RESEARCH ARTICLE

Formulation and Evaluation of Mucoadhesive Buccal tablets using Nimodipine Solid Lipid Nanoparticles

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Abstract: This study aimed to create and describe mucoadhesive nimodipine solid lipid nanoparticles as buccal tablets by altering the amounts of three polymers: Carbopol 934, Hydroxypropyl methylcellulose and Hydroxyethyl cellulose. The Nimodipine-loaded solid lipid nanoparticles (SLN) were formulated by high shear homogenization and ultrasonication process using palmitic and stearic acid as the lipid matrix and Tween-80 as the surfactant. The swelling properties of all formulations were investigated, and it was discovered that all formulations have a good swelling index at 6 hours. The surface pH of each batch varied between 5.6 and 6.1. The mucoadhesive strengths (15.3-29.5 g) varied with polymer concentrations, particularly Carbopol 934. All batches had considerably different dissolution profiles, ranging from a maximum release of 89.08% (at 8h in batch NT3) to a minimum release of 80.32% (at 8h in batch NT2). SLN formulations had the best results in both Entrapment efficiency and *In-vitro* drug release, showing that SLN may be a promising delivery strategy for improving Nimodipine release.

Keywords: Nimodipine; Mucoadhesive buccal tablets; Carbopol 934; Hydroxypropyl methylcellulose; Hydroxyethyl cellulose; Solid lipid nanoparticles.

1. INTRODUCTION

Oral delivery is the most widely used drug administration route because of its painlessness, ease of self-administration, high patient compliance, and feasibility for outpatients. Nevertheless, chemical and enzymatic barriers in the gastrointestinal (GI) tract limit the effectiveness of oral drug delivery. Some poorly soluble drug molecules are difficult to dissolve in the GI tract, resulting in low bioavailability (Harris & Robinson, 1992). To overcome these constraints, novel and sophisticated drug delivery methods are required. Optimizing the formulations improves the delivery efficiency and bioavailability, promoting therapeutic effectiveness with reduced side effects. The oral delivery improvement using nanocarrier systems has gained more attention recently (Lin *et al.*, 2017). Nanoparticles are defined as particles with a size between 1 nm and several hundred nm capable of carrying drugs for effective delivery. The potential use of solid lipid nanoparticles (SLNs) in oral drug delivery systems is at the forefront of the various types of nanocarriers. SLNs are nano colloids developed at the beginning of the 1990s by Schwarz *et al.* They are utilized as an alternate carrier to conventional colloids such as emulsions, liposomes, and polymeric micelles (Müller *et al.*, 2000). SLNs are lipid-based colloidal drug delivery systems consisting of a solid lipid core surrounded by one or more surfactants as

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stabilizing agents (Mishra *et al.*, 2018). Using SLNs for oral administration is a promising approach for improving and controlling drug delivery. The solid state of the nanoparticulate matrix protects chemically labile drugs and prolongs drug release. SLNs can be administered orally as aqueous dispersions or as capsules, tablets and pellets.

There are two main types of drug delivery through the oral mucosal cavity: (a) sublingual delivery, which involves systemic drug distribution through the mucosal membranes lining the floor of the mouth; and (b) buccal delivery, which involves drug delivery through the mucosal membranes lining the cheeks (buccal mucosa). The goal is to achieve drug absorption across the mucosal barrier and into the systemic circulation, as well as site-specific medication release on the mucosa (Drug & Systems, 1993). Since the amount of drug in buccal formulations is typically much lower than that in tablets and capsules, the risk of toxicity or unwanted side effects is significantly reduced. Mucoadhesive tablets directly interact with the mucosal surface, releasing their contents either locally or systemically. These soften and adhere to the mucosa, remaining until breakdown and/or release. Mucoadhesive tablets can be used for controlled drug administration (Salamat-Miller *et al.*, 2005). A few reports describing preparations based on the idea of incorporating SLNs in formulations for buccal administration have also been published in the recent years – SLN-loaded mucoadhesive buccal films (Tzanova *et al.*, 2021) and SLN-loaded mucoadhesive buccal tablets for efficient delivery of Lornoxicom (Zewail *et al.*, 2022). SLNs have been reported as a taste-masking strategy (Walsh *et al.*, 2014), and loading in polymeric mucoadhesive tablets can allow for a prolonged residence time on the buccal mucosa. The apparent advantages of using SLNs are their superior ability to solubilize lipophilic drugs and great biocompatibility.

Hypertension, one of the most common cardiovascular illnesses, necessitates lifelong medication to keep it under control. Nimodipine, a potent antihypertensive agent, has been used to treat hypertensive disorders. It belongs to class II drugs of the biopharmaceutical classification system (BCS), which is characterized by low solubility and high permeability. It is a highly lipophilic drug and poorly water-soluble drug with a bioavailability of 13%. Poor water solubility and high first-pass metabolism are the main causes of reduced bioavailability (Kianfar *et al.*, 2011). The present work illustrates the development of an SLN formulation for Nimodipine with increased bioavailability loaded has mucoadhesive buccal tablets. The buccal mucoadhesive route of drug delivery directly connects the internal jugular vein to the systemic circulation, avoiding first-pass metabolism and

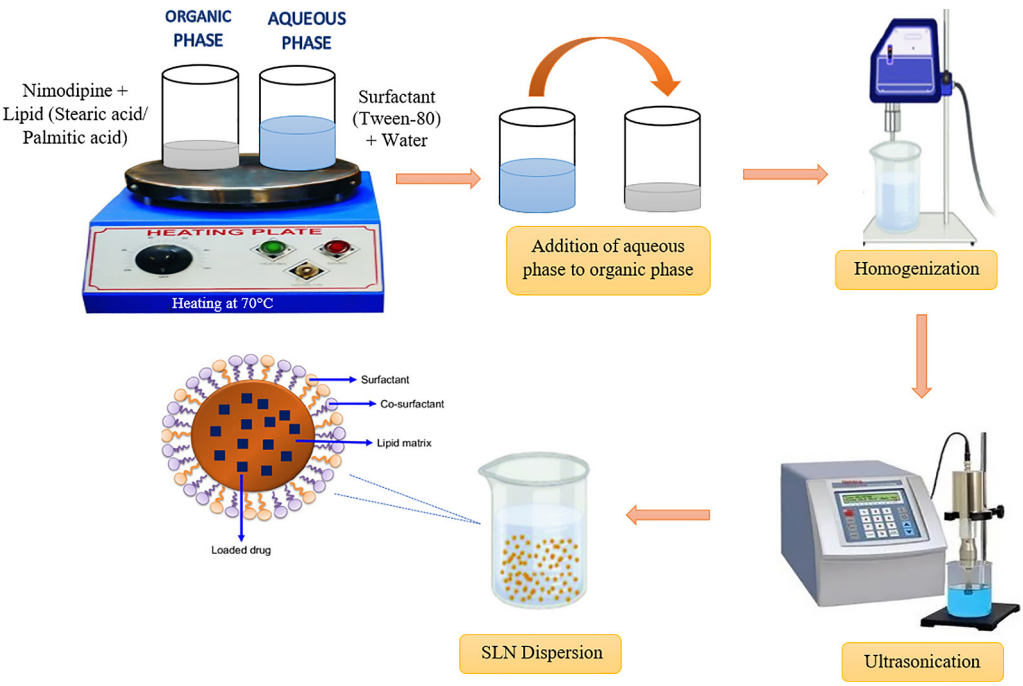

Figure 1. Schematic diagram for preparation of Nimodipine SLN.

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producing excellent bioavailability. The standard antihypertensive dose of Nimodipine is 20-30 mg twice daily; however, a lower effective dose of approximately 10 mg has been reported. By prolonging the contact period and avoiding first-pass metabolism, a smaller amount of the drug can have the same effect as a standard dose. Moreover, frequent drug administration can be avoided by maintaining drug release, hence enhancing patient compliance (Shaikh *et al.,* 2011).

MATERIALS AND METHODS

Nimodipine was obtained from Shreeji Pharma International in Vadodara, Gujarat. Carbopol 934, Hydroxypropyl methylcellulose and Hydroxyethyl cellulose from Sisco Research in Mumbai. All of the reagents utilized in this study are analytical reagent grade.

PREPARATION OF NIMODIPINE SLN

A modified high-shear homogenization and ultrasonication process was used to produce the SLNs. Heating different concentrations of lipids (stearic acid and palmitic acid) and surfactants (10% and 20%) resulted in SLN (Chalikwar *et al.,* 2012). The organic phase containing stearic acid is mixed with the drug Nimodipine and heated to 70 ° C until completely dissolved. After melting at 70°C, the aqueous phase, which contains the surfactant tween 80, is introduced to the organic phase. The mixture is placed in a magnetic stirrer for 30 minutes to obtain a clear solution. It is then homogenized and sonicated for 30 minutes (Arabi *et al.,* 2020). A similar method was used to prepare SLN with palmitic acid. Figure 1 shows the preparation of SLN, and in Table 1 SLNs formulation data was given.

Formulation code	Drug (Nimodipine) (mg)	Stearic Acid (mg)	Palmitic Acid (mg)	Tween 80 (ml)	Soya lecithin (mg)	Distilled water (ml)
S1	100	100	—	10	100	100
S2	100	100	—	20	100	100
S3	100	150	—	10	100	100
S4	100	150	—	20	100	100
P1	100	—	100	10	100	100
P2	100	—	100	20	100	100
P3	100	—	150	10	100	100
P4	100	—	150	20	100	100

Table 1. Formulation of Nimodipine SLNs.

CHARACTERIZATION OF NIMODIPINE SLN

Scanning electron microscopy (SEM) of nanoparticles

The morphology of nanoparticles was investigated by SEM (SE S3400N; HITACHI, Japan). Briefly, 10 mg freeze-dried SLN was suspended in 1 ml distilled water, and 2µl of the suspension was placed on a glass surface. After oven-drying, the samples were coated with gold using an Ion Sputter and examined at an accelerating voltage of 20 kV, and it was given in figure 2 (Hosny *et al.,* 2015).

Fourier-transformed infrared (FTIR) spectroscopic analysis

An FT-IR spectroscopy study has been carried out to check the compatibility between the drug (Nimodipine) and the lipid (SA and PA) separately, which are used for the preparation of nanoparticles. The samples used for the FT-IR study were at a wavelength from 4000 to 400 cm-1 and given in figure 3.

X-ray diffraction studies

The crystalline nature of the nanoparticle formulation was analyzed through a powder X-ray

diffractometer (XRD6000, Shimazdu, Japan). Powder XRD studies were performed on the samples by exposing them to nickel filtered CuKα radiation (40 kV, 30 mA) and scanned from 2 to 70°, 2θ at a step size of 0.045° and step time of 0.5 s. Samples used for PXRD analysis are given in figure 4.

Particle size and zeta potential determination

The lipid particulate dispersions' average particle size, polydispersity index, and zeta potential were performed using a zeta sizer (DTS Ver.5.10, Malvern Instruments). The dispersion was diluted to 1:10 v/v with double distilled water (filtered through 0.45μm membrane filters) to determine that the light scattering intensity was within the instrument's sensitivity range (Mehnert & Mäder, 2001).

Entrapment efficiency of the Nimodipine drug

The centrifugation method was used to determine the entrapment efficiency of the SLN dispersion (Zewail *et al.*, 2022). The SLN dispersion was centrifuged at 2000 rpm for an hour to separate the supernatant liquid, which was then filtered to determine the amount of free drug present. The sample was diluted using phosphate-buffered saline with a pH of 7.4. The absorbance at 238 nm was measured using a UV spectrophotometer, and the equation was used to calculate the entrapment efficiency (1).

$$\text{Entrapment efficiency of the drug} = \frac{\text{Total drug} - \text{Entrapped drug}}{\text{Total drug}} \times 100 \quad (1)$$

In-vitro drug release

The dialysis bag technique was used to determine the in-vitro drug release of various SLN dispersions. A 5 mg Nimodipine dispersion was placed in the dialysis bag and tightly sealed. A magnetic stirrer agitated the sealed bag in the phosphate buffer saline. pH 7.4 and 37°C ± 0.5°C were the parameters for the suspended solution. After that, aliquots were removed at various time intervals for up to 6 hours, and spectrophotometric studiesspectrophotometric studies quantified the amount of drug released quantified the amount of drug released at 238 nm. The samples with the highest entrapment efficiency were chosen, and solubility investigations were performed on them at two different temperatures: 40°C and 25± 2°C. Every 15 days, the drug content was assessed to detect changes in the prepared SLNs, and the results are given in table 3 (Tzanova *et al.*, 2021).

PREPARATION OF MUCOADHESIVE BUCCAL TABLETS

Mucoadhesive buccal tablets containing Nimodipine SLNs were prepared using various polymers like Hydroxy ethyl cellulose (HEC), Hydroxy propyl methyl cellulose (HPMC), Carbopol and ingredients including Spray dried lactose, Mannitol, Magnesium stearate are weighed accurately and mixed (Akter *et al.*, 2012). These polymers were mixed according to formulations with drug and directly punched in a Cadmach tablet punching machine. Tablets were made with a flat-faced 8 mm punch and direct compression. Each tablet had 10 mg of nimodipine and bio-adhesive polymers made of Carbopol, HPMC, HEC, spray-dried lactose, magnesium stearate, and mannitol. Adjusting the tablet's weight to approximately 150 mg (Andrews *et al.*, 2009).

Ingredients	NT1	NT2	NT3	NT4	NT5	NT6
Nimodipine SLN	10mg	10mg	10mg	10mg	10mg	10mg
Carbopol	25mg	42.5mg	60mg	—	—	—
HPMC K4M	60mg	42.5mg	25mg	25mg	42.5mg	60mg
HEC	—	—	—	60mg	42.5mg	25mg
Spray dried lactose	35mg	35mg	35mg	35mg	35mg	35mg
Mannitol	15mg	15mg	15mg	15mg	15mg	15mg
Magnesium stearate	5mg	5mg	5mg	5mg	5mg	5mg

Table 2. Formula table of Mucoadhesive buccal tablets. Total weight of each tablet – 150mg.

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EVALUATION OF MUCOADHESIVE BUCCAL TABLETS

The following parameters were used to evaluate all of the prepared mucoadhesive buccal tablets.

Weight Variation Test

Ten tablets were chosen randomly from each batch and weighed to check for weight variation. The average weight and standard deviation of ten tablets were calculated. The batch passes the weight variation test if no more than one tablet's weight deviates from the average weight by more than a percentage and no more than twice the percentage (Henriksen *et al.*, 1996). The following % deviation in weight variation was permitted. The results were tabulated and given in table 4.

$$+\text{ Deviation} = \frac{\text{Maximum weight} - \text{Average weight}}{\text{Average weight}} \times 100$$

$$-\text{ Deviation} = \frac{\text{Minimum weight - Average weight}}{\text{Average weight}} \times 100$$

Thickness

Three tablets were chosen from each formulation batch, and their thickness was measured using a vernier caliper (Woodley, 2001). The average thickness was then calculated.

Hardness

The hardness of a tablet, which was evaluated using a Monsanto hardness tester, determines its capacity to endure mechanical shocks while being handled (Huang *et al.*, 2000). It is measured in kg/cm^2. The hardness of one tablet was assessed after it was chosen at random, and the results of all physical parameters were reported in table 4.

Friability test

The Roche Friabilator was used to test the friability of tablets. It is given as a percentage (%). The Friabilator was set to 25rpm for 4 minutes, up to 100 revolutions and ten tablets were weighed individually (Initial weight W1) (Boddupalli *et al.*, 2010). The tablets were once more weighed (Final weight W2).

$$\text{Percentage Friability} = \frac{W1 - W2}{W1} \times 100$$

Tablets with a friability of less than 1% were considered acceptable, as shown inTable 4.

Surface pH

The surface pH of the buccal tablets was evaluated to determine the probability of any in-vivo adverse effects. Because an acidic or alkaline pH can irritate the buccal mucosa, the surface pH was kept as close to neutral as possible. A composite glass electrode was employed for this. The tablet was placed in 1 mL of distilled water and swelled for 2 hours at room temperature. The pH was obtained by placing the electrode on the tablet's surface and allowing it to equilibrate for 1 minute (Patel *et al.*, 2011).

Drug content

Three tablets from each batch were placed in a 100ml volumetric flask containing 100ml of pH 6.6 phosphate buffer and stirred continuously for 24 hours. The solutions were then filtered, diluted appropriately, and measured at 238 nm with a UV-spectrophotometer (Bernkop-Schnürch, 2005). The drug content in one tablet unit was calculated as the average of three tablets. The results are tabulated in table 4.

Swelling studies

The degree of swelling of bio-adhesive polymers influences adhesive performance significantly. For six hours, a tablet was weighed and placed in a petri dish containing 5 ml phosphate buffer with a pH of 6.8. After gently removing the tablets from the petridish, excess water was carefully removed with filter paper (Wong *et al.*, 1999). The swelling index

was calculated using the following formula, and the results are tabulated in table 5.

$$\text{Swelling index} = \frac{Wt - Wo}{Wo} \times 100$$

Wt = Weight of the swollen tablet at each time interval

Wo = Weight of the initial tablet

Invitro dissolution studies

This study utilised a Type II dissolution apparatus to assess drug release from buccal tablets. The dissolving medium consisted of 900 ml phosphate buffer (pH 6.8). At a rotational speed of 50 rpm, the release was carried out at 37±0.5 °C. Fresh medium was used to filter samples (5 ml each time). The samples were correctly diluted with phosphate buffer (pH 6.8) and filtered using whatman filter paper no. 41 before being spectrophotometrically measured at 238 nm with phosphate buffer as blank (Yehia *et al.*, 2008). The results were tabulated in table 6 and figure 5.

Determination of Mucoadhesive Strength

The bio-adhesive strength of in-situ gels on tissue samples (goat cheek) was evaluated using a bio-adhesive strength measuring apparatus designed and built in our laboratory. The tissue was frozen in phosphate buffer at pH 6.8 before being thawed to room temperature. During testing, cyanoacrylate adhesive was used to adhere a section of tissue (mucosal side out) to the upper side of a glass vial. Each exposed mucosal membrane is 1.5 cm in diameter. The vials were equilibrated at 37°C for 10 minutes. The balance was attached to one vial containing a piece of tissue, while the second vial was fixed to a pan with adjustable height. The exposed surface of the tissue adhering to the vial was attached to the buccal tablet. Weights were added to the pan on the other side of the modified balance consistently until the two vials were separated. The detachment stress is expressed in dynes/cm as the bio-adhesive force. The minimum weight required to remove tissues from the surface of each formulation (Yedurkar *et al.*, 2012). The results are tabulated in table 7.

RESULTS AND DISCUSSION

Formulation code	Particle size (nm)	PDI	Entrapment efficiency (%)	In-vitro drug release (%)	Zeta potential (mV)
S1	138.71 ± 32.95	0.162 ±0.062	93.8±1.55	86.1	–19.6 ±5.045
S2	132.2 ± 44.13	0.174 ±0.055	95.8±1.35	87.5	–16.4 ±6.055
S3	133.11 ± 34.93	0.169 ±0.046	92.4±4.35	80.2	–19.4 ±7.330
S4	139.3 ± 31.89	0.165 ±0.044	91.3±2.45	85.3	–17.6 ±4.065
P1	133.9 ± 30.96	0.171 ±0.052	89.5±0.45	80.2	–14.2 ±5.054
P2	131.4 ± 33.23	0.170 ±0.056	96.9±0.55	89.4	–13.5 ±8.050
P3	135.0 ± 38.93	0.163 ±0.058	90.7±2.30	85.1	–19.0 ±9.450
P4	137.6 ± 39.93	0.175 ±0.052	91.8±3.45	75.6	–14.0 ±7.055

Table 3. Evaluation parameters of Nimodipine loaded SLN formulations.

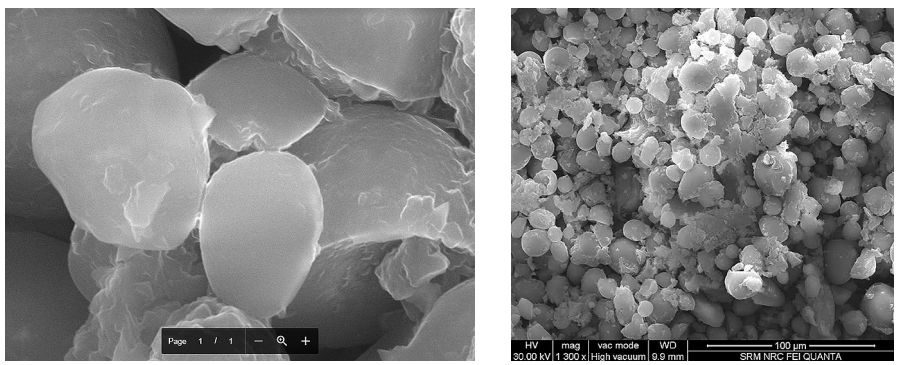

Figure 2. Scanning electron microscopy of Nimodipine SLN P2.

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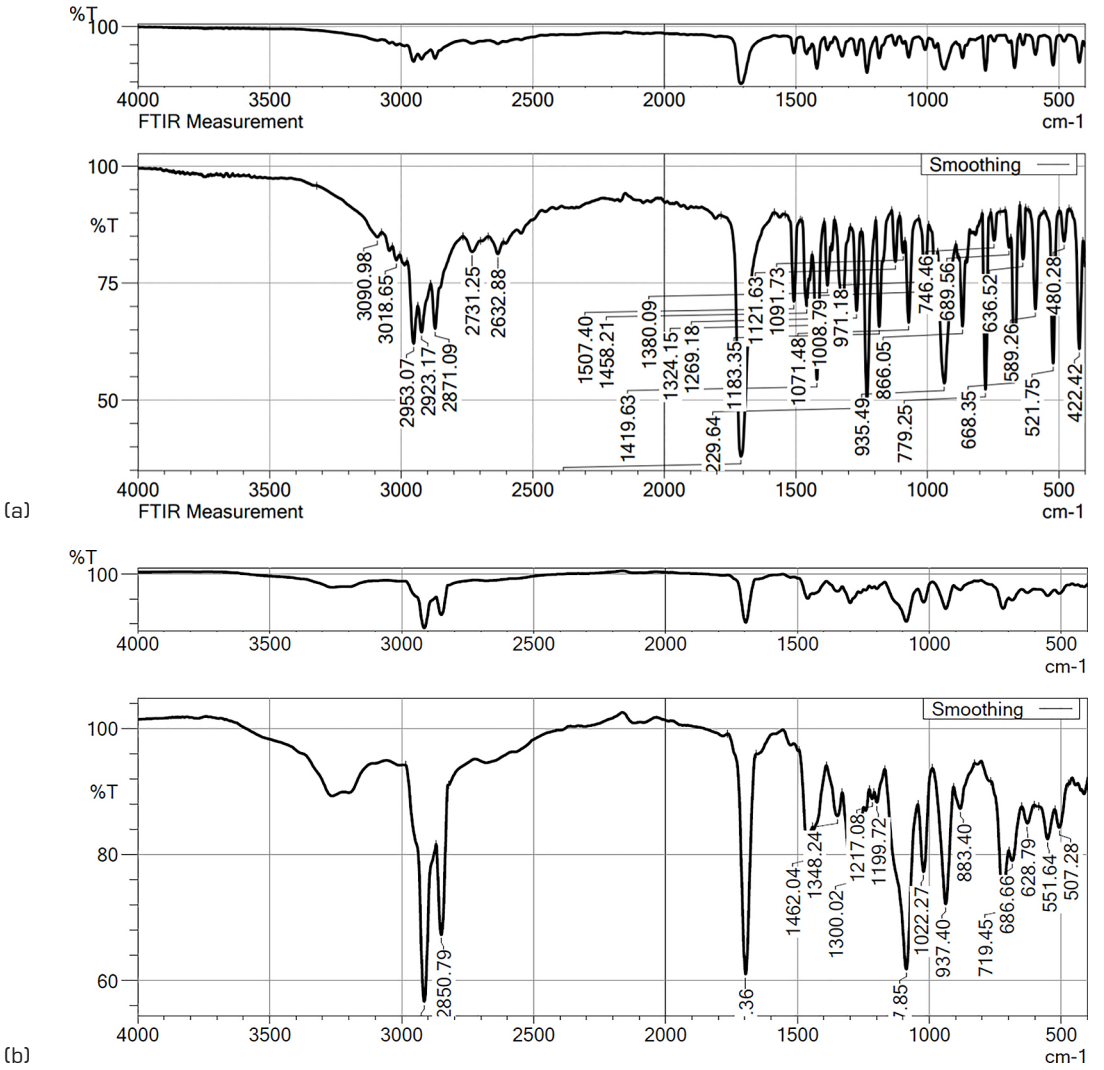
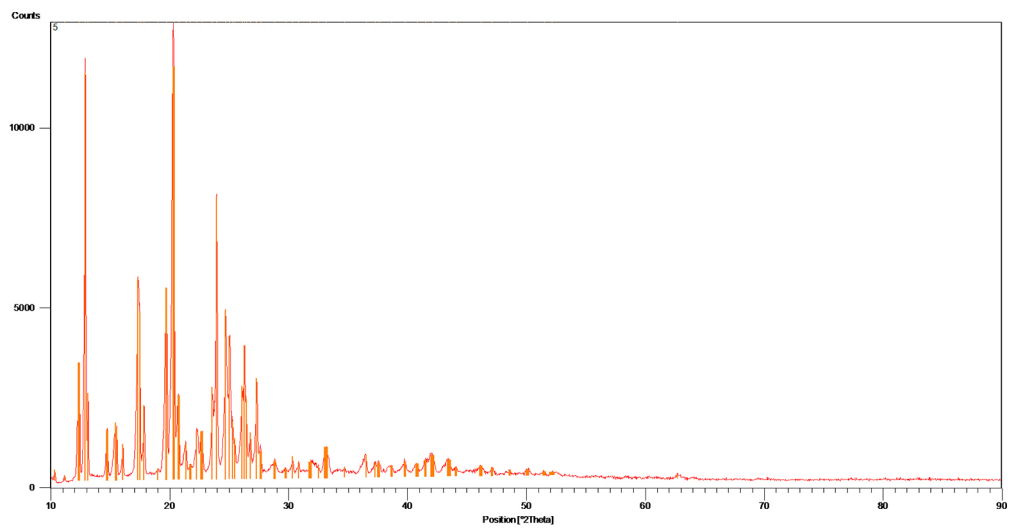
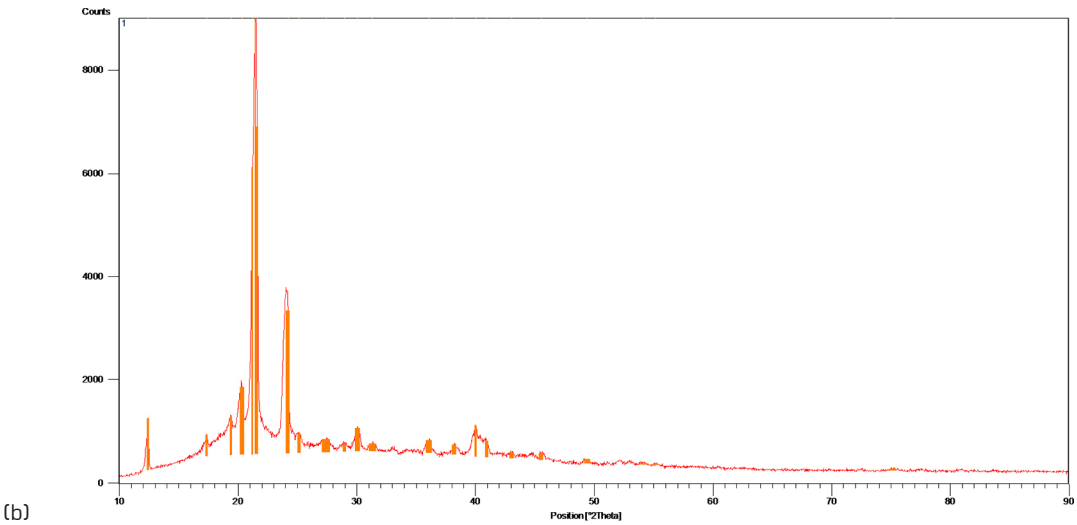


Figure 3: FTIR Spectra of Nimodipine (a) Pure Drug (b) optimized SLN P2.





(b)

Figure 4. Powder X-ray Diffractions of Nimodipine (a) Pure Drug (b) optimized SLN P2.

Formulation Code	Weight variation	Thickness (mm)	Hardness	Friability Test	Surface pH	% Drug Content
NT1	148.43±0.09	5.06±0.02	4.1	PASS	5.6	98.6
NT2	149.52±0.04	4.37±0.02	4.3	PASS	5.9	94.08
NT3	150.08±0.02	4.82±0.02	5.1	PASS	6.1	95.66
NT4	147.87±0.12	5.24±0.02	4.1	PASS	5.6	90.63
NT5	148.60±0.22	4.76±0.02	4.2	PASS	5.7	85.44
NT6	149.88±0.32	5.32±0.02	4.3	PASS	5.8	81.64

Table 4. Evaluation of Nimodipine SLN Mucoadhesive buccal tablets.

Time (hrs)	NT1	NT2	NT3	NT4	NT5	NT6
0	0.623	0.68	0.83	0.44	0.46	0.56
1	2.27	3.31	4.24	0.72	0.81	0.77
2	3.83	6.0	7.03	1.24	1.34	1.32
3	5.66	7.3	8.33	1.56	1.66	1.89
4	8.08	9.83	10.04	1.75	1.84	1.99
5	9.15	10.9	11.14	2.24	2.14	2.47
6	11.03	12	14.33	2.42	2.43	2.68

Table 5. Swelling index of Nimodipine SLN Mucoadhesive buccal tablet of various formulations.

Time (hrs)	NT1	NT2	NT3	NT4	NT5	NT6
1	15	25.33	28.84	27.52	28.52	29.62
2	23	32.56	32.29	32.84	32.97	34.97
3	31.25	38.77	38.56	39.25	38.15	39.15
4	39.75	54.03	59.33	54.65	55.65	54.65
5	48.5	61.54	60.54	61.54	62.34	68.34
6	57.5	66.53	66.57	69.74	69.64	70.65
7	81.7	75.44	75.44	75.19	76.19	77.19
8	84.2	80.32	89.08	81.82	82.55	85.16

Table 6. *In-vitro* dissolution studies of different batches of Nimodipine SLN Mucoadhesive buccal tablet formulations in phosphate buffer.

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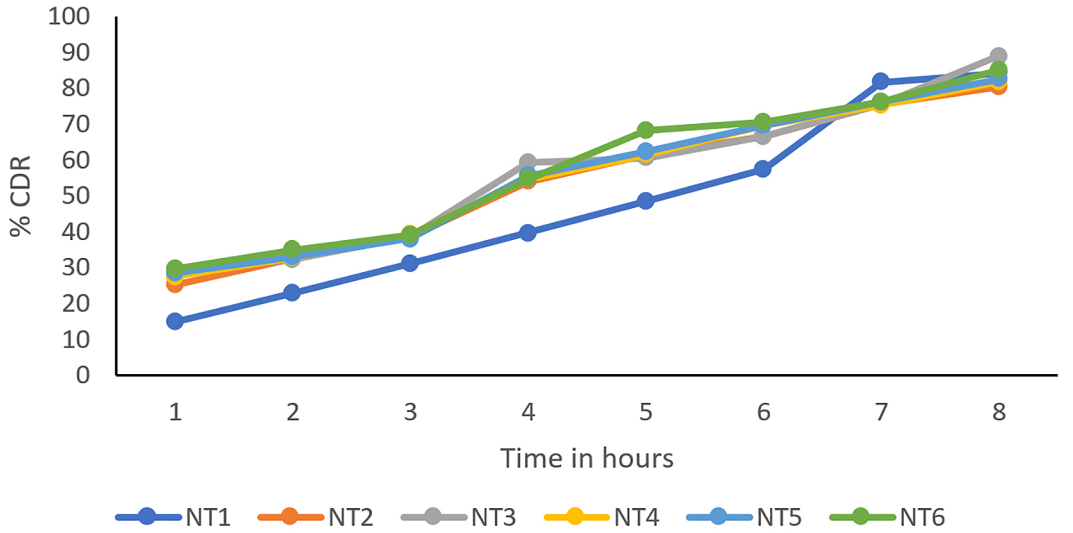

Figure 5. Invitro dissolution studies of different batches of Nimodipine SLN Mucoadhesive buccal tablet.

Formulation code	Ex-vivo Mucoadhesive time (hrs)	Mucoadhesive Strength (gm)
NT1	6	27.3
NT2	6	15.3
NT3	6	29.5
NT4	6	21.5
NT5	6	23.6
NT6	6	25.3

Table 7. *In-vitro* study of mucoadhesive strength of the formulation.

DISCUSSION

Nimodipine solid lipid nanoparticles (SLN) were prepared by high shear homogenization technique followed by ultrasonication. The method was able to produce nanoparticles of an acceptable range. The SEM images for the SLNs loaded with Nimodipine drug are shown in figure 2. From the morphological studies, it is revealed that the SLNs were spherical in shape. FT-IR spectroscopic studies were conducted to determine possible drug: lipid interactions. FT-IR spectrum of pure drug nimodipine and optimized SLN P2 are shown in figure 3. The characteristic peaks of nimodipine and lipids were also present in the spectra of physical mixtures, thus indicating that there is no significant evidence of chemical interaction between the drug and lipids. X-ray diffractometer studies of pure drug and optimized formulation were shown in figure 4. X-ray diffraction analysis shows that the prominent peaks of pure drug nimodipine at 2θ scattered angles of 24, 93, 139, 162, 185, 208 and 231 are due to the presence of a drug in crystalline nature. XRD pattern of solid lipid dispersion of drug shows that the major peaks of nimodipine are entirely absent and one broad peak of a pure drug at 162 to 350. This indicates that the drug changed to an amorphous form from its crystalline nature. Similarly, the major peak of drugs was also absent in SLN P2. This also clearly indicates that the drug converted into the amorphous form.

The SLNs were characterized for average particle size, PDI, zeta potential, percentage drug entrapped efficiency, and in-vitro drug release were given in table 3. The formulation produced consistent nanoparticles with a limited size distribution, with particle sizes increasing slightly from 131.4±33.23 to 139.3±31.89 nm. A narrow particle size distribution indicated the stability and uniform dispersion of nanoparticles. The optimized Nimodipine SLNs were chosen as SLN P2 because they have the least zeta potential and a high Entrapment efficiency.

The smallest particle size was observed when the surfactant mixture concentration increased. It was determined that Tween 80 increases the production of smaller-sized nanoparticles and that higher surfactant content promotes the formation of smaller nanoparticles.

The optimized Nimodipine SLNs are formulated as buccal tablets with varying proportions of polymer composition ranging in weight from 147.87 ± 0.12 mg to 150.08 ± 0.02 mg. The thickness of the tablets in the various formulations ranged from 4.37 ± 0.02 to 5.32 ± 0.02 (Table 4). The quantity and thickness of all crushed tablets were within the USP limit. Tablet hardness was improved based on tablet trial preparation. The hardness of all produced tablets ranged from 4.1 to 5.1 kg/cm^2. Hardness increased as polymer concentration increased. The friability of all tablets was less than 1% ranging from 0.67 to 0.88%, indicating that the formulations have good mechanical strength. Table 4 shows the results of a content uniformity study of all formulations (NT1 to NT6). The drug concentration in different formulations ranged from 81.64% to 98.6%.

Three distinct polymers, Carbopol 940, HPMC K4M, and HEC, were chosen to prepare dosage forms and examine each one's unique drug release behavior to compare various charge bio-adhesive polymers for buccal tablets. It has been observed that the kind of polymers affects how drugs are released, as shown in figure 6. After an 8 hours of study, anionic polymer formulations NT1 and NT2 comprising Carbopol 940, and HPMC K4M retard drug release by 84.2% and 80.32%, respectively. After the 8 hours of experiment, formulation NT3 exhibited the maximum drug release at 89.08%. Formulation NT4 and NT5comprises of HPMC K4M and HEC released 81.82% and 82.55% of the drug within 8 hours, while formulation NT6 showed drug release at 85.16%. In-vitro drug release studies revealed that the type and ratios of the matrix forming mucoadhesive polymers influenced the release of Nimodipine from different formulations. The bio adhesion of buccal tablets prepared with Carbopol 940 and HPMC K4M was considerably greater than that of buccal tablets formulated with HEC and HPMC K4M. Extremely strong muco-adhesion may cause damage to the epithelial lining of the buccal mucosa. The mucoadhesive strength of the formulation NT3 tablets is sufficient to keep them in the oral cavity for more than 8 hours. The surface pH of the oral cavity was evaluated to determine the probability of adverse effects. The nature and composition of mucoadhesive polymers influences the surface pH of buccal tablets. The surface pH of all formulations was between 5.6 and 6.1. Because the pH of the buccal tablet is close to neutral, it does not irritate the mucosa.

CONCLUSION

The present research was conducted to formulate and evaluate mucoadhesive buccal tablets using Nimodipine solid lipid nanoparticles. In this study, the poorly water-soluble Nimodipine was successfully incorporated into SLNs by high shear homogenization and ultrasonication. SLN formulation composed of Tween-80 as surfactant and lower concentration of lipid matrix (Palmitic acid 100 mg) showed the best results because of entrapment efficiency and in-vitro drug release. SLN Particle size analysis revealed that the particles created were of the Nano size. Based on the observations, it is possible to conclude that the developed solid lipid nanoparticle delivery system for Nimodipine may be widely accepted and that physiologically safe lipids were capable of exhibiting sustained properties.

The mucoadhesive buccal tablets of Nimodipine SLN were prepared using three different polymers. All the tablets were oblong with no visible cracks and smooth appearance. The prepared mucoadhesive buccal tablets subjected to an infrared spectrum study suggested nodrug-polymer interaction. All the prepared tablets were in an acceptable range of weight variation, hardness, thickness, friability and drug content as per pharmacopeial specification. The surface pH of prepared buccal tablets was in the salivary pH range, suggesting that prepared tablets could be used without risk of mucosal irritation.

The buccal tablets showed good swelling up to 6 h in distilled water, maintaining the integrity of formulation required for bioadhesion. From the in-vitro release study of all batches, NT3 (Nimodipine 10 mg, HPMC K4M 25 mg, Carbopol 60mg) shows good in-vitro drug release of 89.08% at 8 hours. All the tablets showed a good residence time of 6 h, indicating the good adhesive capacity of polymer. All the tablets showed good mucoadhesive strength of 15.3-29.5 g with high adhesion force. Because of the lack of irritation and acceptable taste, it may be concluded that the mucoadhesive dosage form developed in the laboratory can act as an alternative formulation for Nimodipine SLN and can be

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used for Hypertensive patients. It can also enhance patient compliance by the fascinating extended release of the drug.

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Conflict of interest

The authors declared no conflict of interest. ♦

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