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Herbal Fast-Dissolving Oral Films: Bridging Phytotherapy and Innovative Drug Delivery

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Abstract: *Fast-dissolving oral films (FDOFs), also known as oral thin films (OTFs) or mouth-dissolving films (MDFs), are innovative drug delivery systems designed to dissolve or disintegrate rapidly in the oral cavity without the need for water. These thin polymeric films offer advantages such as ease of administration, portability, improved patient convenience, and suitability for paediatric, geriatric, and dysphagic patients. Herbal fast-dissolving oral films have gained research interest as a potential approach for incorporating plant extracts and phytoconstituents into convenient oral dosage forms. They are generally formulated using natural or synthetic film-forming polymers, plasticizers, sweeteners, flavouring agents, and other suitable excipients. Various manufacturing techniques, including solvent casting and hot-melt extrusion, may be employed depending on the properties of the herbal ingredients and formulation components. The quality and performance of these films are assessed using parameters such as thickness, weight variation, folding endurance, surface pH, content uniformity, mechanical strength, disintegration time, drug release, and stability. Depending on the formulation and absorption pathway, the released constituents may produce local effects or undergo systemic absorption. However, improved bioavailability and therapeutic efficacy must be established experimentally. This review discusses the formulation components, polymer selection, manufacturing methods, packaging materials, evaluation parameters, advantages, limitations, and potential applications of herbal fast-dissolving oral films in pharmaceutical drug delivery.*

Keywords: Herbal fast-dissolving oral films, oral thin films, herbal extracts, film-for.

I. INTRODUCTION

Herbal medicines have been used for centuries in healthcare systems worldwide and continue to attract scientific and pharmaceutical interest. Medicinal plants contain diverse bioactive constituents that may possess antioxidant, antimicrobial, anti-inflammatory, and other pharmacological properties. The incorporation of herbal extracts into novel drug delivery systems offers opportunities to develop convenient dosage forms while addressing challenges associated with the administration, stability, and acceptability of herbal preparations.

The oral route is one of the most widely used routes of drug administration because of its convenience, patient acceptance, and ease of administration. However, conventional oral solid dosage forms, such as tablets and capsules, may be difficult to swallow for certain populations, including paediatric, geriatric, bedridden, and dysphagic patients. These difficulties may reduce patient compliance and interfere with the appropriate administration of medicines. Consequently, alternative oral dosage forms that are easy to administer and do not require water have gained considerable attention.

Fast-dissolving oral films (FDOFs), also known as oral thin films (OTFs) or mouth-dissolving films (MDFs), are thin, flexible polymeric dosage forms designed to dissolve or disintegrate rapidly upon contact with saliva. This technology was influenced by advances in transdermal drug delivery systems and has subsequently been developed for oral drug administration. Unlike orally disintegrating tablets (ODTs), which are compressed solid dosage forms, oral films are prepared as thin polymeric sheets that can be placed on the tongue or against the buccal mucosa.

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Fast-dissolving oral films are generally formulated using hydrophilic film-forming polymers, plasticizers, and suitable excipients such as sweeteners, flavouring agents, saliva-stimulating agents, and preservatives, where necessary. The active ingredient or herbal extract is incorporated into the polymeric matrix to produce a film with acceptable flexibility, mechanical strength, uniformity, taste, and disintegration characteristics. Upon contact with saliva, the film hydrates and dissolves or disintegrates, releasing its incorporated constituents.

Herbal fast-dissolving oral films represent a potential approach for delivering selected plant extracts and phytoconstituents in a convenient dosage form. Depending on the formulation and the properties of the incorporated constituents, these films may be designed for local effects in the oral cavity or for subsequent gastrointestinal or oral-mucosal absorption. However, improved bioavailability, faster onset of action, and therapeutic efficacy cannot be assumed for all herbal formulations and must be established through appropriate experimental studies.

Medicinal plants such as guava (*Psidium guajava*) and betel leaf (*Piper betle*) have been investigated for various biological properties, including antimicrobial and antioxidant activities. Their extracts may be considered for oral film development when supported by suitable evidence regarding their intended application, safety, compatibility, and formulation characteristics. Nevertheless, the effectiveness of a herbal oral film depends on the quality of the extract, the concentration of active constituents, the selected excipients, and the performance of the final formulation.

Therefore, herbal fast-dissolving oral films are an emerging area of pharmaceutical formulation research. Their development requires appropriate selection of herbal ingredients and polymers, optimization of manufacturing methods, and systematic evaluation of physicochemical properties, mechanical performance, disintegration, release characteristics, stability, and safety.

II. NEED FOR PREPARING HERBAL FAST-DISSOLVING ORAL FILMS

Conventional tablets and capsules may present administration difficulties for patients who experience swallowing problems, particularly children, older adults, bedridden patients, and individuals with dysphagia. Some patients may also have difficulty taking medicines when drinking water is inconvenient or unavailable. These challenges create a need for alternative dosage forms that are easy to handle, portable, and convenient to administer.

Herbal fast-dissolving oral films are being investigated as one such alternative. Their thin and flexible structure allows them to be placed on the tongue or at an appropriate oral-mucosal site, where contact with saliva promotes hydration and dissolution or disintegration. This can facilitate administration without the need to swallow an intact tablet or capsule.

The formulation of herbal extracts into oral films may also improve convenience and acceptability when the taste, stability, dose uniformity, and compatibility of the herbal ingredients are adequately addressed. Furthermore, film technology provides a platform for incorporating selected plant-derived constituents into a unit-dose format.

However, oral films do not automatically provide greater safety, bioavailability, or therapeutic efficacy than conventional dosage forms. Their suitability depends on the intended route of absorption, the dose required, the physicochemical properties of the herbal constituents, and the results of formulation and performance studies.

III. CONCEPT OF FAST-DISSOLVING ORAL FILMS

Fast-dissolving oral films are thin polymeric dosage forms containing an active pharmaceutical ingredient or herbal extract dispersed or incorporated within a suitable film-forming matrix. They are designed to hydrate, dissolve, or disintegrate rapidly upon contact with saliva.

The film is placed on the tongue or at a specified oral-mucosal site, depending on its intended use. Saliva penetrates the film matrix, facilitating polymer hydration and the release of the incorporated constituents. The released material may produce a local effect in the oral cavity, be absorbed through the oral mucosa, or be swallowed and subsequently absorbed through the gastrointestinal tract.

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The performance of an oral film depends on its composition, thickness, polymer properties, mechanical strength, disintegration characteristics, and the properties of the incorporated active constituents. Consequently, formulation development and quality-control testing are essential to establish its suitability for the intended application.

4.1. ADVANTAGES OF HERBAL FAST-DISSOLVING ORAL FILMS

- Ease of administration: They can be administered without swallowing an intact tablet or capsule.
- Water-free administration: They generally do not require water for administration.
- Patient convenience: Their thin, lightweight structure makes them convenient to carry and use.
- Suitability for selected patient populations: They may be useful for paediatric, geriatric, and other patients who have difficulty swallowing conventional solid dosage forms, subject to appropriate formulation and clinical suitability.
- Unit-dose delivery: Each film can be manufactured to contain a specified quantity of herbal extract or active constituent, provided adequate content uniformity is achieved.
- Potential for rapid drug release: Hydrophilic polymers can facilitate rapid hydration and dissolution or disintegration of the film.
- Formulation flexibility: Different natural and synthetic polymers can be evaluated to obtain the desired flexibility, strength, disintegration time, and release characteristics.
- Potential for local oral delivery: Selected herbal constituents may be formulated for applications involving the oral mucosa when their safety and efficacy are adequately established.
- Potential to improve acceptability: Suitable sweeteners and flavouring agents may help mask unpleasant tastes associated with some herbal extracts.
- Potential for oral-mucosal absorption: Certain active constituents may be absorbed through the oral mucosa, depending on their physicochemical properties and the formulation design.

4.2. DISADVANTAGES OF HERBAL FAST-DISSOLVING ORAL FILMS

- Limited dose-loading capacity: The thin film matrix may restrict the amount of herbal extract or active constituent that can be incorporated.
- Taste-masking challenges: Some herbal extracts possess bitter, pungent, or unpleasant tastes that may be difficult to mask completely.
- Moisture sensitivity: Certain film formulations may absorb moisture, resulting in changes in mechanical strength, flexibility, disintegration, or stability.
- Mechanical limitations: Films may become brittle, sticky, or prone to tearing if the polymer-to-plasticizer ratio and manufacturing conditions are unsuitable.
- Compatibility concerns: Herbal extracts may interact with polymers or other excipients, potentially affecting film formation, stability, or constituent release.
- Stability challenges: Herbal constituents may undergo degradation due to moisture, light, oxygen, temperature, or other environmental factors.
- Manufacturing and packaging requirements: Uniform thickness, content uniformity, adequate mechanical properties, and suitable moisture-protective packaging must be achieved.
- Limitations for certain ingredients: Constituents that irritate the oral mucosa or are unstable under relevant formulation conditions may be unsuitable without appropriate modifications and safety evaluation.
- Variable herbal composition: The phytochemical profile of herbal extracts may vary with plant species, growing conditions, harvesting, processing, and extraction methods.

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- Bioavailability is not guaranteed: Rapid film dissolution does not necessarily result in increased systemic absorption or avoidance of first-pass metabolism. These outcomes depend on the absorption pathway and the characteristics of the incorporated constituents.

V. MECHANISM OF ACTION

Fast-dissolving oral films are thin polymeric dosage forms designed to release their incorporated active ingredients upon contact with saliva. The film is placed on the tongue or at an appropriate oral-mucosal site, depending on its intended application. Saliva penetrates the hydrophilic polymer matrix, causing hydration, dissolution, or disintegration of the film and facilitating the release of the incorporated drug or herbal constituents.

Following release, the constituents may exert a local effect within the oral cavity, undergo absorption through the oral mucosa, or be swallowed and absorbed through the gastrointestinal tract. The extent and rate of absorption depend on the physicochemical properties of the active constituents, the formulation composition, and the intended site of administration. Therefore, rapid film dissolution does not necessarily indicate rapid systemic absorption or increased bioavailability.

VI. IDEAL FEATURES OF ORAL THIN FILMS

An ideal oral thin film should possess the following characteristics:

- **Acceptable taste:** The film should have a pleasant or acceptable taste to improve patient acceptability.
- **Rapid dissolution or disintegration:** It should dissolve or disintegrate rapidly upon contact with saliva.
- **Adequate mechanical strength:** The film should possess sufficient tensile strength and flexibility to withstand handling, packaging, and transportation.
- **Uniform thickness and content:** The film should have uniform thickness and contain a consistent quantity of the active ingredient or herbal extract.
- **Suitable moisture resistance:** The film should maintain its physical integrity and stability during storage and should be protected from excessive moisture.
- **Appropriate surface pH:** The surface pH should be compatible with the intended oral-mucosal application to minimize irritation.
- **Suitable release characteristics:** The film should release its incorporated constituents according to the intended formulation objectives.
- **Chemical and physical stability:** The film should retain its quality throughout its intended shelf life under recommended storage conditions.
- **Patient convenience:** It should be thin, lightweight, portable, and easy to administer without requiring water.
- **Suitable absorption characteristics:** For formulations intended for oral-mucosal absorption, the active constituents should possess appropriate physicochemical properties for permeation across the mucosa.

VII. DIFFERENCES BETWEEN ORAL THIN FILMS (OTFs) AND ORALLY DISINTEGRATING TABLETS (ODTs)

SN	Oral Thin Films (OTFs)	Orally Disintegrating Tablets (ODTs)
1	Thin, flexible polymeric sheets.	Solid tablets designed to disintegrate rapidly in the oral cavity.
2	Generally have a large surface-area-to-volume ratio, facilitating rapid hydration and dissolution.	Disintegration depends on tablet composition, porosity, and the use of suitable disintegrants.
3	Usually flexible when appropriately formulated but may tear or become brittle.	Generally rigid but may be fragile or friable, depending on the formulation.

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4	Convenient for patients who have difficulty swallowing conventional tablets, subject to suitability.	Also suitable for patients who have difficulty swallowing conventional tablets.
5	Usually have limited dose-loading capacity.	Often accommodate higher doses, depending on tablet size and formulation.
6	May be designed for local oral action, oral-mucosal absorption, or swallowing after dissolution.	Generally disintegrate in the oral cavity, after which the drug is commonly swallowed.
7	Require suitable packaging to protect against moisture and mechanical damage.	Require packaging appropriate to their mechanical strength and moisture sensitivity.
8	Typically prepared using methods such as solvent casting or hot-melt extrusion.	Commonly prepared using direct compression, lyophilization, or other suitable tablet-manufacturing techniques.

VIII. EVALUATION TESTS FOR HERBAL FAST-DISSOLVING ORAL FILMS

The evaluation of herbal fast-dissolving oral films is essential to determine their physical characteristics, mechanical strength, uniformity, stability, and drug-release performance. The selection of tests depends on the formulation composition, intended use, and properties of the herbal extract. The following tests are commonly used during formulation development.

8.1 Morphological and Organoleptic Characteristics

The prepared films are visually examined for colour, appearance, transparency, homogeneity, surface texture, flexibility, and the presence of visible defects such as cracks, air bubbles, particles, or uneven surfaces. Odour and flavour may also be evaluated when appropriate. These observations help assess the general quality and acceptability of the formulation.

For herbal films, the colour and odour may vary depending on the plant extract and its concentration. Taste evaluation should use an appropriate, ethically acceptable method and should not involve unnecessary exposure to potentially irritating or biologically active extracts.

8.2 Thickness Test

Film thickness is measured using a calibrated micrometer screw gauge or digital thickness gauge. Measurements are taken at five or more different positions on each film, and the mean thickness and variability are calculated.

Uniform thickness is important because substantial variation may affect film weight, mechanical properties, disintegration, and dose uniformity. The acceptable thickness depends on the intended formulation and manufacturing process; a single thickness range is not universally applicable.

8.3 Weight Variation Test

Individual films of the same dimensions are cut from different positions or units of the prepared batch and weighed using an analytical balance. The mean weight, standard deviation, and percentage variation are calculated.

Low variation in film weight supports manufacturing consistency. However, uniform weight alone does not establish uniform distribution of the herbal constituents or active ingredient.

8.4 Folding Endurance Test

Folding endurance indicates the ability of a film to withstand repeated folding without breaking. A film is folded repeatedly at the same location until it breaks or a predefined number of folds is reached. The number of folds completed before breakage is recorded.

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Folding endurance is influenced by the type and concentration of the film-forming polymer, plasticizer content, residual moisture, and film thickness. Higher folding endurance generally indicates better flexibility, although the result should be interpreted alongside other mechanical tests.

8.5 Surface pH

Surface pH is evaluated to determine whether the film is likely to have a suitable pH for contact with the oral mucosa. A film is placed in a small, measured quantity of distilled water or another specified medium and allowed to hydrate for a defined period. The pH of the resulting wetted film or dispersion is measured using a calibrated pH meter. Alternatively, a validated surface-pH procedure may be used.

The method, medium volume, hydration time, and temperature should be kept consistent across formulations. The pH should be suitable for the intended site of administration and should not cause unnecessary irritation.

8.6 Disintegration Time Test

Disintegration time is the time required for a film to break up or lose its integrity under specified test conditions. The test may be performed using a suitable pharmacopoeial apparatus or a validated method designed for oral films.

The film is exposed to the specified medium at a controlled temperature, and the time required for the defined endpoint is recorded. The endpoint must be clearly stated, as disintegration does not necessarily mean complete dissolution of the film or complete release of the herbal constituents.

Rapid disintegration is desirable for fast-dissolving films, but the actual time depends on polymer composition, film thickness, plasticizer concentration, and test conditions. Any target range should be justified by the formulation requirements and relevant literature.

8.7 Dissolution or In Vitro Release Test

Dissolution or in vitro release testing evaluates the amount of active constituent released from the film over a specified period under controlled conditions. A suitable dissolution apparatus or validated release-testing method is selected according to the formulation and the properties of the herbal constituents.

The medium, volume, temperature, agitation conditions, sampling intervals, and analytical method should be specified and justified. A temperature of 37 ± 0.5°C may be appropriate for certain methods intended to simulate physiological conditions, but the apparatus and rotation speed must be selected according to the validated protocol rather than treated as universal settings.

For herbal formulations, the analytical method should be capable of measuring a suitable marker compound or other justified measure of release. Because plant extracts contain multiple constituents, the release of one marker does not necessarily represent the release of every constituent. Disintegration time and dissolution or release behaviour are related but distinct parameters.

8.8 Content Uniformity

Content uniformity determines whether individual films contain a consistent amount of the selected active constituent or marker compound. Individual films are analysed using a suitable validated method, such as UV-visible spectrophotometry or HPLC, depending on the chemical characteristics and specificity required.

For herbal films, a suitable marker compound should be selected when possible. The analytical method should account for potential interference from other plant constituents and excipients. Results may be expressed as the measured content per film or as a percentage of the target content, together with the mean, standard deviation, and relative standard deviation.

The number of films tested and the acceptance limits should follow the applicable pharmacopoeial requirements or a justified study protocol. A range such as 85–115% should not be described as a universal acceptance criterion for all oral films.

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8.9 Tensile Strength

Tensile strength measures the resistance of a film to breaking when a pulling force is applied. A suitable tensile-testing instrument is used to apply force to a film specimen until it breaks. The breaking force and dimensions of the specimen are recorded.For a rectangular film specimen, the cross-sectional area is calculated as film width multiplied by film thickness. If force is expressed in newtons and area in square millimetres, tensile strength is obtained in N/mm², equivalent to MPa.

Tensile strength helps characterize the mechanical integrity of the film. The result depends on polymer type, plasticizer concentration, film thickness, residual moisture, and testing conditions.

8.10 Dryness and Tack Test

Dryness testing assesses whether the film has been sufficiently dried and is suitable for handling, cutting, and packaging. The film is examined for surface stickiness, tackiness, ease of removal from the casting surface, and resistance to handling. Residual moisture or solvent may also be determined using an appropriate analytical method.

A tack test may assess the tendency of the film to adhere to a specified probe or surface under defined contact conditions. The method should be standardized because pressure, contact time, temperature, and humidity can influence the result.

Dryness and tack are important for packaging and storage, particularly when hydrophilic polymers and moisture-sensitive herbal constituents are used.

8.11 Moisture Content

Moisture content indicates the amount of water remaining in the prepared film. It can be determined using a suitable moisture analyser, a validated loss-on-drying method, or another appropriate analytical technique. Karl Fischer titration may be used when specific determination of water is required.

For the loss-on-drying method, a pre-weighed film sample is dried under specified conditions until the prescribed endpoint is reached and then reweighed.

The drying conditions must be selected carefully because heating may remove other volatile substances or degrade heat-sensitive herbal constituents. Consequently, weight loss may not always represent water alone.

Lower moisture content may improve handling and reduce stickiness, but excessive drying can make some films brittle. The target moisture content should therefore be optimized for the particular formulation rather than assuming that every film must contain less than 5% moisture.

8.12 Transparency Test

Transparency is evaluated to characterize the optical properties of the film. A film specimen of known dimensions and thickness may be examined using a UV-visible spectrophotometer at a specified wavelength, commonly 600 nm in reported methods.

Transmittance or absorbance is recorded, and results are compared between formulations under identical conditions. The method should state whether transparency is reported as percentage transmittance, absorbance, or a calculated transparency index.

Transparency may be useful for assessing film uniformity and appearance, although a transparent film is not necessarily more effective or more stable than an opaque film.

8.13 Contact Angle Measurement

Contact angle measurement evaluates the wettability of the film surface. A small droplet of distilled water is placed on the dry film surface, and the contact angle is measured using a contact-angle goniometer or suitable imaging system at a defined time after droplet placement.

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Measurements may be taken at more than one location, and the mean value is calculated. A lower contact angle generally indicates greater surface wettability, whereas a higher contact angle indicates lower wettability under the specified conditions.

Wettability may influence hydration and the initial interaction of the film with saliva. However, contact angle alone does not establish mucoadhesion or predict the complete disintegration behaviour of a film.

8.14 Scanning Electron Microscopy (SEM)

Scanning electron microscopy is used to examine the surface morphology and, when appropriate, the cross-sectional structure of the film. It can reveal surface roughness, cracks, pores, particles, and other structural features that may not be visible to the naked eye.

A representative film specimen is mounted on a suitable sample holder and prepared according to the instrument requirements. Non-conductive samples may require an appropriate conductive coating. Images are captured at suitable magnifications and compared across formulations.

SEM is a characterization technique rather than a routine requirement for every batch. It may be particularly useful when investigating the distribution of herbal extract, surface defects, or changes in film structure.

8.15 Differential Scanning Calorimetry (DSC)

Differential scanning calorimetry is used to investigate thermal transitions and possible interactions among formulation components. Samples of the herbal extract or selected marker compound, polymer, physical mixtures, and prepared films may be analysed under defined conditions.

The sample mass, pan type, atmosphere, heating rate, and temperature range must be selected according to the properties of the materials and the instrument protocol. Thermograms are examined for changes in melting events, glass transitions, or other thermal features.

DSC may provide evidence of changes in the physical state or possible interactions among components. However, the absence or shift of a thermal peak alone does not conclusively establish compatibility; results should be interpreted alongside other analytical techniques when necessary.

8.16 Stability Studies

Stability studies evaluate whether the film maintains its quality during storage. Samples are stored in suitable packaging under defined conditions of temperature and relative humidity for a specified period. At predetermined intervals, selected parameters such as appearance, odour, moisture content, mechanical properties, disintegration time, and content of the selected marker compound are evaluated.

For herbal films, stability assessment should also consider changes in colour, odour, and the chemical profile of relevant phytoconstituents. The storage conditions, duration, packaging, and acceptance criteria should be justified by the intended product and applicable stability guidance.

8.17 Summary of Evaluation Parameters

The evaluation tests may be grouped according to their purpose:

Physical evaluation: Appearance, colour, homogeneity, thickness, weight variation, and transparency.

Mechanical evaluation: Folding endurance and tensile strength.

Physicochemical evaluation: Surface pH, moisture content, and tack.

Performance evaluation: Disintegration time and dissolution or in vitro release.

Content and structural evaluation: Content uniformity, SEM, and DSC.

Stability evaluation: Changes in physical properties, moisture, marker content, and performance during storage.

The final selection of tests should be based on the objectives of the study, the properties of the herbal extract, and the intended performance of the oral film.

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IX. TYPICAL FORMULATION COMPONENTS AND APPROXIMATE PROPORTIONS USED IN FAST-DISSOLVING ORAL FILMS

Sr. No.	Ingredient	Approximate proportion (% w/w)	Function
1	Herbal extract / active ingredient	1–30	Provides the intended therapeutic activity
2	Film-forming polymer	20–60	Forms the film matrix
3	Solvent (e.g., purified water)	As required for processing	Dissolves or disperses formulation components; largely removed during drying
4	Plasticizer	5–20	Improves flexibility and reduces brittleness
5	Saliva-stimulating agent	2–6	Promotes salivary secretion, when required
6	Surfactant	0.1–2	Improves wetting or dispersion, when required
7	Sweetening agent	3–6	Improves taste and palatability
8	Flavouring agent	As required	Masks unpleasant taste or odour

X. SELECTED MEDICINAL PLANTS, PHYTOCHEMICAL CONSTITUENTS, REPORTED PHARMACOLOGICAL ACTIVITIES, AND TRADITIONAL USES RELEVANT TO HERBAL ORAL FORMULATIONS

SN	Medicinal plant / Part used	Scientific name	Family	Major phytochemical constituents	Reported pharmacological activities	Medicinal / traditional uses
1	Peepal leaves	*Ficus religiosa*	Moraceae	Flavonoids, tannins, phenolic compounds, sterols, and triterpenoids	Antioxidant, antimicrobial, anti-inflammatory; antidiabetic effects reported in preclinical studies	Traditionally used for respiratory complaints, skin conditions, wounds, and digestive disorders
2	Betel leaves	*Piper betle*	Piperaceae	Hydroxychavicol, chavicol, eugenol, other phenolics, and tannins	Antioxidant, antimicrobial, anti-inflammatory; other activities reported mainly in experimental studies	Traditionally used as a carminative and for oral hygiene, cough, and minor skin complaints
3	Guava leaves	*Psidium guajava*	Myrtaceae	Quercetin and other flavonoids, tannins, phenolic acids, and essential-oil constituents	Antidiarrhoeal, antioxidant, antimicrobial, and anti-inflammatory effects reported in experimental studies	Traditionally used for diarrhoea, digestive complaints, oral discomfort, and

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						minor wounds
4	Neem leaves	*Azadirachta indica*	Meliaceae	Limonoids, including nimbin-related compounds, flavonoids, tannins, and other phenolics	Antimicrobial, antioxidant, anti-inflammatory, and insecticidal activities reported in research	Traditionally used in skin care, oral hygiene, and for minor skin complaints
5	Tulsi / Holy basil leaves	*Ocimum tenuiflorum* L. (syn. *Ocimum sanctum* L.)	Lamiaceae	Eugenol, rosmarinic acid, ursolic acid, flavonoids, and other phenolic compounds	Antioxidant, antimicrobial, anti-inflammatory, and immunomodulatory effects reported in preclinical studies	Traditionally used for coughs, colds, respiratory discomfort, and digestive complaints
6	Liquorice root	*Glycyrrhiza glabra* L.	Fabaceae	Glycyrrhizin, glycyrrhetinic acid, liquiritin, isoliquiritin, and other flavonoids	Demulcent, anti-inflammatory, antioxidant, and antiulcer effects reported in research	Traditionally used to soothe throat irritation, cough, and digestive discomfort
7	Aloe vera leaf gel	*Aloe vera* (L.) Burm.f.	Asphodelaceae	Polysaccharides, including acemannan, and other carbohydrates and minor constituents	Moisturizing, wound-healing-related, and anti-inflammatory effects reported for selected preparations	Traditionally used topically for minor skin irritation and burns; oral use requires appropriate preparation
8	Ginger rhizome	*Zingiber officinale* Roscoe	Zingiberaceae	Gingerols, shogaols, zingerone, and volatile oils	Antioxidant, anti-inflammatory, and antiemetic effects reported in research	Traditionally used for nausea, digestive discomfort, and cold-related complaints
9	Turmeric rhizome	*Curcuma longa* L.	Zingiberaceae	Curcumin, demethoxycurcumin, bisdemethoxycurcumin, and volatile oils	Antioxidant and anti-inflammatory activities; antimicrobial effects also investigated	Traditionally used for inflammatory complaints, minor wounds, and skin care
10	Peppermint leaves	*Mentha* × *piperita* L.	Lamiaceae	Menthol, menthone, rosmarinic acid, and flavonoids	Antispasmodic and carminative effects; antimicrobial activity reported in	Traditionally used for indigestion, abdominal

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					experimental studies	discomfort, and flavouring oral preparations
11	Amla fruit	*Phyllanthus emblica* L. (syn. *Emblica officinalis* Gaertn.)	Phyllanthaceae	Hydrolysable tannins, including emblicanin-related constituents, gallic acid, and ellagic acid	Antioxidant and anti-inflammatory activities reported in research	Traditionally used as a restorative and in digestive and general wellness preparations
12	Clove flower buds	*Syzygium aromaticum* (L.) Merr. & L.M.Perry	Myrtaceae	Eugenol, eugenyl acetate, and other volatile-oil constituents	Local analgesic and antimicrobial activities; effects depend on concentration and preparation	Traditionally used for toothache and oral discomfort; also used as a flavouring agent
13	Fennel fruits	*Foeniculum vulgare* Mill.	Apiaceae	Anethole, fenchone, estragole, and other volatile-oil constituents	Carminative and antispasmodic effects reported in traditional use and research	Traditionally used for flatulence, digestive discomfort, and flavouring
14	Cinnamon bark	*Cinnamomum verum* J.Presl	Lauraceae	Cinnamaldehyde, eugenol, and polyphenolic compounds	Antioxidant and antimicrobial activities; metabolic effects have also been investigated	Traditionally used as a spice and flavouring agent and for digestive complaints

XI. ADVANCEMENTS AND FUTURE PROSPECTS OF ORAL FAST-DISSOLVING FILMS

Oral fast-dissolving films (OFDFs), also known as oral thin films or mouth-dissolving films, represent an innovative approach to oral drug delivery. These films are designed to disintegrate or dissolve rapidly in the oral cavity, generally without requiring water. They may offer advantages for patients who experience difficulty swallowing conventional tablets or capsules, including selected paediatric and geriatric patients and individuals with dysphagia. They may also improve convenience and ease of administration for patients who have difficulty following conventional dosage regimens.

Unlike conventional oral solid dosage forms, oral films can provide accurate unit-dose administration when manufactured with adequate content uniformity. Depending on their composition and intended design, the released active ingredients may act locally in the oral cavity, be absorbed through the oral mucosa, or be swallowed and absorbed through the gastrointestinal tract. However, rapid film disintegration does not necessarily result in rapid systemic absorption or increased bioavailability; these outcomes depend on the physicochemical properties of the active ingredient and the formulation.

Advances in polymer science, mucoadhesive materials, nanotechnology, and formulation engineering are expanding the potential applications of oral films. Novel formulation approaches may improve the dispersion, stability, taste acceptability, and release characteristics of selected active ingredients. Multilayer films are also being investigated as a

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means of incorporating multiple ingredients, separating incompatible components, or achieving different release profiles. Their suitability depends on demonstrated compatibility, manufacturing feasibility, and stability.

Herbal fast-dissolving oral films are an emerging area of formulation research because they offer a convenient dosage-form platform for selected plant extracts and phytoconstituents. Future research may focus on standardization of herbal extracts, improved content uniformity, taste masking, protection from moisture and degradation, and reproducible release of selected marker compounds. Appropriate analytical methods and stability studies are essential to ensure consistent quality.

Further developments may include personalized dosing, advanced manufacturing technologies, and functional films designed for specific therapeutic applications. Nevertheless, these possibilities require systematic formulation development, preclinical evaluation where appropriate, and clinical evidence when therapeutic claims are intended. Oral fast-dissolving films should therefore be considered a complementary drug-delivery option rather than a universal replacement for conventional tablets or capsules.

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