver and renal problems, and coma. Plant-based medications are often regarded as having lower toxicity and fewer adverse effects compared to synthetic drugs. This belief has spurred efforts to discover more potent and safer herbal treatments for diabetes. The World Health Organization states that herbal medicines are essential for primary healthcare for 80% of people worldwide. Throughout history, ethnobotanical remedies have been employed extensively to manage blood sugar disorders. In type 2 diabetes, elevated blood glucose levels stem from factors like poor dietary habits, lack of physical activity, inadequate insulin production following meals, and decreased insulin sensitivity in target tissues. By 2025, the global prevalence of chronic metabolic disorders, currently affecting approximately 150 million individuals, is

projected to rise to 300 million. While insulin and synthetic oral anti-diabetic drugs effectively reduce blood glucose levels, they do not address diabetic complications and have numerous side effects. Traditional medicinal plants are used worldwide to treat various diabetic complications. Historical literature documents numerous herbal medications and minerals used for treating diabetes mellitus, which are generally considered safer and have fewer adverse effects than synthetic drugs. The potential of medicinal plants has become increasingly important in providing humanity with viable herbal medicine alternatives [6].

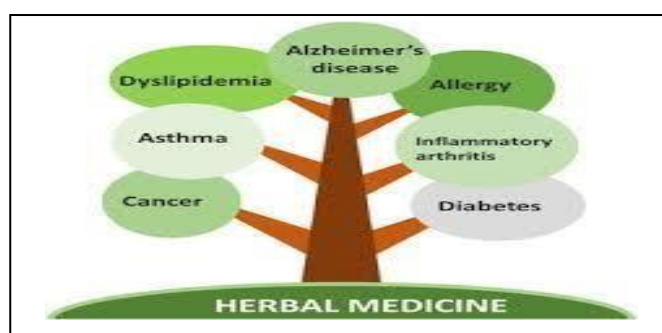


Figure No.1.1: Herbal Medicine used in diseases

1.3 IMPORTANCE

Ayurveda is a traditional medical system that utilizes various techniques to enhance health and well-being. The primary objective of Ayurvedic healthcare is to rebuild physical, mental, and emotional equilibrium in individuals. This approach aims to foster overall health, prevent diseases, and treat existing conditions. There is a growing trend among patients to seek herbal and alternative treatments, leading to a high demand for herbal medications in primary healthcare, particularly in developing countries. Herbal treatments are widely favored due to their affordability, cultural acceptance, compatibility with the human body, and typically minimal side effects [5].

Around 75 to 80 percent of people worldwide, especially in developing nations, rely mainly on herbal medicine for their primary healthcare. Despite the vast variety of plant species, estimated to be between 250,000 to 400,000, research has only been conducted on about 6% of them for their medicinal properties, with approximately 15% studied for their phytochemical characteristics. Therefore, it is crucial to conduct proper evaluations of herbs to ensure their safety and efficacy in primary healthcare. Expanding research to a

wider range of plant species can help unlock the full potential of herbal medicine for global health [6].

Several factors contribute to the use of herbal remedies. First, herbal medicine is an integral part of many cultures and belief systems for maintaining health and treating specific illnesses. Second, the lower cost of herbal products makes them more accessible to individuals with lower incomes. Thirdly, many people believe that herbal remedies are safe because they are natural, unlike modern pharmaceuticals, which are frequently linked to toxicity and adverse effects. Finally, the growing desire for more holistic and natural approaches to healthcare has also contributed to the increasing popularity of herbal remedies[7].

1.4 HERBAL FORMULATIONS

An herbal formulation is a specific type of dosage form containing one or more herbs or processed herbs in precise quantities to deliver particular nutritional or cosmetic benefits. These formulations are intended for various applications in humans or animals, including diagnosis, treatment, or mitigation of illnesses, as well as modifying their physiological functions. Typically, herbal formulations consist of an active ingredient combined with herbal preparations and other components derived from herbs. Transforming homegrown compounds into usable products involves several methods, including grinding, distillation, expression, fractionation, purification, concentration, and fermentation. The creation of these products utilizes various plant materials, which may be whole, divided, or cut, and includes parts of plants, algae, fungi, and lichen, typically in dried form, though sometimes fresh. Each herbal product is identified by its precise botanical name using the binomial nomenclature (genus, species, variety, and author) and the specific part of the plant used. These herbal preparations can take many forms, including tinctures, extracts, and essential oils, expressed juices, and processed exudates.

Unique chemical constituents or groups of constituents in herbal drugs, preparations, or medicinal products are referred to as markers. These markers play a critical role in quality control, regardless of their therapeutic value. By measuring these markers quantitatively in herbal substances or preparations, one can determine the amount of herbal substance or preparation within the herbal formulations.

The characterization of herbal formulations involves several elements such as formulation design and development, adherence to pharmacopoeial standards and criteria for acceptance, regular testing during production, criteria for product release and shelf-life, ongoing in-process testing, exploration of alternative manufacturing methods, adoption of emerging technologies, establishment of reference standards, and application of statistical principles [8].

1.5 TYPES OF HERBAL FORMULATIONS [8-10].

Decoctions:

Decoctions are traditional herbal medicines made by boiling plant materials to extract water-soluble active ingredients. Typically, they are prepared using two to twelve different plant parts and should be consumed within 24 hours. However, they can be stored for up to 72 hours in a very cold environment. In Chinese herbal medicine, formulations such as the Sijunzi decoction comprise ingredients like Panax ginseng, Poria cocos, Atractylodes macrocephala, and Glycyrrhiza uralensis. Modern analytical methods such as chromatography-tandem mass spectrometry (LC/MS) have been used to identify active compounds such as ginsenosides, flavonoids, and triterpenoids in these mixtures, revealing differences in concentration compared to extracts from individual herbs. Studies have demonstrated that decoctions, such as Cassia fistula pod extract, can maintain chemical stability for extended periods when stored properly. The combination of herbs in decoctions can enhance the bioavailability and synergistic effects of active components, emphasizing the therapeutic benefits of traditional herbal formulations.

Tinctures:

Tinctures are extracts of plant materials made using alcohol or hydro-alcoholic solutions to dissolve various plant constituents. This process involves macerating plant materials in a water-ethanol solution to extract a variety of chemical compounds with different polarities. Ensuring the quality and effectiveness of pharmaceutical products is crucial. To achieve this, advanced analytical techniques like nuclear magnetic resonance (NMR) and mass spectrometry (MS) are utilized. These techniques help in identifying individual chemical components, ensuring batch consistency, and assessing product stability over time. These methods provide precise and reliable data crucial for maintaining consistent product quality and safety. Typically containing at least 20% v/v alcohol, tinctures are

preserved for several years. The alcohol content not only enhances the extraction of non-water-soluble compounds but also informs consumers of potential effects and storage requirements.

Herbal Glycerites:

Herbal glycerites use glycerine instead of alcohol for extraction, requiring a final product concentration of at least 50% to 60% glycerine for stability. They have a shelf life ranging from two to six years. Glycerine is effective in preserving fresh plant juices, maintaining their colour and suspension longer than alcohol. Glycerites are particularly suitable for pediatric formulations and remedies for soothing the throat, digestive system, and coughs. They are a preferable option for individuals sensitive to alcohol or with dietary restrictions against its consumption, despite having a shorter shelf life and lower potency compared to alcoholic extracts.

Herbal Alcoholic Beverages (Bitters and Wines):

Herbal alcoholic beverages are made using ethanolic or hydro-ethanolic extracts of plant materials and are traditional in various cultures, notably in African, Southeast European, and Mediterranean regions. The medicinal action of these beverages depends on the herbs used. Alcohol extends shelf life and provides preservative effects. Storage conditions significantly impact their antioxidant, antibacterial, and antifungal activities. For example, the stability of an alcoholic orange juice beverage was maintained in terms of acidity, pH, and alcohol content during 14-hour storage at different temperatures, although degradation markers and colour changes occurred over time.

Oxymels:

Oxymels are sweet and sour mixtures combining honey and vinegar, often used as carriers for herbal infusions, decoctions, and tinctures. Oxymels are versatile in their uses, functioning both as gargles and as vehicles for potent herbs like garlic, cayenne, and lobelia. Their durability depends on the exact proportions of honey, vinegar, and herbal extracts used, with storage methods and the quality of ingredients playing crucial roles in determining their durability. To preserve their effectiveness and prevent decay, it's recommended to store oxymels in a cool, dark environment.

Herbal Capsules:

Herbal capsules are solid dosage forms that contain powdered or granular herbal ingredients encased in either a hard or soft gelatine shell. They disintegrate easily after oral administration, masking the taste of their contents. Capsules provide consistent dosing and superior stability compared to liquid preparations, remaining stable at room temperature for up to two years. The gelatine shell protects active ingredients from degradation due to light, air, and moisture, making capsules a convenient and effective form for herbal supplements.

Herbal Tablets:

Herbal tablets are solid, compressed forms containing herbs and excipients like binders, lubricants, and disintegrants to ensure proper formulation and dissolution in the gastrointestinal tract. Tablets may be coated to mask taste, facilitate swallowing, and protect contents from stomach acid or environmental conditions. Proper coatings enhance stability and shelf life, preventing interactions between active components and moisture or oxygen, thus maintaining efficacy and quality over time.

Herbal Ointments:

Herbal ointments are semi-solid topical preparations designed for application to the skin, nasal mucosa, or rectal area. These hydrophobic preparations do not mix with skin secretions and incorporate extracted or finely sieved plant materials for emollient or medicinal purposes. Stability is a significant concern as natural ingredients may degrade quickly; for instance, ointments containing calendula and arnica tinctures for haemorrhoid treatment have a shelf life of one to two months under appropriate storage conditions and protection from light. These formulations harness the therapeutic properties of various herbs to treat localized conditions, providing a targeted approach to alleviate symptoms and promote healing.

Herbal Balms:

Similar to ointments, herbal balms are designed to relieve body aches and pains, containing herbal ingredients with rubefacient properties that increase blood flow and provide pain relief. Their stability is comparable to ointments, though the variety of herbs used can affect specific stability and effectiveness. Proper storage is crucial to maintain

efficacy and shelf life. Consulting a healthcare professional before use is recommended, particularly for individuals with sensitive skin or allergies.

Herbal Creams:

Herbal creams are typically semi-solid mixtures containing both oil and water, often enhanced with extracts from medicinal plants. These formulations typically include antimicrobial preservatives to enhance stability. However, owing to their water content, herbal creams generally have a shorter shelf life compared to ointments. Creams are hydrophilic and used for various skin conditions, requiring proper classification and labelling to distinguish them from hydrophobic ointments. Following storage instructions is essential to prevent spoilage, making them a versatile option for skincare routines due to their soothing and moisturizing properties.

Herbal Oils:

Herbal oils involve suspending or dissolving plant materials in an oil-based medium. Infused oils, distinct from essential oils, are typically used topically or externally and occasionally for oral consumption. Stability and shelf life depend significantly on the type of oil and extraction method. Store herbal oils in a cool, dark location to prevent oxidation and preserve their potency. Common herbal oils include lavender, tea tree, and chamomile, each offering unique benefits for skin and health.

Herbal Soaps:

Herbal soaps are created by saponifying fatty acids with a base like caustic soda and incorporating herbal components into the soap base. These soaps are used for their antibacterial and antifungal properties to treat skin conditions like eczema, ringworm, and dandruff. Antioxidants or preservatives can extend shelf life. Herbal soaps are popular for their natural fragrances and ability to nourish and moisturize the skin, preferred for their potential health benefits and environmentally friendly ingredients.

Herbal Pastes:

Herbal pastes are topical formulations containing up to 50% powder in a fatty base, used to focus the action of irritating or discolouring agents on the skin. They may also be formulated for oral use, such as herbal toothpaste, provided the ingredients are safe for consumption. The stability of herbal pastes is influenced by the type of base and herbal

ingredients, requiring storage in a cool, dry place to maintain efficacy. Consulting a healthcare professional before use is recommended for specific skin or oral conditions.

Herbal Teas:

Herbal teas are prepared for infusion or tea-making, with infusions needing immediate consumption due to poor storage stability. Herbal teas are offered in tea bags or as powdered herbs, and their longevity hinges on moisture levels and how they are stored. When kept in airtight containers, herbal teas can remain fresh for up to a year; however, tea bags have a shorter shelf life. To maintain their flavour and potency, herbal teas should be stored in a cool, dry place, away from direct sunlight. Proper storage can ensure that suppositories remain effective for several months to a year.

Herbal Suppositories:

Herbal suppositories are solid forms designed for insertion into the rectum, where they melt or dissolve upon reaching body temperature, resulting in either local or systemic effects. Made using a base like cocoa butter combined with powdered herbs or extracts, they treat conditions like constipation, swollen membranes, and inflamed nasal mucosa. Stability is affected by storage temperature and packaging, requiring cool, dry storage to prevent melting or degradation.

Herbal Pessaries:

Similar to suppositories, herbal pessaries are designed for vaginal insertion using bases like glycerated gelatin, which dissolve at body temperature to release herbal components. Stability is comparable to suppositories, providing targeted relief for specific conditions. Consulting with a healthcare provider or herbalist before use ensures safety and efficacy for individual needs.

Herbal Plasters and Poultices:

Poultices are therapeutic preparations crafted by crushing fresh herbs, encasing them in gauze, and applying them externally to alleviate inflammation and manage minor skin conditions such as insect bites and wounds. They leverage the natural properties of herbs to provide localized relief and promote healing. As they are made from fresh herbs, they should be used immediately. Herbal plasters are created by mixing powdered herbs with a substance such as clay or beeswax to form a paste. This paste is then spread onto a cloth

and placed on the skin. This method of preparation helps to extend the shelf life of the herbs by preserving them in this form.

Herbal Fomentations and Compresses:

Compresses involve soaking a cloth in an herbal infusion or tincture and applying it to the skin, used warm or cold, to alleviate pain and inflammation or improve circulation and muscle relaxation. Fomentations are similar but use hot herbal infusions, which are particularly effective for treating muscle aches, menstrual cramps, and chest congestion. Proper temperature testing before application is crucial to avoid burns.

Herbal Liniments:

Liniments are external applications used to relieve pain, often made by combining heat-producing herbs with alcohol or oil. They are applied as warm massage oils for aching muscles and ligaments but should not be used on broken skin. Liniments provide quick relief and are popular for athletes and those with chronic pain. Consulting with a healthcare professional before use is recommended, particularly for individuals with sensitive skin or allergies.

Herbal Baths:

Herbal baths involve adding fresh or dried herbs, or herbal tinctures and infusions, to bathwater. Fragrant herbs containing essential oils promote relaxation and reduce tension, improving circulation and detoxifying the body with regular use. Common herbs include lavender, chamomile, and rosemary.

Herbal Lozenges:

Lozenges are formulated to release therapeutic properties slowly in the mouth and are made by combining pulverized herbs with excipients like sugar, honey, and gums. They treat throat infections and soothe throat pain, with stability comparable to tablets. Proper storage in a cool, dry place is essential to maintaining effectiveness. Lozenges are preferred for their ease of consumption and pleasant taste.



Figure No.1.2: Standardization of Herbal Drug

1.6 WHO DEFINITIONS RELATED TO HERBAL MEDICINE:

The redefinition of certain terms by the World Health Organization (WHO) aims to establish consistency in defining key concepts related to herbal medicine. These definitions serve the purpose of establishing uniform terminology for use in assessing and researching herbal medicines. It is important to note that these definitions may differ from those found in the legislation of countries practicing traditional medicine. Hence, these definitions serve to enhance communication and understanding within the herbal medicine community, encompassing researchers, practitioners, and policymakers. They may evolve with ongoing advancements in herbal medicine research and practices. ^[10-11].

1.7 ADVANTAGES AND DISADVANTAGES OF HERBAL MEDICINES

Advantages

Minor ailments like scrapes, rashes, and burns can be treated with herbal medications. At a very cheap cost, they can also be used to treat depression, arthritis, and migraines, according to the University of New Hampshire. Herbal medicines can be purchased at local supermarkets or cultivated at home, which makes them far less expensive than pharmaceutical drugs. Christopher Golden, affiliated with the Harvard University Center for the Environment, suggests that transitioning from pharmaceuticals to herbal remedies could potentially reduce annual healthcare expenditures by 22–63%. Foods like rhubarb, ginger, and garlic are common examples of common place foods that contain herbal medicine. ^[10,11]

Disadvantages

There may be numerous benefits to using herbal medicines. It does, however, have certain drawbacks as well. For starters, herbal remedies take longer than prescription medications to start working. A person must be very patient if they choose to use herbs as a substitute for prescription medication.

Herbal medicine is frequently taken on its own. That's why there are no warnings or dosage listed. When taken simultaneously, herbal and prescription drugs may have detrimental interactions that are harmful to the user's health.

It is essential to recognize that herbal medicines derived from plants can sometimes cause poisoning rather than healing. Different parts of the same plant may have varying effects, with some being edible and others toxic. For example, the rhubarb plant has an edible stem and roots that are used as laxatives, but its leaves are poisonous. Individuals may fail to identify toxic plants accurately, thereby posing a risk of poisoning themselves or others. It is crucial to seek guidance from a knowledgeable herbalist or botanist before consuming any plant-based medicines. Proper identification and understanding of the potential risks associated with herbal remedies are necessary for safe usage.^[10,11]

Herbs:

Herbs encompass a wide variety of botanical substances sourced from different parts of plants, such as leaves, flowers, fruits, seeds, stems, bark, roots, and rhizomes. These plant components may be utilized in their entirety, fragmented, or ground into powders for various medicinal and therapeutic applications. Herbal materials are often used in different forms like teas, tinctures, capsules, or extracts due to their medicinal benefits. Prior consultation with a healthcare professional is crucial before using herbal remedies to ensure safety and efficacy.^[12]

Herbal Materials:

Herbal materials encompass a variety of substances derived from herbs, including fresh juices, gums, fixed oils, essential oils, and dry powders. These materials undergo preparation using techniques such as steaming, roasting, or stir-baking with honey, alcohol, or other agents, varying by region. Familiarity with these traditional methods is crucial for practitioners, as they can significantly impact the potency and efficacy of herbal materials. Furthermore, herbal materials are utilized in diverse forms such as teas,

tinctures, capsules, and topical applications. ^[10-12]

Herbal Preparations:

The foundation for finished herbal products lies in herbal preparations, which may consist of tinctures, extracts, commented or powdered herbal components, as well as fatty oils and extracts. These preparations are crafted using a range of physical or biological methods, including extraction, fractionation, purification, and concentration. Additionally, treatments involving scalding or soaking herbal components in alcohol, honey, or other substances are incorporated. Herbal formulations are carefully developed to maximize the extraction of beneficial compounds from plants, thus amplifying their medicinal properties. The versatility of herbal preparations allows for a broad spectrum of applications, rendering herbal medicine a versatile and efficacious healing modality. ^[10-12]

1.8 WHO GUIDELINES FOR STANDARDIZATION OF HERBAL FORMULATIONS:

Ensuring the safety and quality of polyherbal formulations is crucial. These mixtures, made from various herbs, aim to deliver targeted health benefits.

1. Standardization of polyherbal formulations plays a crucial role in ensuring their safety, efficacy, quality, and consistent performance across different batches.
2. First, standardization involves implementing quality control measures for raw herbal materials utilized in formulations. This process ensures that these materials conform to established criteria for identity, purity, and potency.
3. Secondly, plant preparations and the finished polyherbal products undergo stringent quality assessments.
4. Another crucial element of standardization is stability evaluation, which includes conducting studies to ascertain the shelf life of polyherbal formulations under different storage conditions.
5. Furthermore, safety assessments are conducted through a combination of historical usage data, traditional knowledge, and modern toxicological studies.
6. Lastly, the efficacy of polyherbal formulations is evaluated through ethno medical information and scientific studies assessing biological activities. ^[12-15]

1.9 HERBAL DOSAGE FORMS-POWDER

Herbal supplies can be prepared as powders, lehiyas, tailas, capsules, tablets, syrups, and more. The powder form, which offers dose accuracy, is the most adaptable. It is simpler to take a prepared powder with active components than it is to ingest the individual herbs.

These treatments consist of powdered herbal ingredients that can be used topically or added to food, drinks, insufflations, and wounds. They could contain carefully sifted herbal ingredients from different plant parts intended to have a specific therapeutic effect. The stability of the powder depends on the characteristics of the herbal ingredients and the moisture content in the packaging, similar to herbal teas.^[15-17]

Advantages of Powders

1. There is a large selection of components, and determining the dosage for patient administration is simple.
2. Powders offer higher physicochemical stability and a longer shelf life as compared to liquid dose forms. For instance, after reconstituted with water, the shelf life of powdered antibiotic syrups is reduced to 1 to 2 weeks from the original 2 to 3 years.
3. Powders are found more acceptable as children and adults who have trouble swallowing tablets or capsules.
4. Powder can be used to administer a big dose that cannot be given in another form. For instance, it is occasionally impractical to create tablets to deliver a medicine to the patient at a dose of 1 to 5 g.
5. Medications administered in powder form are dispersed rapidly in the stomach compared to those in compressed form.
6. Oral powders containing water-soluble medications generally dissolve more quickly than tablets or capsules, as tablets and capsules require shell breakdown before drug absorption can occur.
7. A powder can be more easily swallowed by dispersing in water or another liquid.
8. Oral powders can be combined with a beverage or applesauce, just before using.
9. Powder dosage forms are easier to manufacture than other dosage forms, which results in lower product costs.
10. Powders provide solids compounders a lot of versatility.^[17-21]

Disadvantages of Powders

1. Powders are not the preferred dose form for medications with bad tastes. This is due to the potential issue with this method of preparation in hiding disagreeable flavors.
2. Drugs that quickly lose their potency when exposed to air or an acidic pH shouldn't be given out as powders. For instance, since ferrous iron salts are readily oxidized, powder form should not be used for administration.
3. Powders are heavy and not ease to transport.
4. The administration of medications that are inactivated in the stomach or that can harm the stomach should not be done using powders as a dose form.
5. It might not be appropriate to dispense strong medications that require modest doses as powders (such as bulk powders). This is so that individual doses can be withdrawn from the bulk using a 5 ml spoon, which can be filled differently depending on whether it is level or heaping.
6. Dry or liquescent medications should not be dispensed using powders. ^[17-21]

1.10 ENDOCRINE SYSTEM

The endocrine system comprises glands that produce and release hormones directed towards various parts of the body. These glands are distributed throughout the body, including the neck, brain, and reproductive system, with some being as small as a rice or pea, while others, like the pancreas, can reach lengths of around 6 inches. ^[22-24]

- **Hypothalamus:** The hypothalamus, situated in the brain, plays a crucial role in regulating the endocrine system by directing other glands like the pituitary gland to synthesize hormones in response to neural signals. It oversees various physiological processes such as emotions, hunger, thirst, sleep-wake cycles, and reproductive functions.
- **Pituitary:** The pituitary gland, often referred to as the "master gland," is located at the base of the brain and is about the size of a pea. It releases hormones that regulate the functions of other glands, including the thyroid, adrenal glands, ovaries, and testes. This gland is crucial for physical growth and works in close cooperation with the hypothalamus to maintain hormonal balance.

- **Thyroid:** Situated in the front of the neck, this butterfly-shaped gland controls metabolism, body temperature, heart rate, and blood pressure. Dysfunction of the thyroid gland can lead to symptoms such as weight changes, fatigue, and mood swings.
- **Parathyroid:** These four tiny glands, barely larger than a grain of rice, regulate calcium levels in the body. They release parathyroid hormone to maintain calcium balance in the blood, which is crucial for the proper function of bones, the brain, the heart, and the kidneys.
- **Adrenal:** Two adrenal glands located above each kidney are responsible for metabolism, blood pressure regulation, sexual development, and stress response. They produce hormones like adrenaline and cortisol, vital for the body's fight or flight response.
- **Pineal:** Mainly responsible for releasing melatonin, a hormone that regulates the sleep-wake cycle, this gland also influences circadian rhythms and mood. Dysfunction of the pineal gland can result in sleep disorders and mood disturbances.
- **Pancreas:** Acting as an endocrine and digestive gland, the pancreas produces insulin to regulate blood sugar levels and digestive enzymes for food breakdown. Dysfunction can lead to conditions like diabetes and pancreatic insufficiency.
- **Ovaries:** Found in females, these glands secrete sex hormones like estrogen, progesterone, and testosterone, which are crucial for regulating the menstrual cycle, fertility, and secondary sexual characteristics. They also release eggs for fertilization during ovulation.
- **Testes:** The male testes are responsible for producing testosterone and sperm, which influence sperm production, physical characteristics, and libido. Positioned in the scrotum outside the body, they are situated to maintain an ideal temperature conducive to sperm production.^[22-24]

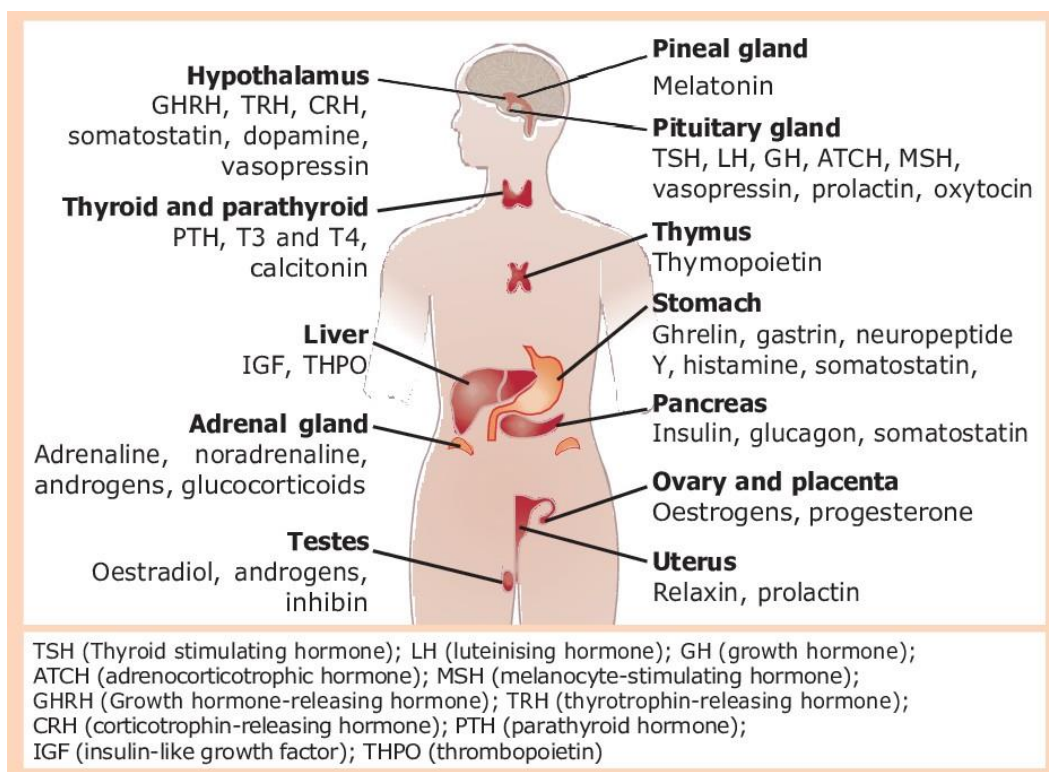


Figure No. 1.3: Major Endocrine glands, Tissues and their hormones [22]

1.11 DIABETES MELLITUS:

Diabetes mellitus remains a significant global health concern, characterized by disrupted insulin secretion and increased blood glucose levels due to liver glucose production and insulin resistance. Traditional medicines derived from medicinal plants are extensively utilized worldwide, with a notable reliance of approximately 60% of the global population on these therapies. In countries like India, diabetes mellitus poses a particularly acute health challenge, especially in urban settings.

Several approaches exist for handling diabetes and its complications. Herbal formulations are favored due to their reduced toxicity, minimal adverse effects, cost-efficiency, and perceived higher efficacy. Many medicinal plants have shown potential for lowering blood sugar levels, leading to continued research efforts. However, additional pharmacological and chemical studies are necessary to fully comprehend how these plants exert their hypoglycemic effects. [25-28]

1.12 TYPES OF DIABETES MELLITUS

1. **Type 1 diabetes** Type 1 diabetes results from the dysfunction or deterioration of pancreatic beta cells, responsible for producing insulin. When these cells are damaged or fail to function properly, insulin production becomes insufficient or ceases altogether. In most instances of type 1 diabetes, the immune system mistakenly attacks and destroys beta cells. To sustain life, individuals require insulin replacement therapy, which can be administered through subcutaneous injections using a syringe or insulin pump.^[25-28]

Subcategories of Type 1 Diabetes Mellitus:

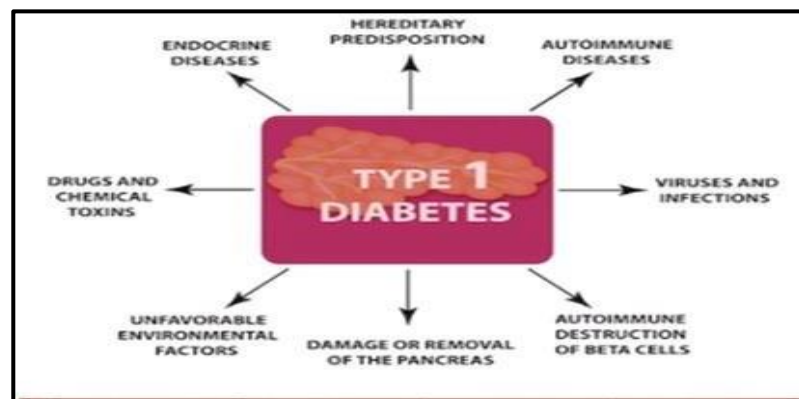


Figure No. 1.4: Type 1 Diabetes

- A) Type 1A Diabetes (Including Latent Autoimmune Diabetes of Adults - LADA):
 - B) Type 1B (Idiopathic or non-immune-mediated diabetes)
2. **Type 2 diabetes:** Type 1B diabetes, alternatively referred to as idiopathic or non-immune-mediated diabetes, is a distinct subtype characterized by insulin deficiency that does not involve autoimmune destruction of beta cells. Unlike Type 1A diabetes, which is largely autoimmune, Type 1B diabetes is observed predominantly in individuals of African or Asian descent and is not linked to autoimmune mechanisms. The exact cause of Type 1B diabetes is not fully understood; however, it is believed to result from a combination of genetic predisposition and environmental factors.

Patients diagnosed with Type 1B diabetes necessitate insulin therapy for effective blood glucose management and to mitigate associated complications like cardiovascular disease, neuropathy, and nephropathy. Treatment strategies for Type

1B diabetes emphasize personalized insulin regimens customized to meet each patient's unique requirements. The goal is to attain optimal glycemic control and enhance long-term health results.

Research into Type 1B diabetes aims to further elucidate its underlying mechanisms and identify potential genetic and environmental triggers that contribute to its development. This knowledge is crucial for developing targeted therapies and personalized treatment strategies to better manage and ultimately prevent Type 1B diabetes in susceptible populations. [25-28].

Causes of Type 2 Diabetes:

Herbal materials: The range of substances extends beyond just herbs. This includes fresh juices, gums, fixed and essential oils, as well as dry powders made from herbs. Regional preparation methods differ and may involve techniques such as steaming, roasting, or stir-baking, often incorporating honey, alcohol, or other ingredients. Understanding traditional preparation methods is essential for practitioners, as these techniques can influence the potency and effectiveness of herbal materials. Moreover, herbal materials are employed in diverse forms including teas, tinctures, capsules, or topical applications. [25-26]

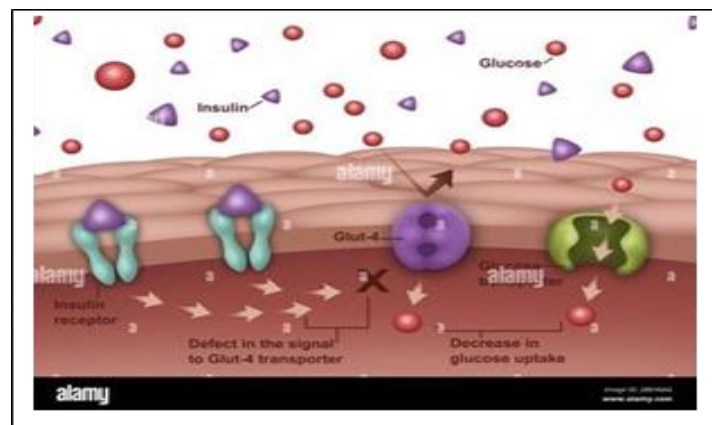


Figure No.1.5: Type 2 Diabetes

3. Gestational diabetes

Gestational diabetes is a form of diabetes that may occur during pregnancy in women who did not previously have diabetes. It affects approximately 2% to 10% of pregnancies annually in the US. Managing gestational diabetes is crucial to promoting a healthy pregnancy for both the mother and the unborn child. [25-26]

Causes of Gestational Diabetes:

Gestational diabetes occurs when the body does not produce enough insulin during pregnancy. The pancreas, which secretes insulin, is crucial for regulating blood sugar levels by helping glucose enter cells for energy production. Throughout pregnancy, hormonal fluctuations and physiological changes, including weight gain, contribute to insulin resistance, wherein cells become less responsive to insulin's actions. Consequently, insulin resistance heightens the body's demand for insulin.

While insulin resistance is a natural occurrence in late pregnancy for all expectant mothers, some women exhibit pre-existing insulin resistance before conception. These individuals necessitate increased insulin production at the onset of pregnancy, rendering them more susceptible to developing gestational diabetes. ^[25-26]

Epidemiology of Diabetes:

The global occurrence of diabetes is rising swiftly, presenting a substantial health challenge globally. In 2010, an estimated 285 million individuals were affected by diabetes, predominantly type II diabetes, which accounted for nearly 90% of cases. However, by 2013, the International Diabetes Federation reported a surge in diabetes prevalence, with approximately 381 million people afflicted worldwide. Projections indicate a continuous rise in diabetes cases, with an estimated 250 million individuals currently living with the condition globally. By 2030, this figure is anticipated to exceed 350 million. ^[25-26]

Pancreatic Pathophysiology:

The pancreas is essential for regulating metabolic processes, especially maintaining blood glucose levels. It functions both as an exocrine gland, secreting digestive enzymes, and as an endocrine gland, producing critical peptide hormones. These hormones—insulin, glucagon, and somatostatin—are crucial for controlling glucose metabolism. They are secreted by specialized cells within the pancreatic islets of Langerhans: β cells produce insulin, alpha cells produce glucagon, and δ cells produce somatostatin, each playing a vital role in metabolic regulation. ^[22-25]

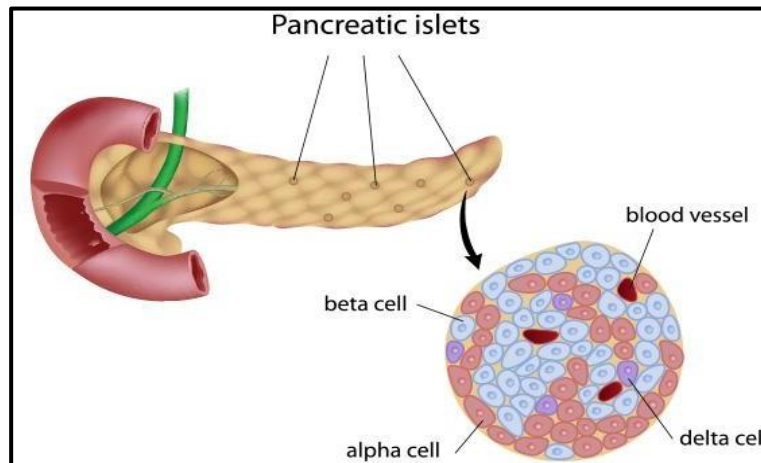


Figure No. 1.6: Islets of Langerhans

1.13 GENES OF DIABETES MELLITUS:

Diabetes mellitus is influenced by genetic predispositions, with two notable genes, MODY1 and MODYII, contributing to approximately 2% to 5% of cases, demonstrating clear heritability. [22-26]

MODY I Gene:

The MODY I gene is located on chromosome 20 and is responsible for encoding hepatocyte nuclear factor-4 α (HNF-4 α). This particular transcription factor plays a crucial role in regulating genes related to glucose metabolism and insulin secretion. Its functions are vital for preserving the functionality of pancreatic beta cells and ensuring proper hepatic glucose balance. Mutations in this gene can decrease HNF-4 α production, resulting in pancreatic beta cell dysfunction and irregular insulin secretion. These mutations are associated with maturity-onset diabetes of the young (MODY), a form of diabetes marked by early-onset hyperglycemia, typically manifesting before the age of 25. [22-26]

MODY II Gene:

The gene associated with MODY II, situated on chromosome 12, encodes the hepatocyte nuclear factor-1 α (HNF-1 α), which acts as a transcription factor present in both liver cells and pancreatic beta cells. Its primary function involves the regulation of genes crucial for glucose metabolism, insulin secretion, and cellular differentiation. Mutations in the MODY II gene can interfere with HNF-1 α function,

resulting in reduced insulin production and impaired glucose regulation. Individuals with MODY II typically present with mild hyperglycemia that is often asymptomatic or manifests later in life compared to other forms of diabetes. Understanding the genetic basis and function of HNF-1 α is essential for diagnosing and managing MODY II and developing targeted therapies that restore normal beta cell function and glucose homeostasis.

Research into the MODY I and MODY II genes continues to uncover insights into the molecular mechanisms underlying monogenic diabetes. [25-26]

1.14 INSULIN

In 1921, Frederick Banting made a ground breaking discovery by isolating insulin and showing its ability to lower blood sugar levels through an extract obtained from the pancreas. The following year, in 1922, a significant milestone was achieved when a 14-year-old boy with severe diabetes mellitus was treated with this insulin extract, leading to remarkable improvements in his condition. This breakthrough led to the purification of insulin within a few years.

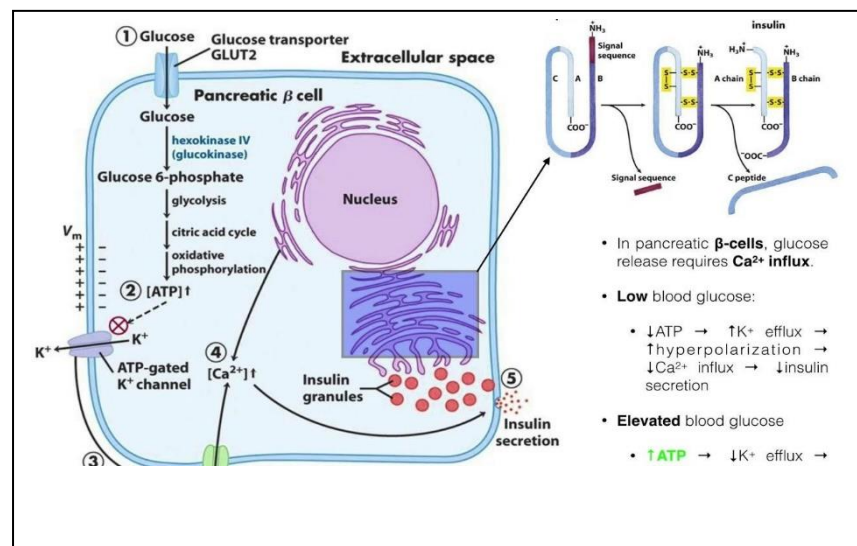


Figure No. 1.7: Secretion of Insulin in β cells

Beta cells, located within the islets of Langerhans in the pancreas, release insulin upon stimulation by rising glucose levels. Insulin is released from these cells in two distinct phases. Initially, there is an immediate release of preformed insulin stored within secretory granules. This is followed by a subsequent release of newly synthesized insulin after a brief pause, which persists for

a longer duration.

The pancreas produces insulin, and these cells form clusters called "Islets of Langerhans," named after their discoverer, a German medical student. Insulin becomes active after release into the bloodstream but has a short half-life of about 6 minutes due to insulinase, an enzyme in the liver and kidneys that breaks it down. This enzymatic degradation leads to rapid fluctuations in blood insulin levels. [23-24]

Action of Insulin

Insulin exerts a wide range of effects across different time spans. When insulin binds to its receptors, it triggers processes in several tissues, particularly skeletal muscle and adipose tissue. This activation leads to the immediate expression of GLUT-4 glucose transporters, which facilitate glucose uptake in response to insulin. Moreover, insulin facilitates the movement of these transporters from internal storage sites to the cell membrane, thereby enhancing their functional capacity and numbers. However, certain tissues, including liver cells, red blood cells, gastrointestinal mucosa, renal cells, and neural cells, utilize alternative glucose transporters that operate independently of insulin regulation. Through the phosphorylation-mediated modulation of specific enzymes, insulin coordinate temporal changes in enzymatic activity spanning minutes to hours.

Moreover, insulin exerts long-term effects by upregulating the expression of numerous metabolic enzymes over several days. These alterations reflect enhanced gene transcription, mRNA synthesis, and enzyme production, thereby contributing to sustained metabolic regulation mediated by insulin. [23-24]

Insulin role on the body

Understanding the significance of insulin therapy becomes more accessible when comprehending the physiological role of this endogenous hormone and the implications of its deficiency in diabetes.

In a non-diabetic state, insulin facilitates two primary functions:

1. Regulation of blood sugar levels:

After carbohydrates are digested into glucose, the pancreas regulates blood glucose levels by secreting insulin. Insulin is a hormone produced by beta cells in the

pancreatic Islets of Langerhans, which responds to increased blood glucose levels following carbohydrate digestion. [23-24]

2. Storage of excess glucose:

When insulin levels rise, such as post-meal, surplus glucose is stored in the liver as glycogen. In periods between meals, when insulin levels drop, the liver releases stored glucose into the bloodstream to uphold blood sugar levels. In cases of diabetes, inadequate insulin production or insulin resistance disrupts this process, resulting in elevated blood glucose levels. Those with type 1 diabetes cannot produce insulin and thus require insulin therapy to substitute the deficient hormone. In type 2 diabetes or gestational diabetes, where insulin production may be inadequate or ineffective, insulin therapy might be recommended if other medications fail to sufficiently manage blood glucose levels. The principal aim of insulin therapy is to sustain blood sugar levels within the recommended range, thereby averting complications associated with diabetes like kidney impairment, vision loss, and neuropathy. [23-24]

1.15 TYPES OF INSULIN

Various types of insulin are available, each with distinct durations and effects on blood sugar levels. Physicians often recommend combining different insulin types based on individual factors such as lifestyle, glucose levels, daily blood sugar fluctuations, and diabetes type.

The primary categories of insulin therapy comprise:

1. Long-Acting, Ultra Long-Acting, or Intermediate-Acting Insulin:

These forms of insulin are designed with extended half-lives to provide sustained glucose-lowering effects over prolonged periods, particularly during fasting or between meals. Examples include:

- a. Glulisine (sold under brand names Lantus and Toujeo)
- b. Detemir (marketed as Levemir)
- c. Degludec (commercially available as Tresiba)
- d. NPH (Neutral Protamine Hagedorn sold under various brands such as Humulin N, Novolin N, and Novolin ReliOn Insulin N)

Their duration of action ranges from eight to forty hours, making them suitable for basal insulin replacement therapy.

2. Rapid-Acting or Short-Acting Insulin:

These insulin types are characterized by their rapid onset of action, making them effective in managing post-meal glucose spikes. They typically begin to work within minutes after administration, ensuring timely control of blood sugar levels. Examples include:

- a. Aspart (marketed as NovoLog and Fiasp)
- b. Glulisine (sold under the brand name Apidra)
- c. Lispro (available as Humalog and Admelog)
- d. Regular (products such as Humulin R, Novolin R, Myxredlin, and ReliOn R)

Rapid-acting insulins have a shorter duration of action, typically lasting between two and four hours, thereby requiring frequent dosing to maintain optimal glycemic control throughout the day. Insulin is not available in tablet form due to its susceptibility to digestion in the gastrointestinal tract. However, several administration methods exist, and the most suitable option depends on individual preferences and lifestyle considerations. These methods include:

- **Injections (shots or pens):** Insulin administration involves injecting it into the layer of fat just beneath the skin using either a syringe with a needle or a pen-shaped device. The frequency of injections depends on factors such as the type of diabetes, blood glucose levels, and how often meals are consumed, varying from once daily to multiple times per day.
- **Insulin pump:** This apparatus delivers small, regular amounts of fast-acting insulin through a slender tube inserted under the skin. These amounts are distributed over the course of the day, and various types of insulin pumps are available for acquisition. Despite the difficulties linked to insulin treatment, like handling blood sugar swings, choosing a personalized insulin plan that suits one's lifestyle can aid in averting diabetes-related problems and enhancing overall health and well-being.^[27-28]

1.16 DIABETES SYMPTOMS

Following are symptoms of Diabetes mellitus

- Frequent urination, particularly during the nighttime
- Excessive thirst
- Unintended weight loss
- Increased appetite
- Blurred vision
- Persistent fatigue
- Dry skin
- Slow-healing sores
- Increased susceptibility to infection.^[27-28]

Symptoms of Type 1 Diabetes:

Individuals diagnosed with type 1 diabetes often experience symptoms such as nausea, vomiting, or abdominal discomfort. These symptoms typically arise rapidly over a period of weeks to months and can be quite severe. Although type 1 diabetes is frequently diagnosed in childhood, adolescence, or early adulthood, it can also manifest at any stage of life.^[25-28]

Symptoms of Type 2 Diabetes:

Type 2 diabetes symptoms usually develop slowly over a period of years, with some people experiencing no symptoms initially. Although it traditionally affects adults, there are a growing number of cases being diagnosed in children and teenagers. Given its subtle symptomatology, understanding the risk factors for type 2 diabetes is crucial. If any symptoms are noticed, it is advisable to consult a healthcare professional promptly.^[25-28]

Symptoms of Gestational Diabetes:

Gestational diabetes, which occurs during pregnancy, typically does not present obvious symptoms. It is recommended to screen for gestational diabetes between the 24th and

28th weeks of pregnancy. If detected, necessary measures can be implemented to safeguard the well-being of both the mother and the baby. [25-28]

Symptoms in Male:

Men suffering from diabetes may experience particular symptoms beyond those commonly observed. These can encompass reduced libido, erectile dysfunction (ED), and diminished muscular endurance. [25-28]

Symptoms in Female:

In contrast, females diagnosed with diabetes may encounter particular symptoms like lack of moisture in the vaginal area, urinary tract infections, yeast infections, and dry, irritated skin. [25-28]

1.17 DIABETES PREVENTION

Since an immune system problem is the root cause of type 1 diabetes, it cannot be prevented. You also have no control over some of the factors that contribute to type 2 diabetes, such as your age or DNA. However, many additional risk factors for diabetes are controllable. The majorities of diabetes prevention techniques call for minor dietary and exercise modifications. Here are some strategies to postpone or avoid type 2 diabetes if you have been diagnosed with prediabetes:

To reduce the chances of developing diabetes, people should engage in a minimum of 150 minutes of physical activity each week, such as walking or cycling. It is recommended to reduce intake of saturated fats, trans fats, and refined carbohydrates. Consuming more fruits, vegetables, and whole grains is advantageous, along with managing portion sizes by opting for smaller servings. Additionally, overweight or obese individuals should aim to reduce their body weight by 5% to 7%.

While these strategies are beneficial, exploring additional approaches is recommended to further prevent this chronic health condition. [25-28]

Treatment of Diabetes**Type 1 Diabetes**

Type of Insulin	Onset Time	Duration of Action
Rapid-acting insulin	Within 15 minutes	2 to 4 hours
Short-acting insulin	Within 30 minutes	3 to 6 hours
Intermediate-acting insulin	Within 2 to 4 hours	12 to 18 hours
Long-acting insulin	2 hours after injection	Up to 24 hours
Ultra-long acting insulin	6 hours after injection	36 hours or more
Premixed insulin	Within 5 to 60 minutes	10 to 16 hours

Type 2 diabetes

Individuals with type 2 diabetes may get relief from Diabetes Mellitus by benefit from diet and exercise. You may need to take medicine to decrease your blood sugar if making lifestyle changes isn't enough. These medications reduce blood sugar in several ways, including:

Table 1.1 List of Chemical drugs used as Antidiabetic

Drug	How it works	Examples
Alpha-glucosidase inhibitors	slow your body's breakdown of sugars and starchy foods	Acarbose(Precose) andMiglitol
Biguanides	Reduce the amount of glucose your liver makes	Metformin (Glucophage,Riomet)
DPP-4 inhibitors	Improve your blood sugar without making it drop too low	Alogliptin(Nesina),Linagliptin (Tradjenta),Saxagliptin (Onglyza),and Sitagliptin(Januvia)
Glucagon-like	stimulate your pancreas	Semaglutide (Ozempic),

peptides	to produce more insulin; slow stomach emptying	Dulaglutide (Trulicity), Exenatide (Byetta), and Liraglutide (Victoza)
Meglitinides	Stimulate your pancreas to release more insulin	Nateglinide and Repaglinide
SGLT 2 inhibitors	Release more glucose in to the urine	Canagliflozin (Invokana), Dapagliflozin (Farxiga), and Empagliflozin (Jardiance)
Sulfonyl ureas	Stimulate your pancreas to release more insulin	Glyburide (Glynase), Glipizide (Glucotrol), and Glimepiride (Amaryl)
Thiazolidinediones	Help insulin work better	Pioglitazone (Actos) and Rosiglitazone

To effectively manage type 2 diabetes, it may be necessary to prescribe several medications concurrently. Additionally, some individuals with type 2 diabetes may require insulin therapy. ^[29-30]

Gestational diabetes

During pregnancy, it is crucial to regularly monitor blood sugar levels throughout the day. Adjustments in physical activity and diet are often sufficient to control high blood sugar levels. Nevertheless, research suggests that around 15% to 30% of expectant mothers diagnosed with gestational diabetes may require insulin therapy to effectively manage their blood sugar levels. Importantly, it should be noted that insulin treatment does not present risks to the developing foetus. ^[27-29]

Diabetes diagnosis

Diagnosing diabetes often includes screening for gestational diabetes during the second or third trimester of pregnancy. Healthcare providers use several blood tests to detect prediabetes and diabetes, including:

- **Fasting Plasma Glucose (FPG) Test:** Measures blood sugar levels after an overnight fast of at least 8 hours.
- **HbA1C Test:** Provides information about average blood sugar levels over the past three months.
- **Gestational diabetes:** Diagnosis typically involves healthcare professionals conducting blood sugar level assessments during weeks 24 to 28 of pregnancy. Two different types of tests are commonly employed for this evaluation.
- **Glucose challenge test:** An hour after consuming a sugary beverage, blood sugar is measured for a glucose challenge test. No further testing is necessary for typical findings. However, if your blood sugar levels are elevated, a glucose tolerance test is required.
- **Glucose tolerance test:** Your blood sugar is measured during a glucose tolerance test following an overnight fast. After receiving a sugar-filled beverage, blood sugar is checked again an hour later and again two hours later. In the event that any of these three blood sugar values are not high, gestational diabetes is diagnosed. ^[28-30]

1.18 DIABETES PREVENTION:

Type 1 diabetes develops due to an autoimmune disorder and cannot be prevented. On the other hand, factors like genetic predisposition, age, and others contribute to type 2 diabetes, which are not controllable. However, there are several modifiable risk factors for diabetes. Strategies for prevention focus on adjustments in diet and exercise.

For individuals with prediabetes, steps can be taken to delay or prevent progression to type 2 diabetes:

- Engage in at least 150 minutes of aerobic exercise weekly.
- Reduce intake of saturated fats, Tran's fats, and refined carbohydrates.

- Increase consumption of fruits, vegetables, and whole grains.
- Control portions during meals.
- Aim to lose 5% to 7% of body weight if overweight or obese. [25-29]

1.19 ROLE OF HERBAL MEDICINE IN DIABETES MANAGEMENT:

In the management of diabetes, traditional herbal medicines are commonly administered in extract form due to their observed efficacy. Numerous clinical studies have validated the anti-diabetic properties of medicinal plant extracts, which have been shown to aid in restoring the functionality of pancreatic β -cells. [31-32]

Allium sativum:

Garlic, scientifically identified as *Allium sativum* and part of the Liliaceae family, is recognized for its ability to lower blood sugar levels. Research indicates that garlic extract, when given at a dosage of 10 ml/kg/day, demonstrates significant hypoglycemic effects. It has been shown to be more efficacious in reducing blood glucose levels than Glibenclamide; a frequently prescribed medication for diabetes. Research conducted on rats treated with STZ has shown that different extracts of garlic (ethanol, ethyl acetate, and petroleum ether) possess anti-diabetic properties. Apart from its anti-diabetic effects, garlic is also recognized for its medicinal advantages, including antibacterial, anti-platelet, and properties that contribute to lowering blood pressure and cholesterol.

Aloe borbadensis:

Aloe vera, also known as Ghikanvar and belonging to the Liliaceae family, features cactus-like characteristics with thick, tapered, hairy, green leaves filled with a clear gel. Research indicates that administering 150 mg/kg of aloe vera aqueous extract orally significantly lowers blood glucose levels. Moreover, aloe vera gel provides various therapeutic benefits including anti-diabetic effects and antioxidant properties, while also increasing glutathione levels by up to fourfold in diabetic rats.

Azadirachta indica:

Azadirachta indica, commonly known as neem and belonging to the Meliaceae family, is native to India and Burma. Studies have indicated that both ethanolic and aqueous extracts of neem can effectively lower blood glucose levels, particularly in high dosages. This makes it a potential adjunct to allopathic drugs for managing type 2 diabetes when

conventional treatments alone are insufficient. Neem tablets derived from natural extracts are widely used in the treatment of diabetes globally, known for their ability to improve blood circulation by dilating blood vessels while reducing blood glucose levels in the body.

Brassica juncea:

It is a member of the Cruciferae family and is referred to as Rai. It's commonly used as a spice in a variety of dishes. In diabetic rats given alloxan, aqueous seed extract was shown to have blood sugar-lowering properties. The extract exhibits hypoglycemic action at dosages of 250, 350, and 450 mg/kg.

Carica papaya:

Carica papaya, belonging to the Caricaceae family and commonly referred to as papaya, has shown positive impacts like lowering blood sugar levels, reducing lipids, and improving wound healing in diabetic rats induced with alloxan. Extracts derived from its seeds and leaves were utilized to illustrate these advantageous properties.

Catharanthus roseus:

Catharanthus roseus, also known as Vinca roseus and belonging to the Apocynaceae family, has been found to exhibit hypoglycemic effects in alloxan-induced diabetic rats when treated with methanolic extracts from its leaves and twigs. Oral administration of a 500 mg/kg dose of these extracts effectively reduces blood glucose levels in animals. This effect is believed to occur through the stimulation of insulin synthesis from the β cells of Langerhans.

Coriandrum sativum:

Coriandrum sativum, also known as coriander and belonging to the Umbelliferae family, is widely utilized as a spice in different culinary traditions. According to research results, the seed extract shows promising insulintropic effects by enhancing the β cells of Langerhans and reducing serum glucose levels in alloxan-induced diabetic rats when administered at a dose of 200 mg/kg.

Eugenia jambolana:

Eugenia jambolana, known as jamun and belonging to the Myrtaceae family, contains bioactive compounds such as malvidin 3-laminaribioside and ferulic acid. The dried seed

extract of *Eugenia jambolana* is used at a dose of 200 mg/kg for treating individuals with diabetes.

Gymnema sylvestre:

Gymnema sylvestre, also known as Gudmar and part of the Asclepidaceae family, has demonstrated potential in reducing blood sugar levels in streptozotocin-induced rats when treated with its leaf extract. This herb is widely utilized in traditional Indian ayurvedic medicine for diabetes management. Its constituents include alkaloids, flavonoids, saponins, and carbohydrates, which are also employed in treating conditions like cancer, inflammation, and microbial infections.

Mangifera indica:

Mangifera indica, also known as mango and classified in the Anacardiaceae family, has been studied for its potential anti-diabetic properties. Studies have shown that administering a leaf extract at a dose of 250 mg/kg effectively lowers blood glucose levels. However, orally administering the aqueous extract did not significantly impact blood glucose levels in diabetic rats induced with alloxan.

Momordica charantia:

Momordica charantia, also known as bitter melon or karela, belongs to the Cucurbitaceae family. It contains bioactive compounds such as Momordic I, Momordic II, and Cucurbitacin B, which contribute to its hypoglycemic properties. These effects are believed to be mediated by a lectin that mimics insulin and interacts with body tissues. Research has shown significant hypoglycemic effects from an extract of *M. charantia* fruit administered at a dose of 200 mg/kg in studies.

Armillaria mellea:

Armillaria mellea, a frequently consumed edible mushroom, is recognized for its polysaccharides that exhibit anti-inflammatory, antioxidant, and immunomodulatory effects. Studies suggest that these polysaccharides may enhance insulin secretion in pancreatic cells exposed to alloxan by neutralizing free radicals.

Zingiber officinale:

Zingiber officinale, commonly known as ginger, exhibits glycemic control in diabetes mellitus by inhibiting critical enzymes involved in carbohydrate metabolism and enhancing insulin release and sensitivity. Its lipid-lowering effects improve insulin resistance, and it also protects against diabetic-related complications.

Sesbania grandiflora:

Sesbania grandiflora is employed for multiple purposes such as anticancer, antioxidant, cardioprotective, antiulcer, and hepatoprotective effects. It is rich in campesterol and beta-sitosterol found in both its pods and leaves. Research indicates that the aqueous leaf extract helps lower elevated blood glucose levels and lipid profiles in diabetic rats induced by STZ.

Beta vulgaris:

Beta vulgaris widely recognized as beetroot and beet leaves, has a history of medicinal use. It has been noted for its hypoglycemic, insulin-sensitizing, and antioxidant effects. Studies have demonstrated potential in decreasing hepatic steatosis and liver damage in rats with type 2 diabetes mellitus through augmentation of PPAR α activity. [31-35]

1.20 FUTURE PERSPECTIVES OF HERBAL REMEDIES FOR DIABETES MELLITUS:

The utilization of herbal medicines continues to expand, with numerous traditional remedies incorporated into modern therapeutic practices. In many developing regions, especially rural areas, approximately 80% of the population relies on traditional medicine to fulfil their healthcare needs. Furthermore, developed countries are experiencing renewed interest in herbal medicines, driven by an increasing preference for natural products. It is crucial to differentiate between herbal remedies prescribed by healthcare professionals and those widely available for self-medication.

The increasing global prevalence of diabetes mellitus highlights the urgency of investigating alternative therapies. Recent breakthroughs in medical research have unveiled new bioactive compounds sourced from plants, demonstrating enhanced anti-diabetic efficacy compared to traditional oral hypoglycemic medications. There is a rising enthusiasm for identifying plants harboring potential anti-diabetic properties, which may

facilitate the future development of novel oral therapies for diabetes mellitus management.

Ongoing research in this area could lead to new methods for managing diabetes, providing additional natural remedy options to support current treatments. Utilizing the healing properties of herbal remedies may improve the overall effectiveness and outcomes of diabetes care. ^[35]

