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Formulation And Characterization Of Nicardipine Hydrochloride Solid Dispersions And Oro dispersible Tablets Using Natural Seed Starch as Super disintegrant

Battula Sowjanya Lakshmi[1,*2], Hariom Sharma[3], Suryadevara Vidyadhara[4]

[1]Research Scholar, School of Pharmacy, Raffles University, Neemrana, Alwar, Rajasthan- 301705.

Email ID: miriampalli.sowjanyalakshmi@gmail.com

[2]Assistant Professor, Department of Pharmaceutics, Chebrolu Hanumaiah Institute of Pharmaceutical Sciences, Chandramoulipuram, Chowdavaram, Guntur, Andhra Pradesh, India – 522019

[3]Guide, Professor and Principal, School of Pharmacy, Raffles University, Neemrana, Alwar, Rajasthan- 301705.

[4]Cosupervisor, Professor and Principal, Chebrolu Hanumaiah Institute of Pharmaceutical Sciences, Chandramoulipuram, Chowdavaram, Guntur, Andhra Pradesh, India – 522019

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ABSTRACT

The current research aimed to improve the solubility and rate of dissolution of Nicardipine HCl, which is a drug that has low water solubility. This was achieved by utilizing solid dispersions and orodispersible tablets made from ESS4 (Entada scandens seed starch). The starches were extracted using water and alkali as solvents. The study evaluated the chemical composition and physical properties of seed starches. The solid dispersions were made utilizing a modified method of evaporating solvents with ESS4 as carrier in various amounts. Direct compression (DC) technique has been utilized in making tablets with optimized solid dispersions of Nicardipine HCl and various quantities of SSG (Sodium Starch Glycolate) along with CCS (Croscarmellose Sodium). Optimized solid dispersions as well as orodispersible tablets were also subjected for characterization including Scanning Electron Microscopy (SEM) and FTIR (Fourier Transform Infra-Red Spectroscopy). These findings indicated that ESS4 which was made using a 0.5% sodium hydroxide (ESS4). Demonstrated superior physicochemical characteristics compared to other starches. The solid dispersions made with ESS4 exhibited more drug release. The optimized dispersion NS4 was employed for the preparation of orodispersible tablets with CCS and SSG. The prepared tablets exhibited pre as well as post compression parameters within specified limits. The in-vitro drug release studies exhibited release of drugs more quickly. FTIR research demonstrated that there has been no drug-excipient interaction. Moreover, SEM images revealed nature of drug and excipients used. The study determined that the ESS4 has exceptional super disintegrant properties, indicating its potential application in developing an innovative formulation for the treatment of angina utilizing Nicardipine HCl.

Keywords: *Nicardipine Hydrochloride, Solid Dispersions, Orodispersible Tablets, Croscarmellose Sodium*

1. INTRODUCTION

Approximately 30 to 40% of newly discovered therapeutic compounds exhibit limited water solubility which affects their bioavailability and absorption. Enhancing solubility can improve the dissolving behavior of drugs and increase their therapeutic effectiveness (1). Enhancement in solubility can be achieved through a range of methods such as salting out, complexation, micronization, solid dispersion, pH adjustment, co-solvency, co-crystallization and amorphous states. These approaches are commonly employed to disperse active substances effectively (2, 3). The dispersion's interaction with water increases its surface area, therefore improving the pace at which the drug dissolves and becomes available for biological processes(4). Solid dispersion systems encounter constraints such as medication degradation, lack of compatibility, and elevated expenses. To get over these problems, a modified solvent evaporation process has been created (5).

Carriers, which can be water-swellable, hydrophilic, or hydrophobic, are crucial in preparation of solid dispersions. They influence the release of substances and affect drug molecule dissolution. Synthetic carriers like Brij35, Pluronic F-127, Carboxymethylcellulose, and Eudragit are used, but they have limitations like toxicity, inflammation, high production costs, water solubility issues, and lack of inherent biocompatibility and bioactivity.

Gum, cellulose, starch, and cyclodextrin are plant-based polymers that are gaining popularity in the medical field due to their wide range of applications, compatibility with living organisms, lack of toxicity, and resistance to chemical reactions. These biopolymers are beneficial for delivering drugs because of their physical and chemical properties, safety, capacity to break down naturally, and compatibility with living organisms. Starch is a widely utilized natural polymer in pharmaceuticals because it is affordable, easily accessible, and has a high yield. It is chosen for its similarity to disintegrants, lubricants, and binders (6,7)

Nicardipine HCl has an extensive hepatic first pass metabolism following oral administration with systemic bioavailability is about 35%. Because of its poor aqueous solubility in biological fluids having pH of 5 to 8, the drug has to be given frequently (30mg, 3 times daily)(8-10). So, there is a necessity to enhance the dissolution of the drug and convert into melt in mouth tablet to ensure maximum therapeutic utility of the drug.

Orodispersible tablets, also known as fast dispersing tablets, are beneficial for pediatrics, geriatrics, dysphagia, and travel. They disintegrate within a time frame of less than 3 minutes and can be consumed without the need for water. Nevertheless, there have been no studies that have employed the modified solvent evaporation process for making solid dispersions and orodispersible tablet formulations. The objective of this work is to improve Nicardipine HCl solubility and dissolution characteristics, as well as to make Nicardipine HCl melt in mouth tablets utilizing the direct compression method using specialized carriers including SSG, CCS, as well as ESS4.

2. MATERIALS AND METHODS

Materials

Nicardipine HCl, SSG, CCS had been obtained as gift samples from NATCO, Hyderabad. Entada. scandens seeds had been procured Tirumala, AP, India local market and had been carefully transported to Chowdavaram, Guntur district, A.P. India. Seeds have been identified as well as authenticated by Dr. K. Ammani, Department of Botany, Acharya Nagarjuna University, Guntur and voucher specimen (CHIPS-01/17) had been preserved in Department of Pharmaceutics, Chebrolu Hanumaiah Institute of Pharmaceutical Sciences, Guntur, India.

Extraction of Entada scandens Seed Starch

The starch from Entada. scandens seeds was extracted utilizing alkali as well as aqueous extraction techniques. 5g of Entada scandens seed flour had been mixed with 100ml of distilled water and NaOH with concentrations of 0.1%, 0.25% as well as 0.5%. Mixture was soaked at room temperature for 6 to 8 hours, while being continuously stirred. The slurry was filtered using a 212 mesh stainless steel sieve. The mixed and resulting sediment had been rinsed with distilled water for three times. Collected liquids were allowed to form solid particles by cooling overnight at a temperature of 4°C. Liquid portion was discarded, and starch was rinsed with distilled water. The process was repeated thrice. The starch cake was subjected to drying for 24h at 40°C temperature in oven. Starch was crushed using mortar and pestle (11) and stored till further usage

Phytochemical tests for Entada scandens seed powder and extracted starches

Raw Entada. Scandens seed powder as well as starches gathered had been tested for the presence of various phytochemicals, such as proteins, carbohydrates, alkaloids, steroids, glycosides, flavonoids, as well as saponins (12). These results were indicated in Table1.

Evaluation of physicochemical properties of Entada. scandens seed powder and extracted starches

Different physicochemical characteristics including pH, gelatinization temperature, viscosity, water absorption index, swelling index, total microbial load, fluorescence, acidity, oxidizing substances, loss on drying sulphated ash, along with amylose content had been examined utilizing appropriate approaches (13).Results are given in Table 2.

Preparation and Evaluation of Nicardipine HCl Solid Dispersions

Preparation of Nicardipine HCl Solid Dispersions by Modified Solvent Evaporation Method

The modified solvent evaporation approach had been employed for solid dispersions preparation. Specified Nicardipine HCl quantity was dissolved in suitable amount of dichloromethane and the solution was kept aside for 10 min. In another beaker, a suitable amount of ESS4 was dispersed in 100ml of distilled water at room temperature. This solution was subjected to heating at 60oC with continuous stirring at 1500rpm. The solution containing drug was slowly injected into this solution with a syringe. The stirring was continued for 30 min. Further, solution was filtered and resultant dispersion was dried at 60oC for 1 h. The final dispersion was stored in a well closed container. Solid dispersions NS1 to NS5 were made using various amounts of the ESS4 by maintaining constant drug amount. Compositions were provided in table 3.

Evaluation of Nicardipine HCl Solid Dispersions

Different physical parameters including Carr's index, angle of repose, Hausner's ratio, along with drug content were evaluated for prepared solid dispersions as per the Indian Pharmacopeia (I.P) specifications (14).Results have been given in table 4.

In-vitro Dissolution Studies of Nicardipine HCl Solid Dispersions

Using 900ml of 1.2pH as dissolution medium along in calibrated eight station dissolution test apparatus (LABINDIA DS8000) with paddles (USP apparatus II technique), dissolution tests was conducted for all solid dispersions at temperature of 37±1ºC and 50rpm. To keep sink conditions constant throughout the experiment, 5ml samples had been taken out at5, 10, 15, 20, 30minutes and replaced with equivalent volume of same medium. Lab India double beam UV spectrophotometer (UV3000+) was utilized in estimating amount of drug dissolved at 237nm(15). Fig1 showed dissolution profiles for each formulation.

Preparation and Evaluation of Nicardipine HCl Orodispersible Tablets

Nicardipine HCl orodispersible tablets with various concentrations of SSG as well as CCS were prepared by Direct Compression approach using optimized solid dispersions (NS4)(8). Micro crystalline cellulose was employed as diluent and the weights of all formulations were kept uniform. Increasing concentrations of CCS and SSG were used. Sorbitol was dispersed with a little quantity of vanilla flavor and mixed with optimized Nicardipine HCl solid dispersion, blended for 15min using double cone blender. Then 0.5% of magnesium stearate as well as talc were added, and tablets were prepared utilizing CLIT10 station mini press. Formulations N1 to N5 were prepared by using 2.0 to 10% of CCS along with optimized Nicardipine HCl solid dispersion. Formulations N6 to N10 were prepared by using 2.0 to 10% of SSG along with optimized Nicardipine HCl solid dispersion. N formulation lacks any super disintegrant. NN contains only solid dispersion. Compositions were given in Table 5.

Evaluation of Pre-Compression and Post Compression Parameters for Prepared Nicardipine HCl Granules and Nicardipine HCl Tablets

Prepared granules and tablets were assessed for pre-compression parameters including Carr's index, angle of repose, Hauser's ratio, along with post-compression parameters like hardness, weight uniformity, friability, dispersion test, wetting time along with drug content as per official compendium standards (16-17).Results were provided in tables 6 and 7.

In-vitro Dissolution Studies of Nicardipine HCl Tablets

900ml of 1.2pH was used as dissolution medium in USP Apparatus TypeII(paddle) dissolution test. At 5, 10, 15, 20, 30minutes, samples was withdrawn. Samples were diluted with dissolution media as required. At 237nm, absorbance was measured, and cumulative percentage drug release was calculated. The dissolution profiles were illustrated in figures 2 and 3.

3. CHARACTERIZATION STUDIES

Following investigations were conducted for optimized formulations based on dissolution tests conducted on each formulation.

Fourier-Transform Infrared (FTIR) Spectroscopic Analysis

FTIR spectra of powdered samples of Nicardipine HCl pure drug CCS as well as starch along with optimized formulation, were analyzed using KBr (potassium bromide) pellet approach (15). Results were illustrated in fig4.

Scanning Electron Microscopy (SEM)

Sputter coater unit (SPI, Sputter, USA) applied thin layer of gold to samples. SEM (SEM JSM-6390, Japan) running at voltage of 15kV was utilized in taking SEM images. Fig 5 showed the SEM images.

Accelerated Stability Studies

These studies were conducted to evaluate the temperature effect on prepared Nicardipine HCl orodispersible tablets' stability. Orodispersible tablets were kept in petri dishes, preserved in thermo-stated oven at temperature, relative humidity of 400C±2□C/75±5% for 3months as well as 25□C±2□C/60 ±5% for 6 months. Then samples were assessed for drug release studies that had previously been highlighted (18). Results were given in fig 6.

4. DISCUSSION OF RESULTS

Many drugs taken orally with poor water solubility have had their absorption limited by their dissolution rate. Therefore, drug solubility for increasing its biological availability continues to be one of the primary difficult areas of drug research. Nicardipine HCl belongs to the dihydropyridine class of calcium channel blockers and is used in the treatment of both angina pectoris and hypertension which is a BCS Class-II drug. Based on physicochemical and biopharmaceutical characteristics, Nicardipine HCl was chosen as drug candidate for making solid dispersions and orodispersible tablets to enhance dissolution rate along with bioavailability.

Extraction and Evaluation of Entada scandens Seed Starches

Extraction of Starch from Entada scandens Seeds

Entada Scandens seeds were used for extraction of starches according to the techniques described in the protocols, using alkali and aqueous extraction [Fateatun et al., 2014]. The starch produced by various extraction techniques was dried under room temperature for 24 h. The produced starches exhibited a crisp texture, mild granularity, free-flow and stability.

Phytochemical Screening of Entada scandens Seed Powder and Starches

Phytochemical tests revealed that raw Entada. Scandens seed powder has proteins, alkaloids, glycosides, carbohydrates, polysaccharides, along with steroids. Gathered starches verified that only polysaccharides and carbohydrates had been present. This indicated the presence of only starches in the extracts. [Joerg et al., 2020] The phytochemical tests investigated were given in table 1.

Evaluation of Entada scandens Seed Extracted Starches

Table 1: Phytochemical Tests for Entada scandens Seed Powder and Extracted Starches

Chemical Tests		**ESSP**	**ESS1**	**ESS2**	**ESS3**	**ESS4**
Tests for Carbohydrates	Molisch's Test	+	+	+	+	+
	Benedicts Test	+	+	+	+	+
	Barfoed's Test	-	-	-	-	-
Test for Polysaccharides	Iodine Test	+	+	+	+	+
Test for proteins	Biuret Test	+	-	-	-	-
Test for Alkaloids	Mayer's Test	+	-	-	-	-
Test for glycosides	Baljet Test	+	-	-	-	-
	Keller – Killani Test	-	-	-	-	-
Test for Steroids	Salkowski Test	+	-	-	-	-
	Liebermann Burchard's Test	-	-	-	-	-
Test for Flavonoids	Ferric Chloride Test	+	-	-	-	-
	Lead Acetate Test	+	-	-	-	-
Test for Saponins	Foam Test	+	-	-	-	-

+ indicates present; – indicates absent; ESSP – Entada scandens seed powder; ESS1 – Entada scandens seed starch extracted using distilled water; ESS2 – Entada scandens seed starch extracted using 0.1% sodium hydroxide; ESS3 – Entada scandens seed starch extracted using 0.25% sodium hydroxide; ESS4 – Entada scandens seed starch extracted using 0.5% sodium hydroxide.

Physicochemical Parameters of Entada Scandens Seed Powder and Starch Extracts

The physicochemical characteristics of extracted starches, including pH, gelatinization temperature, viscosity, and swelling index were within the specified ranges as per official compendium. They had a high water absorption index and minimal microbial growth, making them ideal for formulations enhancing solubility of all the extracted starches, ESS4 exhibited high swelling index and amylose content making it the suitable starch for incorporation into further formulations. [Nargis et al., 2017] Outcomes were presented in table 2.

Table 2: Physicochemical Properties of Entada scandens Seed Powder and Extracted Starches

Properties	ESSP	ESS1	ESS2	ESS3	ESS4
Gelatinization Temperature	118-121^{0}C	120-123^{0}C	122-126^{0}C	124-127^{0}C	126-129^{0}C
pH	6.32	6.50	6.62	6.78	6.98
Viscosity	1.856 cps	2.089 cps	2.166 cps	2.265 cps	2.312 cps
Swelling Index (%)	64	150	171	200	228
Water Absorption Index	Less	More	More	More	More
Total Microbial Load	Absent	Absent	Absent	Absent	Absent
Loss on drying (%)	9.0	9.2	8.3	8.5	8.8
Oxidizing substances	No brown (or) blue coloured was observed	No brown (or) blue coloured was observed	No brown (or) blue coloured was observed	No brown (or) blue coloured was Observed	No brown (or) blue coloured was observed
Fluorescence	No fluorescence was observed	No fluorescence was observed	No fluorescence was observed	No fluorescence was observed	No fluorescence was observed
Acidity	Non-acidified	Non-acidified	Non-acidified	Non-acidified	Non-acidified
Sulphated Ash	0.07%	0.08%	0.05%	0.06%	0.05%
Amylose Content	7.98%	9.62%	11.44%	13.75%	15.30%

Preparation of Nicardipine HCl Solid Dispersions

Nicardipine HCl solid dispersions were prepared by modified solvent evaporation technique utilizing ESS4 as carrier in various ratios by keeping drug dose constant. Solid dispersions, NS1 to NS5 were prepared by ESS4 using modified solvent evaporation technique. All solid dispersions were made under similar conditions for avoiding process variables. Solid dispersions of Nicardipine HCl were granular in nature and observed as white to pale white dispersions. The prepared solid dispersions were also evaluated based on physical factors to check their flow characteristics, uniformity of drug loading and particle size. The compositions of different Nicardipine HCl solid dispersions were shown in table 3.

Preparation and Evaluation of Nicardipine HCl Solid Dispersions

Table 3: Compositions of Various Nicardipine HCl Solid Dispersions Prepared by Modified Solvent Evaporation Method

Formulation	Composition	Drug: Carrier Ratio
NS1	Nicardipine HCl : ESS4	1:1
NS2	Nicardipine HCl : ESS4	1:2
NS3	Nicardipine HCl : ESS4	1:3
NS4	Nicardipine HCl : ESS4	1:4
NS5	Nicardipine HCl : ESS4	1:5

Physical Parameters of Nicardipine HCl Solid Dispersions

Physical parameters of different solid dispersions were given in table 4. The studies revealed that the prepared Nicardipine HCl solid dispersions were discovered to be stable and showed good to excellent characteristics of flow and compressible characteristics. Nicardipine HCl amount loaded in these solid dispersions was more than 95%. As modified solvent evaporation technique prepared solid dispersions were identified as stable, and exhibited good flow properties, they were further subjected to in-vitro dissolution studies.

Table 4: Physical Parameters of Nicardipine HCl Solid Dispersions

S. No	Solid Dispersion	Angle of Repose (^{O})	Carr's Index (%)	*Hausner's Ratio*	*Particle Size (µm)*	Drug Content* (mg/tablet)
1	ND	32.14	23.14	*1.28*	*39 ± 2*	20.00 ± 1.52
2	NS1	23.55	13.54	1.16	169 ± 3	19.25 ± 1.03
3	NS2	22.65	14.99	1.14	172 ±1	19.85 ± 1.85
4	NS3	22.36	12.84	1.15	175 ± 2	20.01 ± 1.55
5	NS4	20.87	11.01	1.17	170 ± 3	20.01 ± 1.24
6	NS5	23.14	14.25	1.17	180 ± 1	20.33 ± 1.77

***Mean ±SD (N = 3)**

In-vitro Dissolution Studies of Nicardipine HCl Solid Dispersions

Dissolution studies were conducted on Nicardipine HCl solid dispersions using USP paddle model (apparatus II) with 1.2 pH as dissolution medium. The dissolution profiles of solid dispersions were shown in fig 1. Solid dispersions prepared by ESS4 exhibited more drug release than compared to the pure drug. Pure drug Nicardipine HCl displayed drug release of 29.33% only after 30min of dissolution. Among all the solid dispersions, NS4 which was prepared using Nicardipine HCl and ESS4 in 1:4 ratios by modified solvent evaporation approach exhibited the highest drug release of 99.11% at 30min of dissolution. With further increase in ESS4 concentration, a reduction in drug release had been noted. This drug release pattern could be due to the presence of optimal proportions of hydrophilic and lipophilic moieties. [Shrawan et al., 2018]

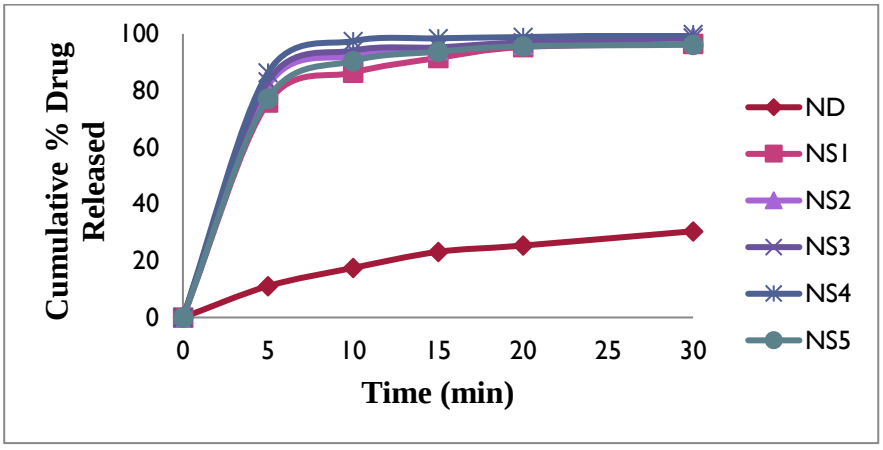

Fig 1: Drug Release Profiles of Nicardipine HCl Solid Dispersions Prepared using ESS4

Preparation and Evaluation of Nicardipine HCl Orodispersible Tablets

Preparation of Nicardipine HCl Orodispersible Tablets

All the orodispersible tablet formulations were formulated using Direct compression approach. Solid dispersion that showed high dissolution profile (NS4) compared to Nicardipine HCl pure drug was chosen for orodispersible tablets preparation. Micro crystalline cellulose (PH-102) was utilized as diluent in all the formulations. Sorbitol (0.2%) was used as a sweetening agent. The orodispersible tablets were prepared by Direct compression method by blending known proportions of NS4 solid dispersion containing Nicardipine HCl equivalent to 20mg dose with diluents and various concentrations of superdisintegrants and further mixed with a total of 1% of lubricant and glidant before Direct compression as tablets.

Formulation N was compressed without adding any superdisintegrant. NN was compressed with only optimized solid dispersion NS4. Formulations N1 to N5 were prepared by using 2.0 to 10.0% of CCS along with optimized Nicardipine HCl solid dispersion NS4. Formulations N6 to N10 were prepared by using 2.0 to 10.0% of SSG along with optimized Nicardipine HCl solid dispersion NS4. All these formulations were prepared with a uniform weight of 250mg. These blends were further compressed into tablets employing CLIT 10station mini-press having 6mm flat punches. All the tablets have been compressed in exact mode to minimize processing variables. Composition of Nicardipine HCl orodispersible tablets were given in table 5.

Table 5: Composition of Nicardipine HCl Orodispersible Tablet Formulations

S.No	Ingredient (mg/tablet)	Formulations											
		N	NN	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10
1	**Nicardipine HCl**	20	-	-	-	-	-	-	-	-	-	-	-
2	**Optimized Solid Dispersion (NS4)**	-	100	100	100	100	100	100	100	100	100	100	100
3	**CCS**	-	-	5	10	15	20	25	-	-	-	-	-
4	**SSG**	-	-	-	-	-	-	-	5	10	15	20	25
5	**MCC PH 102**	221	141	136	131	126	121	116	136	131	126	121	116
6	**Sorbitol**	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
7	**Vanilla Flavor**	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S
8	**Talc**	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
9	**Magnesium Stearate**	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75	3.75
10	**Total Weight**	250	250	250	250	250	250	250	250	250	250	250	250

*Q.S. – Quantity Sufficient

Evaluation of Nicardipine HCl Orodispersible Tablets

Pre-Compression Parameters of Nicardipine HCl Orodispersible Tablets

Pre-compression parameters for tablet blends were evaluated before compression into orodispersible tablets. Findings indicated the angle of repose values for Nicardipine HCl tablet formulations made using CCS and SSG along with NS4 dispersion were within accepted limits, suggesting superior flow characteristics. Hausner's ratio, Carr's index values were within acceptable limits, indicating good repacking ability for compression. The pre-compression parameters were listed in table 6.

Table 6: Evaluation of Pre-Compression Parameters of Nicardipine HCl Granules

S.No	Formulation	Angle of Repose (^{0})	Carr's Index (%)	Hausner's Ratio
1	N	31	21	1.17
2	NN	23	18	1.15
3	N1	24	15	1.19
4	N2	22	12	1.12
5	N3	21	11	1.11
6	N4	22	12	1.13

7	N5	24	13	1.14
8	N6	26	14	1.11
9	N7	25	15	1.16
10	N8	22	11	1.15
11	N9	22	12	1.14
12	N10	24	16	1.16

Post Compression Parameters of Nicardipine HCl Orodispersible Tablets

The study found that all tablet formulations made using CCS and SSG along with NS4 dispersion mentioned as per I.P specifications for hardness, weight uniformity, and friability loss. The drug content was uniform across various formulations. Formulations N3 and N8 had wetting times of 20 and 22 seconds due to rapid water uptake by ESS4, CCS and SSG as superdisintegrants. Dispersion tests showed uniform suspension in water within 3 min, except for formulation N, which failed to form a uniform suspension within 3 min. Based upon these post compression evaluation parameters, it was noted that all the tablets prepared by Direct compression process were found as stable. Post compression parameters of Nicardipine HCl tablet formulations were given in table 7.

Table 7: Evaluation of Post Compression Parameters of Nicardipine HCl Orodispersible Tablet Formulations

Formulation	Weight uniformity (mg)	Hardness (kg/cm^2)	Friability (% loss)	Wetting Time (sec)	Dispersion Test	Drug Content (mg/tablet)
N	248 ± 1.09	3.8 ± 0.11	0.3	186	Passed	246.41±1.01
NN	247 ± 1.11	3.6 ± 0.01	0.3	141	Passed	249.27±1.94
N1	249 ± 1.32	3.8 ± 0.15	0.2	46	Passed	249.07±1.57
N2	248 ± 1.01	3.7 ± 0.09	0.2	23	Passed	249.61±2.20
N3	248 ± 1.24	3.6 ± 0.19	0.3	20	Passed	249.44±1.85
N4	246 ± 1.08	3.8 ± 0.14	0.2	55	Passed	249.04±1.71
N5	247 ± 1.10	3.7 ± 0.07	0.2	67	Passed	249.17±1.22
N6	249 ± 1.05	3.8 ± 0.15	0.3	51	Passed	248.97±1.45
N7	248 ± 1.34	3.7 ± 0.13	0.2	45	Passed	249.15±1.86
N8	249 ± 1.66	3.9 ± 0.18	0.3	22	Passed	249.02±1.75
N9	248 ± 1.33	3.7 ± 0.10	0.2	25	Passed	247.77±1.14
N10	249 ± 1.44	3.8 ± 0.21	0.3	26	Passed	249.21±1.11

In-vitro Dissolution Studies of Nicardipine HCl Orodispersible Tablet Formulations

Direct compression method was found to be appropriate to compress optimized solid dispersions into orodispersible tablets. Dissolution studies were conducted using U.S.P paddle approach with 1.2pH. Formulations N1 to N5 were made employing NS4 solid dispersions as well as CCS as superdisintegrant, while N6 to N10 were made employing NS4 solid dispersions, SSG as superdisintegrant. Formulations N3 and N8 showed high drug release within 5 min. Dissolution profiles of the orodispersible tablets were given in fig 2 and 3.

ESS4 is a promising superdisintegrant for the formulation of orodispersible tablets of Nicardipine HCl. Its hydrophilic nature, moderate swelling, rapid water uptake and swelling lead to hydrostatic pressure in tablet crust, causing tablets to dissolve more quickly [Nor et al., 2018]. In addition to this starch, usage of CCS and SSG as superdisintegrants also aided in the faster drug release.

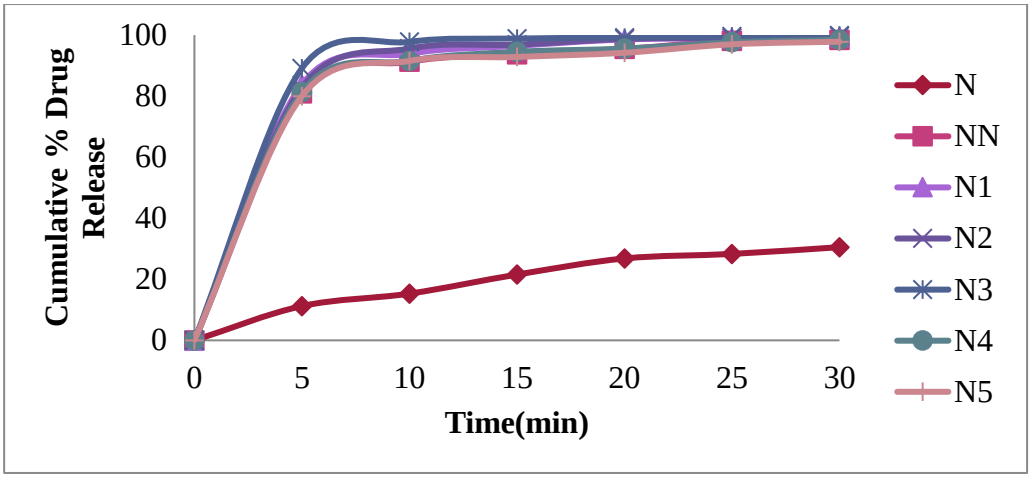

Fig 2: Drug Release Profiles of Nicardipine HCl Orodispersible Tablets prepared using ESS4 and CCS

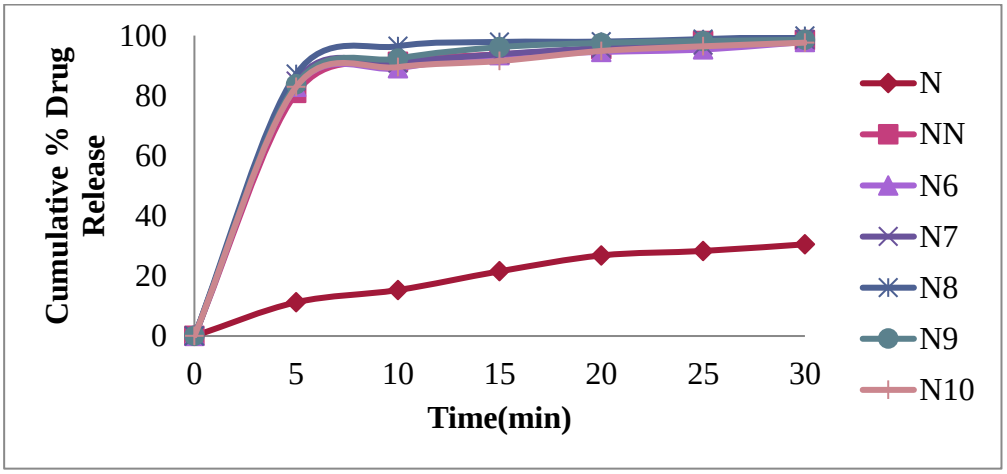

Fig 3: Drug Release Profiles of Nicardipine HCl Orodispersible Tablets prepared using ESS4 and SSG

Characterization Studies of Nicardipine HCl Orodispersible Tablets

As per dissolution tests conducted on each formulation, optimized orodispersible formulations were chosen and examined in more detail for FTIR and SEM.

Fourier Transform Infrared Spectroscopy (FTIR)

FTIR spectral investigations on Nicardipine HCl pure drug, ESS4, CCS, NS4 and N3 revealed the presence of –OH stretching, C-H stretching, and N-O asymmetrical stretching. The orodispersible formulation N3 prepared with ESS4 and NS4 solid dispersion showed -OH stretching, C-H stretching, N-O asymmetrical stretching, and C-O stretching. The specific spectral peaks observed in Nicardipine HCl pure drug was also observed in the solid dispersions NS4 and orodispersible tablets N3 containing ESS4 and CCS. Thus, the FTIR spectral investigations indicated no drug-carrier and excipient interactions. The detailed spectral elucidations were shown in figure 4.

CHARACTERIZATION STUDIES

FTIR Spectra

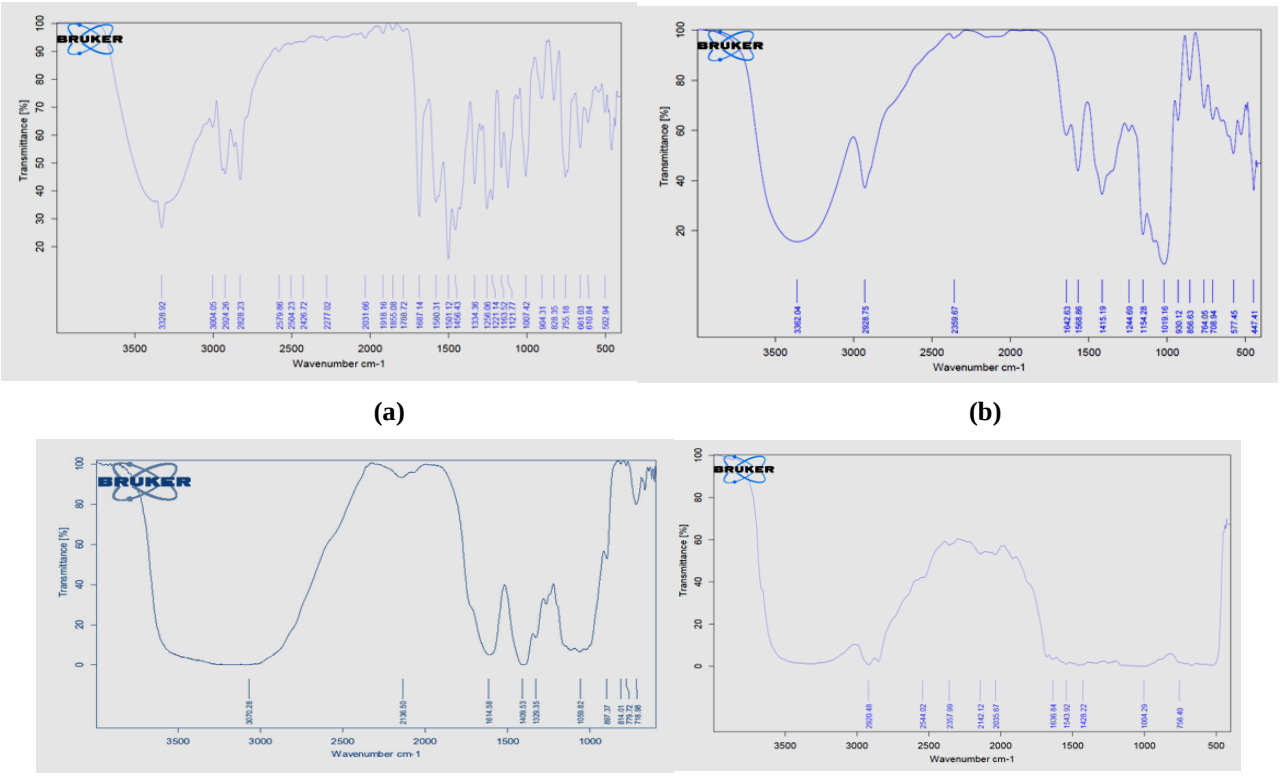

Fig 4: FTIR Spectra of (a) Nicardipine HCl (b)ESS4 (c) Croscarmellose Sodium (CCS) (d) Nicardipine HCl with ESS4 and CCS

Scanning Electron Microscopy

SEM images were taken for Nicardipine HCl pure drug, ESS4, CCS, NS4 and N3. SEM image of Nicardipine HCl exhibited a highly crystalline form of the drug. ESS4 showed spherical free-flowing starch grains without intact resinous or mucilaginous mass. The SEM image of CCS showed long cylindrical crystals. The SEM image of the NS4 formulation showed uniformly distributed spherical starch grains with Nicardipine HCl. N3 formulation showed well-distributed forms of drug crystals with spherical starch grains and cylindrical CCS crystals. The SEM images were shown in figure 5.

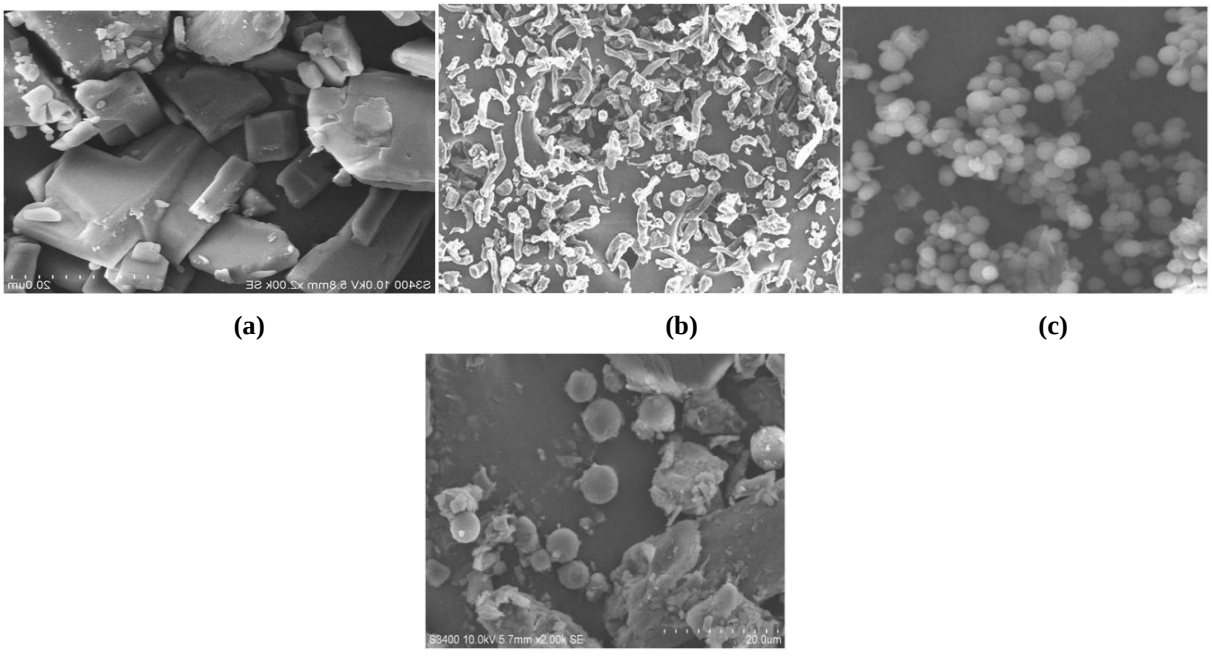

Fig 5: SEM Image of (a) Nicardipine HCl (b) Croscarmellose Sodium (CCS) (c) Entada scandens Seed Starch (ESS4) (d) Nicardipine HCl with ESS4 and CCS

Accelerated Stability Studies of Nicardipine HCl Orodispersible Tablets

The optimized orodispersible tablets of Nicardipine HCl, N3 were subjected to accelerated stability studies as per ICH guidelines. No physical change in tablets was observed before and after storage. The results showed that there were no changes in the dissolution profiles of Nicardipine HCl orodispersible tablets even after storage. The results were indicated in figure 6. Based on all these studies, it was observed that the orodispersible tablets prepared were found to be highly stable.

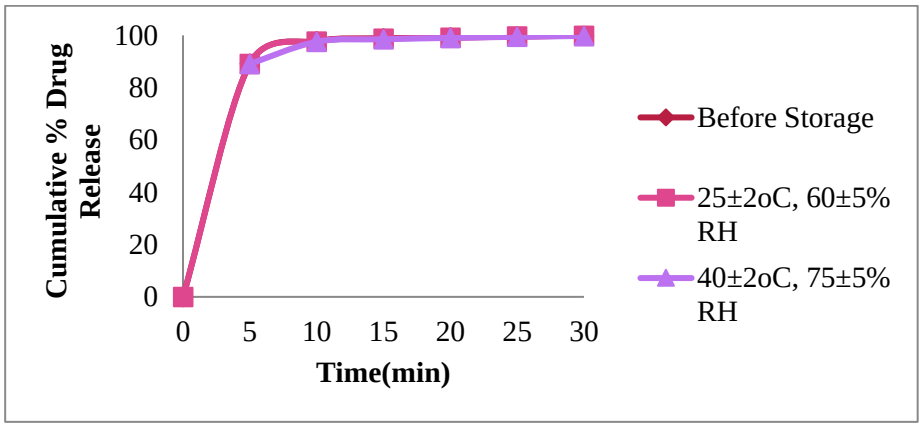

Fig 6: Release of Nicardipine HCl Orodispersible Tablets N3 Before and After Storage at Different Conditions

5. CONCLUSION

Orodispersible tablet preparation is a technique used to improve the dissolution profiles of poorly soluble drugs. Several synthetic and semi-synthetic polymers are being used, but only a few novel natural agents have been employed. E. scandens in the current study is used as a natural polymer in the design of Nicardipine HCl solid dispersions. Exploring other novel polymers could help in developing new formulations with faster drug release. ESS4 is found to be a suitable excipient for orodispersible tablet formulation. Further research could explore the wider applications of the extract and to conduct in-vivo pharmacodynamic screening using suitable animal models.

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Conflict of Interest

The authors have no conflicts of interest regarding this research.

REFERENCES

[1] Jindal. Review on solubility: A mandatory tool for pharmaceuticals. International Research Journal of Pharmacy. 8(11):11-5, 2017.

[2] Saharan, Kukkar, Kataria, Gera, Choudhury. Dissolution enhancement of drugs. Part I: technologies and effect of carriers. International Journal of Health Research.;2(2), 2009.

[3] Lewis, Udupa, Atin. Solid dispersions: a review. Pak J Pharm Sci. Apr;22(2):234-46, 2009.

[4] Chiou, Riegelman. Preparation and dissolution characteristics of several fast-release solid dispersions of griseofulvin. Journal of pharmaceutical sciences. Dec 1;58(12):1505-10, 1969.

[5] Pawar, Barhate. Solubility enhancement (Solid Dispersions) novel boon to increase bioavailability. Journal of Drug Delivery and Therapeutics. Mar 22;9(2):583-90, 2019.

[6] Tekade, Yadav. A review on solid dispersion and carriers used therein for solubility enhancement of poorly water soluble drugs. Advanced pharmaceutical bulletin. Jul;10(3):359, 2020.

[7] Siripruekpong, Issarachot, Kaewkroek, Wiwattanapatapee. Development of Gastroretentive Carriers for Curcumin-Loaded Solid Dispersion Based on Expandable Starch/Chitosan Films. Molecules. Jan 1;28(1):361,

2023.

[8] Jyoti Patil, Dr. Arunkumar Walikar, Preparation and Evaluation of Melt in Mouth Tablets of Nicardipine HCl by Using Liquisolid Technique International Journal of Pharmaceutical Research and Applications, Volume 10, Issue 1 Jan - Feb 2025, pp: 1605-1618

[9] Chabria NB, Narayanan N. Formulation and in-vitro evaluation of oral floating Nicardipine HCl hydrochloride tablets. Hygeia. JD Med. 2013; 5(2):63-75.

[10] https://www.drugbank.ca/drugs/DB00622/28/03/2020.

[11] Mannem V, Suryadevara V, Doppalapudi S. Formulation and evaluation of telmisartan solid dispersions using Entada scandens seed starch and poloxamer-188 as superdisintegrants. Asian J Pharm Clin Res;11(9):474-81, 2018.

[12] Venkatarao Mannem, Vidyadhara Suryadevara, Sandeep Doppalapudi.Formulation and Evaluation of Telmisartan Solid Dispersions Using Entada Scandens Seed Starch And Poloxamer-188 as Superdisintegrants, Asian J Pharm Clin Res, Vol 11, Issue 9, 474-481, 2018.

[13] Xueling Z, Hao M, Mei L, Ying L, Le S and Wenqian D. Research progress on properties of pre-gelatinized starch and its application in wheat flour products. Grain and Oil Science Technology, 5(2): 87-97, 2022.

[14] Kokott M, Klinken S, Breitkreutz J, Wiedey R. Downstream processing of amorphous solid dispersions into Orodispersible tablets. Int J Pharm. 2023;631:122493. doi: 10.1 016/j.ijpharm.2022.122493, PMID 36528189.

[15] Dasari N, Kumar CSP, Gummadi RK, Pindiprolu SSSK, Balla S, Masa A, et al. Application of Novel Natural Sweetening Agent-Stevia in Formulation, Evaluation of Nicardipine HCl Hydrochloride Orodispersable for Rapid Absorption. Indian J of Pharmaceutical Education and Research. 2024;58(1s):s176-s186.

[16] Preethi GB, Sayan B, Shivakumar HN and Ravi KM. Formulation of fast-dissolving tablets of Doxazosin mesylate drug by direct compression method, International Journal of Applied Pharmaceutics, 9(5): 22-28, 2017.

[17] Balakrishna T, Vidyadhara S, Murthy TEGK, Viswanadh K and Tejasri M. Formulation and evaluation of Orodispersible tablets of Zolmitriptan,Asian Journal of Pharmaceutics, 10(4): S683-S687, 2016.

[18] Vidyadhara S, Sasidhar R, Lakshmi H, Vijetha P and Vijetha K. Studies on jackfruit seed starch as a novel natural superdisintegrant for the design and evaluation of irbesartan fast dissolving tablets. Integrative Medicine Research,6(3): 280-291, 2017.

[19] Fateatun N, Jiaur R, Sultan M, Sorifa A, Aminul IT and Maruf A. Physicochemical properties of flour and extraction of starch from jackfruit seed. International Journal of Nutrition and Food Sciences, 3(4): 347-354, 2014.

[20] Joerg F, Henrike B and Slawomir O. Strach and glycogen analyses: methods and techniques, Biomolecules, 10(7): 1020, 2020.

[21] Nargis Y, Fiza N, Rehana S, Hafiza A and Adnan S. Water solubility and water absorption index of extruded product from rice and carrot blend, Journal of Pharmacognosy and Phytochemistry, 6(6): 2165-2168, 2017.

[22] Shrawan B, Helen C and Niall J R. Investigation into the solid state properties an dissolution profile of spray dried ternary amorphous solid dispersions: a rational step toward the design and development of a multicomponent amorphous system. Molecular Pharmaceutics, 15(9): 3796-3812, 2018.

[23] Nor K A, Nor M S and Meor M A. “Roles of polysaccharides in transdermal drug delivery system and future prospects”, Journal of Applied Pharmaceutical Science, 8(3): 141-157, 2018.