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DEVELOPMENT AND COMPARATIVE EVALUATION OF POLYHERBAL HEPATOPROTECTIVE TABLETS PREPARED BY DIFFERENT GRANULATION TECHNIQUES

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Keywords:

Polyherbal tablets, Hepatoprotective, Wet granulation, Herbal formulation, Tablet evaluation, Stability studies

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ABSTRACT

Liver disorders remain a significant global health concern, necessitating the development of safe and effective therapeutic alternatives. Herbal medicines have gained considerable attention because of their hepatoprotective, antioxidant, anti-inflammatory, and regenerative properties. The present study aimed to formulate and evaluate polyherbal hepatoprotective tablets containing *Echinops echinatus*, *Clitoria ternatea*, *Phyllanthus emblica*, and *Curcuma longa* using three different manufacturing techniques, namely direct compression, dry granulation, and wet granulation. Compatibility between herbal ingredients and excipients was evaluated by FTIR spectroscopy, which confirmed the absence of significant interactions. Nine formulations with varying concentrations of herbal ingredients were prepared and subjected to comprehensive pre-compression studies, including bulk density, tapped density, Carr's compressibility index, Hausner's ratio, and angle of repose. Post-compression evaluation included hardness, thickness, weight variation, friability, disintegration time, and accelerated stability studies according to ICH guidelines.

The prepared blends demonstrated acceptable flow properties suitable for tablet compression. Among the manufacturing methods, wet granulation exhibited superior flowability with lower Carr's index and Hausner's ratio compared with direct compression and dry granulation. Tablets prepared by wet granulation showed greater hardness, acceptable friability (<1%), uniform weight variation, and satisfactory disintegration characteristics while maintaining excellent physical integrity during accelerated stability testing. FTIR studies confirmed compatibility of herbal ingredients with formulation excipients throughout the study. The findings demonstrate that the selected herbal combination can be successfully formulated into stable tablets, with the wet granulation technique producing the most desirable pharmaceutical characteristics. The developed formulation provides a promising oral polyherbal dosage form for hepatoprotective therapy and warrants further pharmacological and clinical investigations to establish its therapeutic efficacy and safety.

INTRODUCTION

The liver is one of the most vital organs responsible for numerous physiological functions, including metabolism, detoxification, protein synthesis, bile secretion, nutrient storage, and maintenance of homeostasis [1]. Owing to its central role in xenobiotic metabolism, the liver is continuously exposed to toxins, environmental pollutants, alcohol, infectious agents, and therapeutic drugs, making it highly susceptible to injury [2]. Liver diseases such as hepatitis, fatty liver disease, cirrhosis, and drug-induced hepatotoxicity continue to represent major healthcare challenges worldwide. Although several synthetic hepatoprotective agents are available, their long-term use is often associated with adverse effects, limited efficacy, and high treatment costs. Consequently, increasing attention has been directed toward herbal medicines as safer and more effective alternatives for liver protection [3].

Medicinal plants contain a wide range of bioactive phytoconstituents including flavonoids, phenolic compounds, tannins, alkaloids, terpenoids, and curcuminoids that exhibit antioxidant, anti-inflammatory, immunomodulatory, and hepatoprotective activities. Polyherbal formulations, which combine multiple medicinal plants, are considered more effective than single-herb preparations because they provide synergistic pharmacological effects while minimizing toxicity. Such formulations have been widely employed in traditional systems of medicine for the prevention and treatment of liver disorders [4-5].

The present formulation incorporates four medicinal plants with well-documented hepatoprotective properties (Figure 1-4). *Echinops echinatus* possesses antioxidant, anti-inflammatory, and hepatoprotective activities attributed to its diverse phytochemicals. *Clitoria ternatea* is rich in flavonoids and anthocyanins that protect hepatic tissue by reducing oxidative stress and inflammation. *Phyllanthus emblica* (Indian gooseberry) is an excellent natural source of vitamin C and polyphenols, exhibiting potent antioxidant and free radical scavenging activities that protect hepatocytes from oxidative damage [6]. *Curcuma longa* contains curcumin, a bioactive polyphenol recognized for its antioxidant, anti-inflammatory, antifibrotic, and hepatoprotective effects through modulation of multiple cellular signaling pathways. The combination of these herbal ingredients is expected to provide synergistic protection against hepatic injury [7].

For successful development of herbal tablets, appropriate formulation and manufacturing methods are essential to ensure acceptable flow properties, compressibility, mechanical strength, content uniformity, and stability. Among the commonly employed manufacturing techniques, direct compression offers simplicity and cost-effectiveness but requires excellent powder flow characteristics. Dry granulation improves compressibility without the use of solvents, whereas wet granulation generally provides superior granule formation, improved flowability, enhanced compressibility, and better tablet quality [8-9].

In the present investigation, polyherbal tablets were prepared using direct compression, dry granulation, and wet granulation techniques to compare their influence on tablet quality. The formulations were subjected to compatibility studies, pre-compression evaluation, post-compression quality control tests, and accelerated stability studies in accordance with standard pharmacopoeial procedures and ICH recommendations. The objective of the study was to identify the most suitable manufacturing method capable of producing stable, pharmaceutically acceptable polyherbal tablets with desirable physical characteristics for potential hepatoprotective therapy [10].

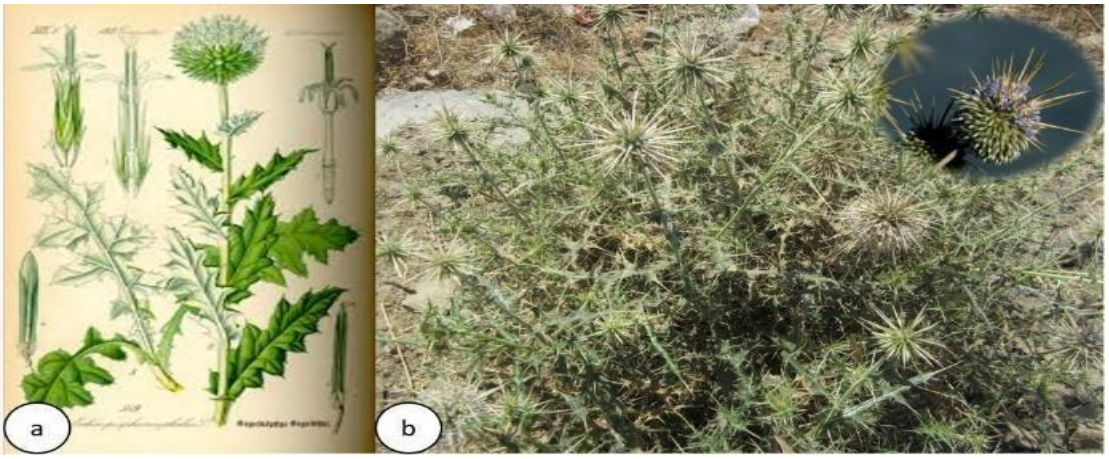

Figure 1. ***Echinopus echinatus*** **Plant**

Figure 2. ***Clitoria ternatea***

Figure 3.*Phyllunthus emblica*

Figure 4.*Curcuma longa*

MATERIALS&METHODS

Materials

Dried root and leaf powder of *Echinops echinatus* was procured from SidharaBetta Herbals, while dried seed and leaf powder of Clitoria ternatea was obtained from PahariHaat. Dried fruit powder of Phyllanthus emblica was purchased from Prakash Herbal, and Curcuma longa rhizome powder was obtained from Biogenero Labs Pvt. Ltd. Microcrystalline cellulose was procured from Research Lab. Povidone K-30 (PVP K-30) was supplied by BASF. Isopropyl alcohol and magnesium stearate were purchased from Merck, whereas talc, methyl paraben, and propyl paraben were obtained from Loba Chem. All other chemicals and reagents used in the study were of analytical reagent (AR) grade and were used as received without further purification.

Compatibilitystudies

Compatibility studies were performed to check drug and excipients interaction. These studies were done by mixing drug with individual excipients in the ratio 1: 1.Then these individualmixturessiftedthroughsieveno.#40,filledinvials,sealedandkeptfor15days in stability chambers at room temperature, 40ºC/75% RH, (±2ºC,±5%RH) and higher temperature. After 15 days these vials were examined for physical appearance, colour, and nature [11].

Polyherbal Tablet Formulation

The polyherbal tablets were formulated using three manufacturing techniques, namely direct compression, dry granulation, and wet granulation, to obtain tablets with desirable pharmaceutical characteristics such as appropriate disintegration time, drug release, friability, thickness, and hardness (Table 1). Granulation is a process in which powder particles are aggregated by compression or by the addition of a binding agent to form granules with improved flowability and compressibility, thereby ensuring consistent tablet production. In the wet granulation method, accurately weighed active ingredients and excipients were blended uniformly, followed by the preparation of a binding solution by dissolving polyvinylpyrrolidone (PVP K-30) in isopropyl alcohol. The binder solution was gradually incorporated into the powder blend with continuous kneading to obtain a cohesive wet mass, which was passed through sieve No. 14 to produce wet granules. These granules were dried in a tray dryer at 50°C, milled to obtain uniform granule size, lubricated with talc and magnesium stearate, and evaluated for pre-compression parameters before tablet compression. In the dry granulation method, the powder blend was compressed under low pressure to produce slugs, which were subsequently crushed, sieved to obtain granules of the desired size, lubricated, and subjected to pre-compression evaluation. For the direct compression method, all ingredients, including the herbal powders, microcrystalline cellulose, PVP K-30, talc, and magnesium stearate, were accurately weighed, blended thoroughly to achieve a

homogeneous mixture, and directly evaluated for pre-compression properties before compression into tablets. The prepared formulations from all three methods were subsequently compared to identify the most suitable manufacturing technique for producing stable polyherbal hepatoprotective tablets with acceptable pharmaceutical quality attributes [12-13].

Table 1. Formulation Table of Tablets Prepared by Various Methods

Ingredients	DC1 mg	DC2 mg	DC3 mg	DR1 mg	DR2 mg	DR3 mg	WT1 mg	WT2 mg	WT3 mg
Echinops echinatus	50	100	150	50	100	150	50	100	150
Clitoria ternatea	25	50	75	25	50	75	25	50	75
Phyllanthusemblica	50	100	150	50	100	150	50	100	150
Curcumalonga	10	15	20	10	15	20	10	15	20
MicrocrystallineCellulose	174	144	114	174	144	114	174	144	114
Povidone(PVPK-30)	15	15	15	15	15	15	15	15	15
Isopropylalcohol	--	--	--	--	--	--	QS	QS	QS
Talc	15	15	15	15	15	15	15	15	15
Magnesiumstearate	10	10	10	10	10	10	10	10	10
MethylParaben	1	1	1	1	1	1	1	1	1
TOTALWEIGHT	350	450	550	350	450	550	350	450	550

(DC: Direct Compression; DR: Dry Granulation; WT:Wet Granulation**)**

The hepatoprotective herbal ingredients served as the active components of the formulation. As reported in the literature, no standardized doses are available, with variable quantities used in previous studies and traditional medicine. Therefore, formulations containing low, intermediate, and high concentrations of the herbal ingredients were prepared using direct compression, dry granulation, and wet granulation techniques. The effect of each manufacturing method on the pharmaceutical properties of the tablets was subsequently evaluated [14].

Pre-compressional analysis of blend

Pre-compression evaluation is an essential preformulation step carried out to assess the physical properties of the powder blend before compression into tablets. These studies help determine the flowability, compressibility, and packing characteristics of the blend, which directly influence weight uniformity, content uniformity, tablet hardness, friability, and overall manufacturing performance. The powder blend was evaluated for bulk density, tapped density, Carr's Compressibility Index, Hausner's Ratio, and angle of repose according to standard pharmacopoeial procedures [15].

Bulk Density

Bulk density was determined by accurately weighing approximately **10 g** of the powder blend into a **50 mL graduated measuring cylinder** without compacting the material. The initial volume occupied by the powder was recorded, and the bulk density was calculated [16].

Tapped Density

The same measuring cylinder containing the powder blend was tapped mechanically using a bulk density apparatus until a constant volume was obtained. The final tapped volume was recorded, and the tapped density was calculated [16].

Carr's Compressibility Index

Carr's Compressibility Index was calculated from the bulk and tapped densities to evaluate the compressibility and flow characteristics of the powder blend. Lower Carr's Index values indicate better flowability and compressibility of the powder blend [16].

Hausner's Ratio

Hausner's Ratio was determined as the ratio of tapped density to bulk density. A Hausner's Ratio of **1.00–1.25** indicates good flow properties, whereas higher values suggest increased cohesiveness and poor flowability [16].

Angle of Repose

The angle of repose was determined using the fixed-funnel method. The powder blend was allowed to flow freely through a funnel to form a conical heap on a flat surface. The height (**h**) and radius (**r**) of the powder cone were measured, and the angle of repose (**θ**) was calculated using the following equation: An angle of repose below **30°** indicates excellent flow properties, while higher values suggest increased interparticle friction and reduced flowability [16].

Blend Uniformity

Blend uniformity was assessed to ensure homogeneous distribution of the active ingredients throughout the powder blend. Representative samples were collected from different locations of the blend and analyzed for drug content. The blend was considered acceptable when the assay values complied with the specified pharmacopoeial limits, confirming uniform mixing prior to tablet compression [16].

FlowCharacterization

Thefrictionalforcesinaloosepowdercanbemeasuredbytheangleofrepose,θ.The powder mixture was allowed to flow through the funnel fixed to a stand at definite height.Theangleofreposewasthencalculatedby measuringtheheightandradiusofthe heap of powder formed. Angle of Repose(θ) In Degree (^{o}) when it is less than 25^{o}then it is excellent, when it is in the range 25–30^o then it is good, when it is in the range 30–40^o then itisaverageandwhen it is greater than 40^o then the flow property is noted as bad [17].

Compression of tablet

After satisfactory evaluation of powder blend for precompression parameter, tablet was preparedusingtabletmachineusing8mmand10 mmconcavepunch.Thehardnesswas3.5 -4.8kg/cm^2 and the tablet thickness was 3.9 - 4.3mm. The prepared granules came from hopper to feed frames where theyoccupied the die cavity. The hardness and thickness was tested after final weight adjusted, after confirming the friability and disintegration time result compression was continued The tablets were visually inspected for uniformity of color, shape, texture and further evaluation is done by following official and nonofficial tests for tablets [18].

Evaluation of Tablets

Uniformity of Weightof Tablet

By calculating Average weight (mg) of 20 Tablets [19-20].

Hardness

The hardness of the tablets was determined using a **Pfizer hardness tester**. Ten tablets from each batch were randomly selected, and the crushing strength required to break each tablet was measured and expressed in **kiloponds (kp)**. The average hardness was calculated to ensure adequate mechanical strength for handling, packaging, and transportation while maintaining acceptable disintegration and dissolution characteristics [19-20].

Thickness

The thickness of the tablets was measured using a **micrometer screw gauge**. Ten tablets from each batch were evaluated, and the mean thickness was calculated. The thickness of the tablets was maintained within the acceptable pharmacopoeial limit (±5% of the standard value) to ensure uniformity and suitability for packaging [19-20].

Friability

Friability was evaluated using an Electrolab Friabilator**.** A pre-weighed sample of tablets was placed in the friabilator and rotated at **25** rpm for 100 revolutions**.** After completion of the test, the tablets were dedusted and reweighed. Percentage weight loss was calculated [19].

Disintegration Time

The disintegration test was performed to determine the time required for the tablets to break down into smaller particles under specified conditions, as per the Indian Pharmacopoeia (IP). Twelve tablets were individually placed in the tubes of the IP disintegration test apparatus containing distilled water as the immersion medium. The apparatus was operated at 28–32cycles/min with a stroke length of 50–60 mm. The time required for complete disintegration of each tablet was recorded. A tablet was considered to have passed the test when no residue remained on the screen except fragments of insoluble coating, if present. The formulation complied with the pharmacopoeial acceptance criteria for tablet disintegration [19-20].

Stability studies

Accelerated stability studies were conducted to evaluate the physical stability of the optimized polyherbal tablet formulations in accordance with ICH guidelines. The tablets were packed in PVC–PVDC blister strips and amber-colored PVC–PVDC blister strips, each containing 12 tablets, and stored under accelerated conditions of 30 ± 2°C/75 ± 5% RH and 40 ± 2°C/75 ± 5% RH. Samples were withdrawn at predetermined intervals and evaluated for physical appearance, hardness, friability, weight variation, disintegration time, assay, and dissolution. The stability assessment confirmed that the optimized formulations maintained their critical quality attributes throughout the study period, demonstrating satisfactory stability under the prescribed storage conditions [19-20].

RESULTS& DISCUSSION

The present study aimed to develop polyherbal hepatoprotective tablets using ***Echinops echinatus***, ***Clitoria ternatea***, ***Phyllanthus emblica***, and ***Curcuma longa***, selected for their reported hepatoprotective, hepatostimulant, and antioxidant activities. The formulations were prepared using microcrystalline cellulose as a diluent, PVP K-30 as a binder, isopropyl alcohol as the granulating solvent, and talc and magnesium stearate as glidant and lubricant, respectively, to evaluate their suitability as a stable oral solid dosage form.

Preformulationstudies

Preformulation stabilitystudies areusuallythe first qualitativeand quantitativeassessment before start of any studies. The drug and excipients procured were evaluated by preformulation studies. As per the need the drug and excipients were studied for the following tests (Table 2 & 3).

Table 2. Morphological Characterization of Herbal Active Ingredients

Herbal Ingredient	Colour	Odour	Taste	Texture	Inference
Echinops echinatus *(Leaf Powder)*	Dark green	Aromatic and pungent	Bitter and astringent	Coarse with hard, woody fragments	Complies with standard
Echinops echinatus *(Root Powder)*	Greyish brown	Aromatic and pungent	Bitter and astringent	Coarse with hard, woody fragments	Complies with standard
Clitoria ternatea *(Leaf Powder)*	Green	Characteristic aromatic	Bitter	Hairy with hard fragments	Complies with standard
Clitoria ternatea *(Seed Powder)*	Light brownish	Characteristic aromatic	Bitter	Hairy with hard fragments	Complies with standard
Phyllanthus emblica *(Fruit Powder)*	Light yellowish-brown	Characteristic	Sour and astringent	Fibrous with small, hard fragments	Complies with standard
Curcuma longa *(Rhizome Powder)*	Yellow to orange	Strong aromatic	Bitter	Smooth and waxy	Complies with standard

PreformulationStudiesofHerbalActiveIngredients

Table 3. Preformulation Evaluation of Herbal Active Ingredients

Parameter	*Echinops echinatus*	*Clitoria ternatea*	*Phyllanthus emblica*	*Curcuma longa*
Ash Value (% w/w)	8.2	8.2 (Leaves), 15.6 (Seeds)	7.8	15.8
Water Extractive Value (% w/w)	4.85	14.40	20.50	8.40
Alcohol Extractive Value (% w/w)	2.90	16.66	12.40	8.60
Loss on Drying (% w/w)	3.40	4.60	3.40	6.20
Bulk Density (g/mL)	0.62	0.58	0.36	0.64
Tapped Density (g/mL)	0.74	0.76	0.68	0.74
Inference	All values complied with reported literature standards			

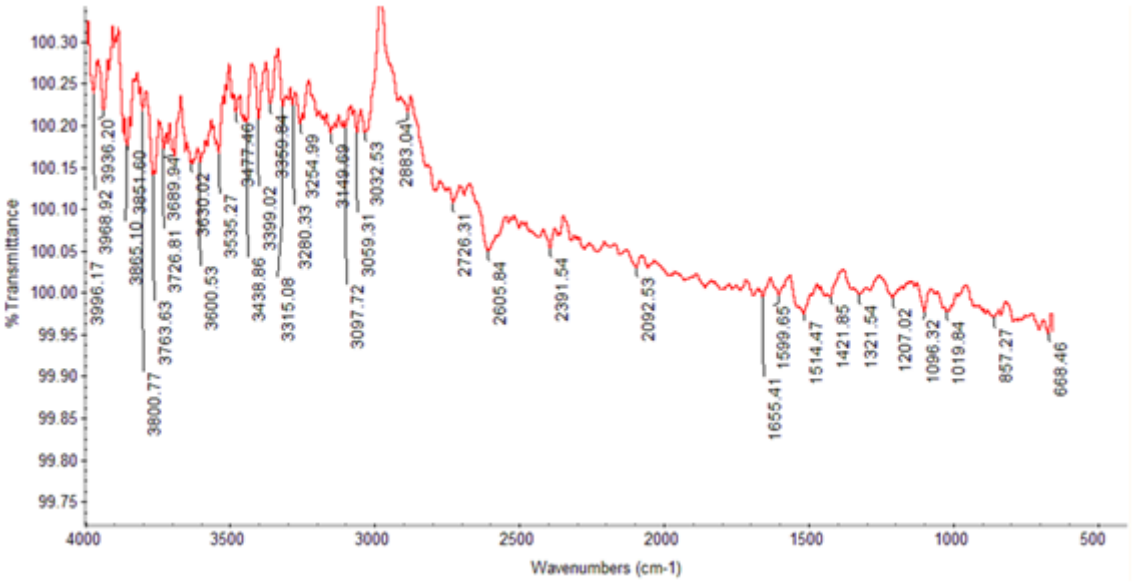

Figure 5. FTIRspectraof drug mixture

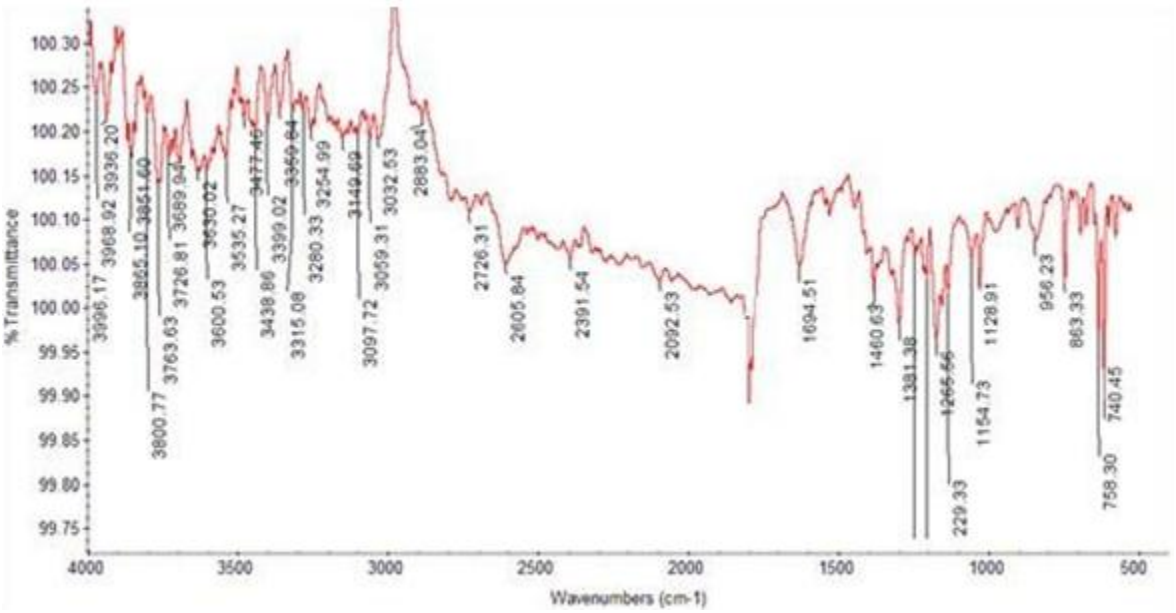

Figure 6.FTIRspectraof Drug+ Excipients

FTIR spectra of powder active drug and mixture of drug and excipients revealed number of peakscorrespondingpresenceofmanyfunctionalgroupsfromthecomponentsoftheherbal agents (Figure 5 & 6).Astherenomajordeviationinthepeaksthusindicatingnointeractionbetweendrug and excipients.

Pre-compressionalanalysisofblend

Table 4. Pre-compression Evaluation of Direct Compression (DC) Granules

Parameter	DC1	DC2	DC3
Bulk density (g/mL)	0.57 ± 0.09	0.60 ± 0.08	0.63 ± 0.08
Tapped density (g/mL)	0.60 ± 0.03	0.74 ± 0.04	0.77 ± 0.06
Carr's Index (%)	16.17 ± 0.03	18.91 ± 0.02	18.18 ± 0.05
Hausner's Ratio	1.19 ± 0.03	1.23 ± 0.03	1.22 ± 0.04
Angle of Repose (°)	35.20 ± 1.02	33.14 ± 0.80	32.40 ± 1.20

The pre-compression evaluation demonstrated satisfactory flow characteristics for all three direct compression formulations (Table 4-6). The Carr's Index (16.17–18.91%), Hausner's Ratio (1.19–1.23), and Angle of Repose (32.40–35.20°) indicated fair to good flow properties. Among the formulations, **DC1** exhibited the lowest Carr's Index, suggesting better compressibility, whereas **DC3** showed the highest bulk density and the lowest Angle of Repose, indicating improved particle packing and reduced interparticle friction. Overall, all formulations were suitable for further processing.

Table 5. Pre-compression Evaluation of Dry Granulation (DR) Granules

Parameter	DR1	DR2	DR3
Bulk density (g/mL)	0.66 ± 0.09	0.72 ± 0.07	0.73 ± 0.08
Tapped density (g/mL)	0.78 ± 0.04	0.82 ± 0.06	0.89 ± 0.07
Carr's Index (%)	15.38 ± 0.03	12.19 ± 0.04	17.97 ± 0.06
Hausner's Ratio	1.18 ± 0.02	1.13 ± 0.01	1.21 ± 0.01
Angle of Repose (°)	25.26 ± 0.24	24.12 ± 0.32	24.40 ± 0.26

All dry granulation formulations exhibited good to excellent flow characteristics. The Angle of Repose (<30°), Carr's Index (12.19–17.97%), and Hausner's Ratio (1.13–1.21) confirmed good flowability and compressibility. **DR2** demonstrated the best overall flow properties, exhibiting the lowest Carr's Index and Hausner's Ratio, indicating minimal interparticle friction and excellent flow behavior. These findings suggest that the prepared granules were suitable for tablet compression.

Table 6. Pre-compression Evaluation of Wet Granulation (WT) Granules

Parameter	WT1	WT2	WT3
Bulk density (g/mL)	0.72 ± 0.06	0.75 ± 0.08	0.78 ± 0.07
Tapped density (g/mL)	0.83 ± 0.03	0.86 ± 0.05	0.89 ± 0.04
Carr's Index (%)	13.25 ± 0.02	12.79 ± 0.03	12.35 ± 0.04
Hausner's Ratio	1.15 ± 0.01	1.14 ± 0.01	1.14 ± 0.01
Angle of Repose (°)	25.26 ± 0.12	24.18 ± 0.14	24.40 ± 0.20

The wet granulation formulations exhibited excellent pre-compression characteristics. Bulk and tapped density increased progressively from WT1 to WT3, indicating improved particle packing. Carr's Index (12.35–13.25%), Hausner's Ratio (1.14–1.15), and Angle of Repose (24.18–25.26°) were within acceptable limits, confirming excellent flowability. Among the three formulations, **WT3** exhibited the highest density and the lowest Carr's Index, suggesting superior packing efficiency and flow behavior. Overall, all wet granulation batches demonstrated excellent suitability for compression into tablets.

Evaluation of Tablets Uniformity of Weight of Tablet

To confirm the no variation between the tablets this testis performed as perthe procedure prescribed by Indian Pharmacopoeia 2007 Vol I. Hardness was determined using Pfizer hardness tester, thickness was determined using screw guage, friability was determined using standard procedure. The results of all these evaluation parameters are reported in the following table 7.

Table7.ResultsofTabletEvaluation

Formulation Code	Hardness Kg/cm^2	Thickness (mm)	Avg.Wtof Tablet(mg)	Friability (%w/w)	Disintegration Time in Min
DC1	3.2 ±0.22	3.2 ±0.02	358.20 ±0.32	1.82 ±0.12	4.18 ±0.52
DC2	3.6 ±0. 34	3.6 ±0.04	461.60 ±0.68	1.18 ±0.02	4.40 ±0. 34
DC3	3.2 ±0.18	4.2 ±0.04	558.40 ±0.88	0.86 ±0.22	4.30 ±0.20
DR1	5.4 ±0.42	3.3 ±0.03	356.16 ±0.24	0.78 ±0.18	5.40 ±0.40
DR2	5.8 ±0.44	3.4 ±0.05	459.18 ±0.46	0.82 ±0.16	5.58 ±0.20
DR3	5.8 ±0.36	4.1 ±0.02	556.40 ±0.74	0.74±0.24	6.10 ±0.30
WT 1	6.6 ±0.48	3.8 ±0.04	354.14 ±0.22	0.66 ±0.16	7.26 ±0.30
WT 2	6.8 ±0.28	4.0±0.02	456.20 ±0.56	0.72 ±0.20	7.34 ±0.28
WT 3	7.2 ±0.32	4.2 ±0.03	558.40 ±0.64	0.70 ±0.24	7.22 ±0.32

DisintegrationTime

Thistestdetermineswhetherdosageformssuchastablets,capsules,bolusespessariesand suppositories disintegrate within a prescribed time when placed in a liquid medium under the prescribed experimental conditions.Thetimerequiredfordisintegrationofdifferentformulationsarereportedinthefollowing table 8.

Table8.ResultsofDisintegrationTestofTablets

Formulation Code	DisintegrationTimein Min
DC1	4.18 ±0.52
DC2	4.40 ±0. 34
DC3	4.30 ±0.20
DR1	5.40 ±0.40
DR2	5.58 ±0.20
DR3	6.10 ±0.30
WT1	7.26 ±0.30
WT2	7.34 ±0.28
WT3	7.22 ±0.32

Stabilitystudies

In any rational design and evaluation of dosage forms for drugs, the stability of the active component must be major criteria in determining their acceptance or rejection. During the stability studies the product is

exposed to normal conditions of temperature and humidity. However, the studies will take a longer time and hence it would be convenient to carry out the accelerated stability studies where the product is stored under extreme conditions of temperature. Tablets from each of the method of formulation were exposed to these tests andevaluatedforgeneralcharacteristicsandalsostudiedforvarioustest (Table 9).Thecharacteristics before and after test were compared.

Table9.Results ofStabilityTestofTablets

Formulation Code	Hardness Kg/cm^2		Thickness (mm)		Avg.WtofTablet (mg)		Friability (%w/w)	
	Before	After	Before	After	Before	After	Before	After
DC3	3.2 ± 0.18	3.3± 0.14	4.2± 0.04	4.2 ± 0.08	558.40 ±0.88	560.40 ±0.24	0.86 ± 0.22	0.80 ± 0.22
DR2	5.8 ± 0.44	5.9± 0.48	3.4± 0.05	3.4± 0.02	459.18 ±0.46	460.18 ±0.24	0.82± 0.16	0.83± 0.16
WT2	6.8± 0.28	7.0± 0.42	4.0± 0.02	4.0± 0.04	456.2± 0.56	458.20 ±0.40	0.72± 0.20	0.80± 0.28

CONCLUSION

The present investigation successfully developed polyherbal hepatoprotective tablets containing *Echinops echinatus*, *Clitoria ternatea*, *Phyllanthus emblica*, and *Curcuma longa* using direct compression, dry granulation, and wet granulation techniques. Compatibility studies confirmed the absence of significant interactions between the herbal ingredients and formulation excipients, indicating the suitability of the selected excipients for tablet development.All prepared formulations demonstrated acceptable pre-compression characteristics and complied with pharmacopoeial quality requirements following compression. Comparative evaluation revealed that the method of granulation significantly influenced the pharmaceutical performance of the tablets. Wet granulation produced granules with superior flowability, lower Carr's compressibility index, favorable Hausner's ratio, and excellent angle of repose, facilitating efficient tablet compression. Tablets prepared by wet granulation exhibited higher mechanical strength, acceptable friability, uniform weight distribution, satisfactory disintegration time, and excellent physical appearance compared with formulations prepared by direct compression and dry granulation.Accelerated stability studies demonstrated that the optimized formulations retained their physical characteristics without significant changes under ICH storage conditions, confirming adequate formulation stability. These findings indicate that wet granulation is the most suitable manufacturing technique for preparing this polyherbal hepatoprotective tablet formulation. Thus, the developed formulation represents a promising herbal solid dosage form with desirable pharmaceutical quality attributes. However, further investigations involving dissolution profiling, phytochemical standardization, in vivo hepatoprotective efficacy studies, toxicity assessment, and well-designed clinical trials are required to establish its therapeutic effectiveness, safety, and potential for commercialization as a standardized polyherbal hepatoprotective product.

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