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Original Article

A Review on Herbal Excipients Derived from Agro-Industrial Wastes

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ABSTRACT

Excipients are ingredients used in pharmaceutical preparation that are essential for product analysis, drug distribution, stability, preservation, and bioavailability. Agar, starch, alginate, carrageenan, xanthan gum, gelatin, acacia, pectin, tragacanth, guar gum, and cellulose are examples of natural excipients that are used in the pharmaceutical industry as binders, retainers, preservatives, disintegrants, gelling agents, colloids, thickeners, suppository bases, stabilisers, and coatings. Intellectual property rights, integrated processes, and low energy consumption are some of the challenges faced by plant-based products. Natural polymers are the subject of most pharmaceutical research. The most widely used natural material, cellulose, generates 50 billion tonnes of biomass yearly. The length of the sugar chains determines the wide, rod-like shape of this linear polymer.

Keywords: Herbal excipients, Agro-industrial waste, Plant-derived excipients, Natural polymers

INTRODUCTION

Agro-industrial waste has become a promising renewable source for creating natural pharmaceutical excipients. Each year, significant amounts of by-products such as fruit peels, seed husks, pomace, stalks, and fiber residues are produced by the food processing and agricultural sectors. Rather than being disposed of, these materials can be converted into valuable plant-derived polymers like mucilage, pectin, starch, cellulose, and natural gums. Their widespread availability, biodegradability, and minimal environmental impact make them compelling alternatives to standard synthetic excipients in modern formulations. These waste materials are used to make herbal excipients, which offer unique functional advantages. In a variety of delivery forms, including tablets, suspensions, gels, and controlled release systems, many exhibit exceptional qualities for binding, disintegration, swelling, stabilisation, and film formation. When compared to their synthetic counterparts, these compounds frequently offer improved biocompatibility and reduced toxicity because they are derived from edible or medicinal plants. [1]

1.1 Classification of Herbal Excipients from Agro-Industrial Waste:

1.1.1 Classification based on their functional role in formulation:

- **Binders:** Herbal substances that provide binding properties, holding the tablet or capsule together. Examples: starch, cellulose, pectin.
- **Fillers:** Herbal substances that add bulk to the formulation, improving its size and flow. Examples: lactose, mannitol, herbal powders.
- **Disintegrants:** Herbal substances that help break down the tablet or capsule, releasing the API. Examples: croscarmellose, crospovidone, herbal gums.
- **Lubricants:** Herbal substances that reduce friction, improving the flow of the formulation. Examples: magnesium stearate, herbal waxes.

1.1.2 Classification based on their sources of agro-industrial waste:

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- **Fruit Waste:** Excipients derived from fruit peels, seeds, and pulp.

Examples: pectin from citrus peels, starch from banana peels.

- **Grain Waste:** Excipients derived from grain husks, bran, and straw.

Examples: starch from rice bran, cellulose from wheat straw.

- **Vegetable Waste:** Excipients derived from vegetable peels, leaves, and stems.

Examples: cellulose from sugarcane bagasse, pectin from potato peels.

- **Seed Waste:** Excipients derived from seed husks and shells.

Examples: starch from sesame seeds, oil from neem seeds.

1.2 Advantages of Herbal Excipients from Agro Waste:

- **Cost-efficient:** Agro-industrial waste is typically plentiful and low cost, serving as an affordable source for producing excipients.
- **Environmentally friendly and sustainable:** Leveraging waste helps minimize environmental pollution and supports sustainability by repurposing plant-based by-products.
- **Safe and biocompatible:** Herbal excipients are usually non-toxic, biodegradable, and better tolerated by the body compared to synthetic alternatives
- **Natural functional characteristics**: Numerous herbal excipients have innate functions, such as binding, emulsifying, gelling, thickening, or stabilizing, which can improve drug formulations.
- **Renewable resource:** Plants and their by-products are renewable, ensuring a consistent supply for excipient manufacturing.

1.3 Disadvantages of Herbal Excipients from Agro Waste:

- **Quality inconsistency:** The chemical makeup of plant-based excipients can fluctuate due to differences in species, growing conditions, harvest timing, and processing methods, resulting in variability between batches.
- **Risk of microbial contamination:** As natural substances, these excipients are susceptible to microbial growth, necessitating meticulous sterilization or preservation measures.
- **Stability concerns:** Some herbal excipients may be affected by moisture, light, temperature, or pH variations, potentially compromising the stability of the final product.
- **Weaker mechanical properties:** Certain natural excipients might possess inferior binding or compressibility compared to synthetic counterparts, which can restrict their application in various solid dosage forms.
- **Allergen potential:** Some plant-based excipients could trigger allergic reactions in individuals who are sensitive.

OBJECTIVES

- **Develop and Characterize Novel Excipients**: To isolate, purify, and characterize functional polymeric materials from agro-industrial waste for use as excipients.
- **Evaluate Excipient Performance:** To evaluate the functional properties of the derived herbal excipients in various pharmaceutical dosage forms.
- **Enhance Biocompatibility and Safety:** To utilize materials that are inherently non-toxic, biocompatible, and biodegradable, thereby improving the safety profile of the final pharmaceutical product compared to certain synthetic alternatives.
- **Improve Drug Delivery Systems:** To chemically or physically modify the natural polymers to enhance their functional properties, enabling their application in advanced drug delivery systems.

3. Herbal Excipients from Agro-Industrial Waste and Their Sources:

3.1 Cellulose

3.1.1 Cotton Fibres

Fig 1. Cotton Fibres

- **Synonyms:** Goni cotton, Cotton wool
- **Biological Source:** Cotton fibres are derived from the seeds of plants belonging to the genus Gossypium.
- **Family:** Malvaceae
- **Chemical Constituents:** Cellulose (90-95%), wax, pectin, proteins, and other minor components.
- **Pharmaceutical Application:**
  - Used as a filter aid and adsorbent in pharmaceutical manufacturing.
  - Used in wound dressings and medical textiles due to its absorbent and breathable properties.
  - Can be used as a natural polymer in drug delivery systems and tissue engineering. [2]

3.1.2 Corn Husks and Stalks

Fig 2. Corn Husks and Stalks

- **Synonyms:** Maize husks, Corn stover
- **Biological Source:** Zea mays
- **Family:** Poaceae
- **Chemical Constituents:** Cellulose (30-40%), hemicellulose (20-30%), lignin (10-20%), and other minor components
- **Pharmaceutical Application:**
  - Used as a source of cellulose for pharmaceutical excipients, such as microcrystalline cellulose.
  - Can be used as a natural adsorbent and binder in tablet formulations.
  - Potential use in bioactive packaging and biomedical applications due to its biocompatibility and biodegradability. [3]

3.1.3 Wheat Straw

Figure 3. Wheat Straw

- **Synonyms:** Triticum aestivum straw, Wheat residue
- **Biological Source:** Triticum aestivum
- **Family:** Poaceae
- **Chemical Constituents:** Cellulose (30-40%), hemicellulose (20-30%), lignin (10-20%), and other minor components
- **Pharmaceutical Application:**
  - Used as a source of cellulose for pharmaceutical excipients, such as microcrystalline cellulose
  - Can be used as a natural adsorbent and binder in tablet formulations
  - Potential use in bioactive packaging and biomedical applications due to its biocompatibility and biodegradability. [4]

3.2 Pectin

3.2.1 Citrus Peels

Figure 4. Citrus Peels

- **Synonyms:** Orange peel, Lemon peel, Lime peel
- **Biological Source:** Citrus sinensis, Citrus limon, Citrus aurantifolia
- **Family:** Rutaceae
- **Chemical Constituents:** Pectin, flavonoids (hesperidin, naringin), limonene, and other volatile oils
- **Pharmaceutical Application:**
  - Used as a source of pectin, a natural gelling agent and thickener
  - Exhibits antioxidant and antimicrobial properties, making it useful in pharmaceutical and cosmetic applications
  - Can be used as a natural adsorbent and binder in tablet formulations. [5]

3.2.2 Watermelon Rinds

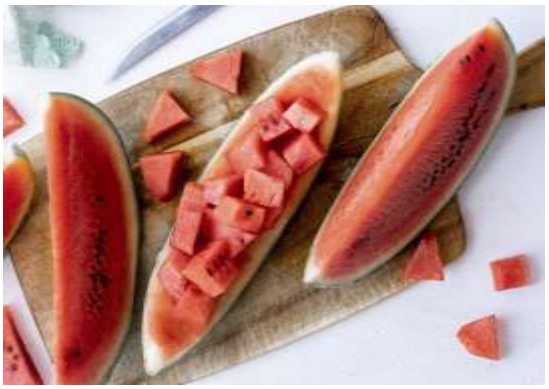

Figure 5. Watermelon Rinds

- **Synonyms:** Citrullus lanatus rind, Watermelon peel
- **Biological Source**: Citrullus lanatus
- **Family:** Cucurbitaceae
- **Chemical Constituents:** Citrulline, pectin, flavonoids, and other phytochemicals
- **Pharmaceutical Application:**
  - Used as a natural source of citrulline, an amino acid with potential cardiovascular benefits
  - Exhibits antioxidant and anti-inflammatory properties, making it useful in pharmaceutical and cosmetic applications
  - Can be used as a natural adsorbent and binder in tablet formulations. [6]

3.2.3 Banana Peels

Figure 6. Banana Peels

- **Synonyms:** Musa acuminata peel, Banana skin
- **Biological Source:** Musa acuminata
- **Family:** Musaceae
- **Chemical Constituents:** Potassium, vitamins, antioxidants, and dietary fiber
- **Pharmaceutical Application:**
  - Used in wound healing and skin care products due to its antioxidant and antimicrobial properties
  - Can be used as a natural adsorbent and binder in tablet formulations
  - Potential use in food and pharmaceutical industries as a natural preservative. [7]

3.3 Starch

3.3.1 Jackfruit Seeds

Figure 7. Jackfruit Seeds

- **Synonyms:** Artocarpus heterophyllus seeds, Kathal seeds
- **Biological Source:** Artocarpus heterophyllus
- **Family:** Moraceae
- **Chemical Constituents:** Carbohydrates, proteins, dietary fiber, and phytochemicals like artocarpin and cycloartenol
- **Pharmaceutical Application:**
  - Used in traditional medicine for its anti-inflammatory and antimicrobial properties
  - Potential use in pharmaceutical applications due to its antioxidant and anti-diabetic properties
  - Can be used as a natural adsorbent and binder in tablet formulations. [8]

3.3.2 Cassava Stem Residues

Figure 8. Cassava Stem Residues

- **Synonyms:** Manihot esculenta stem, Tapioca stem
- **Biological Source:** Manihot esculenta
- **Family:** Euphorbiaceae
- **Chemical Constituents:** Cellulose, hemicellulose, lignin, and other minor components
- **Pharmaceutical Application:**
  - Can be used as a natural adsorbent and binder in tablet formulations
  - Potential use in bioactive packaging and biomedical applications due to its biocompatibility and biodegradability
  - Used in traditional medicine for its anti-inflammatory and antimicrobial properties. [9]

3.3.3 Potato Peels

Figure 9. Potato Peels

- **Synonyms:** Solanum tuberosum peels, Aloo peels
- **Biological Source:** Solanum tuberosum
- **Family:** Solanaceae
- **Chemical Constituents:** Glycoalkaloids, flavonoids, and dietary fiber
- **Pharmaceutical Application:**
  - Exhibits antioxidant and antimicrobial properties, making it useful in pharmaceutical and cosmetic applications
  - Potential use in pharmaceutical applications due to its anti-inflammatory and anti-cancer properties
  - Can be used as a natural adsorbent and binder in tablet formulations [10].

3.4 Mucilage

3.4.1 Hibiscus Leaves

Figure 10. Hibiscus Leaves

- **Synonyms:** Hibiscus sabdariffa leaves, Roselle leaves
- **Biological Source:** Hibiscus sabdariffa
- **Family:** Malvaceae
- **Chemical Constituents:** Flavonoids, anthocyanins, and other phytochemicals
- **Pharmaceutical Application:**
  - Used in traditional medicine for its anti-inflammatory and antimicrobial properties
  - Exhibits antioxidant and anti-hypertensive properties, making it useful in pharmaceutical applications
  - Can be used as a natural food colorant and dye. [3]

3.4.2 Tamarind Seed Coat

Figure 11. Tamarind Seed Coat

- **Synonyms:** Tamarindus indica seed husk, Imli seed coat
- **Biological Source:** Tamarindus indica
- **Family:** Fabaceae
- **Chemical Constituents:** Polyphenols, flavonoids, and polysaccharides
- **Pharmaceutical Application:**
  - Used as a natural adsorbent and binder in tablet formulations
  - Exhibits antioxidant and antimicrobial properties, making it useful in pharmaceutical applications
  - Potential use in wound healing and skin care products. [7]

3.4.3 Bael Fruit Pulp

Figure 12. Bael Fruit Pulp

- **Synonyms:** Aegle marmelos pulp, Bilva fruit pulp
- **Biological Source:** Aegle marmelos
- **Family:** Rutaceae
- **Chemical Constituents:** Alkaloids, flavonoids, and other phytochemicals
- **Pharmaceutical Application:**
  - Used in traditional medicine for its anti-inflammatory and antimicrobial properties
  - Exhibits antioxidant and anti-diabetic properties, making it useful in pharmaceutical applications
  - Can be used as a natural expectorant and cough suppressant. [4]

3.5 Natural Waxes

3.5.1 Sunflower Seed Husks

Figure 13. Sunflower Seed Husks

- **Synonyms:** Helianthus annuus husks, Sunflower seed coats
- **Biological Source:** Helianthus annuus
- **Family:** Asteraceae
- **Chemical Constituents:** Cellulose, hemicellulose, lignin, and other minor components
- **Pharmaceutical Application:**
  - Can be used as a natural adsorbent and binder in tablet formulations
  - Potential use in bioactive packaging and biomedical applications due to its biocompatibility and biodegradability
  - Exhibits antioxidant and antimicrobial properties, making it useful in pharmaceutical applications. [2]

3.5.2 Coconut Husks

Figure 14. Coconut Husks

- **Synonyms:** Cocos nucifera husks, Coir
- **Biological Source:** Cocos nucifera
- **Family:** Arecaceae
- **Chemical Constituents:** Cellulose, hemicellulose, lignin, and other minor components
- **Pharmaceutical Application:**
  - Can be used as a natural adsorbent and binder in tablet formulations
  - Potential use in bioactive packaging and biomedical applications due to its biocompatibility and biodegradability
  - Exhibits antimicrobial properties, making it useful in pharmaceutical applications. [6]

3.5.3 Peanut Shell Residues

Figure 15. Peanut Shell Residues

- **Synonyms:** Arachis hypogaea shells, Groundnut shells
- **Biological Source:** Arachis hypogaea
- **Family:** Fabaceae
- **Chemical Constituents:** Cellulose, hemicellulose, lignin, and other minor components
- **Pharmaceutical Application:**
  - Can be used as a natural adsorbent and binder in tablet formulations
  - Potential use in bioactive packaging and biomedical applications due to its biocompatibility and biodegradability
  - Exhibits antioxidant and antimicrobial properties, making it useful in pharmaceutical applications. [8]

CONCLUSION

Herbal excipients sourced from agro-industrial waste offer a sustainable and environmentally friendly alternative to traditional synthetic excipients in pharmaceutical formulations. Their abundant availability, biodegradability, and low environmental impact make them appealing for use in various dosage forms like tablets, capsules, suspensions, and emulsions. Research has shown that these natural excipients including mucilage, pectin, starch, cellulose, and natural gums act not only as binders, disintegrants, and stabilizers but also provide extra benefits such as controlled release and improved bioavailability. In summary, the use of agro-industrial waste for producing herbal excipients is in line with green chemistry principles and sustainable pharmaceutical development. With further optimization and regulatory backing, these natural excipients have the potential to play a significant role in creating safe, effective, and environmentally friendly pharmaceutical products.

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