Research Article

Hacettepe University Journal of the Faculty of Pharmacy
Volume 43 / Number 4 / December 2023 / pp. 310-322

Development and Evaluation of Buspirone Hydrochloride Loaded Transdermal Patch Using Natural Polymers

Komal PARMAR[1]
ORCID: 0009-0009-9678-5044
Meshva PATEL[1]
ORCID: 0000-0001-7598-5623
Mehul PATEL[1]*
ORCID: 0000-0002-5823-9706
Tejal SONI[1]
ORCID: 0000-0002-9159-4400
Bhanubhai SUHAGIA[1]
ORCID: 0000-0002-2527-9963

[1]Faculty of Pharmacy, Dharmsinh Desai University, Nadiad, Gujarat, India

Corresponding author:
Mehul PATEL
Faculty of Pharmacy, Dharmsinh Desai University, Nadiad, Gujarat, India
E-mail: mehul1982@gmail.com
Tel: +91 9909055265

Received date : 03.12.2022
Accepted date : 07.11.2023

DOI: 10.52794/hujpharm.1214109

ABSTRACT

The main objective of this present study was to design and develop a Buspirone hydrochloride matrix type transdermal drug delivery system (TDDS) with four natural gum polymers Guar gum, Gellan gum, Xanthan gum, Karaya gum. A total of twelve batches of matrix patches were formulated with the use of the above-stated polymers and other excipients like Glycerin, Propylene glycol (PG), and Polyethylene glycol (PEG) as plasticizers. These all batches were characterized by evaluation parameters which included drug content, flatness, thickness, uniformity of weight, folding endurance, moisture content, and moisture uptake to determine the amount of Buspirone hydrochloride present in the matrix of patches in vitro dissolution study of all twelve formulations were performed. FTIR and DSC were carried out to determine the interaction between Buspirone HCl and excipients that are present in the patch. Permeation study of a patch of Buspirone HCl was performed in Franz's diffusion cell to evaluate In-vitro skin permeation and it was found that batch G3 shows 98.89% permeability. After evaluating all batches and based on results which are obtained from physical and chemical characterization and In-Vitro diffusion study it was concluded that patches containing natural polymers are not showing any interaction and better release study.

Keywords: Transdermal Drug Delivery, Buspirone hydrochloride, Guar gum, Gellan gum, Xanthan gum.

1. Introduction

A programmed continuous intravenous infusion is recognized as a superior method for delivering drugs. It not only avoids the liver's initial filtering of the drug but also maintains a consistent, extended, and effective therapeutic drug level in the body. While closely monitored intravenous infusion offers the advantages of direct drug entry into the bloodstream and precise control of drug levels, it comes with certain risks that require patient hospitalization and vigilant medical supervision. However, there is a growing awareness that the benefits of intravenous drug infusion can be replicated safely by continuous transdermal drug administration through intact skin. In response to this concept, several transdermal drug delivery systems (TDDS) have been recently developed with the goal of achieving systemic medication through topical application to the intact skin surface [1].

Conventional oral drug forms require multiple doses at specific intervals and precise amounts for effective therapy. Administering drugs in this manner has several disadvantages, including discomfort during administration, the risk of overdose if doses are given too closely together, low patient compliance, missed doses, and fluctuations in drug levels in the bloodstream. To address these issues, transdermal drug delivery systems have been developed. A transdermal patch is a discreet, self-contained medication patch that provides a convenient and reliable method for addressing various skin and body-related issues, eliminating the drawbacks associated with multiple drug administrations [2].

The transdermal route to deliver drugs is highly preferred for drug delivery through intact skin providing both systemic and local or topical therapeutic effects with other advantages [3,4]. Transdermal route for drug delivery provides many advantages such as avoiding problems related to gastric irritation, gastric emptying time, and pH, Avoiding first-pass (hepatic) metabolism leads to the improvement in bioavailability of chemical entity and another hand reduces the risk side effect related to systemic circulation because it minimizes the fluctuation in plasma drug concentration, [5] transdermal route is suitable for sustained delivery to the application site, one can remove the device from application site easily so rapid termination of therapy is also possible, also avoid the pain which may occur through intravenous injection [6].

In order to transport the active ingredient to the systemic circulation after passing through the skin barriers, transdermal patches are a better option for drug delivery. Transdermal films or patches are pharmaceutical formulations of varied sizes, comprising one or more active pharmaceutical ingredients, and are designed to be placed on unbroken skin. At a predefined and controlled rate, it disperses the medications for systemic effects [7]. Due to hepatic first-pass metabolism, the conventional oral dose forms suffer from substantial drawbacks of inadequate bioavailability. A transdermal drug delivery system (TDDS) was developed to improve the therapeutic efficacy and safety of medications by targeting particular target locations of the body, hence minimizing the amount and number of dosages. Skin is a useful medium from which medication absorption occurs and comes into regular circulation over a specific time period [8].

Polymers are the most important aspect of the transdermal drug delivery route because polymers are responsible for regulating the drug release from its formulation [9]. In recent years, various natural gums and mucins have been investigated as polymers for regulating and sustaining medication release. High viscosity, wide pH tolerance, non-carcinogenicity, mucoadhesive nature, and biocompatibility are some characteristics of a natural polymer. Polymers are used for various purposes such as it can be used as binders, stabilizers, gelling agents, and thickening and gelling agents in pharma industries [10]. There are some advantages of the polymer as not having side effects, being biocompatible, environmentally ecofriendly, bio-acceptable, having good locally available properties is, being non-toxic, having better patient tolerance, and widely acceptable. Can make formulation inexpensive with the use of natural polymer and make it locally available [11]. Guar gum and gellan gum play essential roles in the preparation of transdermal patches. Guar gum contributes to adhesive properties and sustained drug release, [12] while gellan gum is crucial for forming a gel matrix, controlling drug release, and enhancing skin permeation. Together, they help optimize the effectiveness of transdermal drug delivery systems.

Buspirone is a selective anxiolytic drug, which is widely used in the treatment of anxiety disorder (generalized) and attention deficit hyperactivity disorder, in children. Recently, buspirone has also been found useful in smoking cessation and rehabilitation

ISSN: 2458 - 8806

of alcohol addicts [6]. Buspirone is a potent drug; it has a wide therapeutic window making the drug safe for its use in a variety of patients. Approximately 1 to 1.5 mg of the drug out of 20-30 mg administered dose per day is actually responsible for crean ate ordinary therapeutic effect. This fact strongly suggests that there is a need for an alternative dosage form administrable by another route to avoid oral first pass presystemic metabolism [13]. In addition to this, alternative dosage forms provide a steady flux of drug in systemic circulation; avoiding fluctuation commonly observed with oral therapy. Buspirone tablets are generally taken 3-4 times a day; but if an alternative dosage form provides once-a-day administration, then it will substantially improve patient compliance [14].

The aim of the present study Is to prepare and evaluate sustained released transdermal patch of buspirone Hydrochloride by using different natural polymers to minimize adverse effects associated with oral administration. The conventional oral dosage forms have significant setbacks of poor bioavailability due to hepatic first-pass metabolism. To avoid it to improve the therapeutic efficacy transdermal drug delivery was emerged.

2. Material and Methods

2.1. Materials

Buspirone hydrochloride (BPH) was obtained from Astron Research Ltd as a gift sample. Guar gum, Xanthan gum, Gellan gum, Karaya gum, Glycerin, and PEG 400 were procured from S.D. Fine-Chem Ltd., Mumbai. Sodium alginate was procured from Chemdyes Corporation. Propylene glycol was purchased from Sulab Chemicals. Other chemicals that had been used during this study were grade analytical reagents.

2.2. Analytical Method for Estimation of Buspirone Hydrochloride

To prepare the Buspirone hydrochloride stock solution, 100mg of Buspirone hydrochloride was accurately weighed and transferred into a previously calibrated 100 ml volumetric flask. It was then dissolved in 40ml of distilled water by shaking for 10 minutes and was make up the volume to 100ml, resulting in a concentration of 1mg/ml (referred to as solution A). From this solution, an aliquot of 10ml was withdrawn and further diluted to 100ml with distilled water, yielding a concentration of 100µg/ml (referred to as solution B). Subsequently, aliquots 10,20,30,40,50ml were withdrawn and further diluted with distilled water, yielding a concentration of 10-50µg/ml respectively. The absorbance of these prepared solutions was measured at 303nm using a UV Spectrophotometer, with a blank serving as the reference [15,16]. The intra-day and inter-day precisions of the proposed method was determined by measuring the corresponding responses 3 times on the same day and on 3 different days over a period of 1 week for 3 different concentrations of Buspirone HCl respectively. The results were reported in terms of relative standard deviation (%RSD).

2.3. Drug-Excipient Compatibility Study of Buspirone Hydrochloride

2.3.1. FTIR Study

An FTIR analysis was carried out to confirm any potential physical or chemical interactions between the drug and formulation excipients. By comparing the obtained spectra for the existence of functional groups, FTIR spectra of the pure drug Buspirone hydrochloride, Guar gum, Gellan gum and formulation were performed.The process was carried out using pellets of potassium bromide (KBr). Infrared scanning was done on the samples, region between 400 and 4000 cm-1 with a resolution of 4 cm-1 using a mixture of approximately 5 mg of samples and 50 mg of spectroscopic grade KBr [17,18].

2.3.2. Differential Scanning Calorimetry Study

The DSC thermograms of pure drug, patch of guar gum, and gellan gum were recorded on a DSC (Shimadzu). The samples were weighed and hermetically sealed in aluminum pans. Thermal analysis system instrument Pyris-1 DSC with intracooler, a refrigerator cooling system, was used. The indium standard was used to calibrate the DSC temperature and enthalpy scale. The system was purged with nitrogen gas to a flow rate of 80 ml/min. Initially, samples were held at 500ºC for 1 min, and after the heating was performed from 500ºC-3000ºC at a rate of 100ºC/min.

2.4. Preliminary Trials of Buspirone Hydrochloride

Buspirone-loaded matrix-type transdermal patches were prepared with the use of the solvent-casting method. Solution of polymer (Guar gum, Karaya gum, Gellan gum, Xanthan gum, and Sodium alginate) and drug along with plasticizer (Glycerin, PEG 400, PG) was prepared in water as a solvent system. The uniform mixture of drugs with excipients was poured into the clean and dry Petri dish as a film on it. Then evaporation of the solvent was done in a rate-controlled manner by setting up the Petri dish covered with an inverted funnel. The evaporation control is a must for uniform drying of films. The drying of BPH loaded patch was carried at 60° C temperature for 24 hours duration. After periods of 24 hours, all dried films were taken out from Petri dish covered with aluminum foils and stored in desiccators until used [1].

2.5. Characterization of the Transdermal Patches

2.5.1. Uniformity of weight or Weight variation

Weight variation of all prepared formulations was carried out to check the deviation of weight from its average weight. For this 10 patches were randomly selected and their average weight was calculated. The weight of individual patches must not significantly deviate from its average weight [19].

2.5.2. Thickness

Measurement of thickness of all prepared film was obtained by traveling microscope, screw Gauge, or micrometer at various seven points of the film of a rectangular patch of 2*2cms [20].

2.5.3. Content uniformity test

For the determination of content uniformity about 10 patches were selected and the content of the individual patch. It was done to evaluate the uniformity of the drug in the patches and the test is positive if out of these 10 patches, 9 patches should have a content range among 85% - 115 % and it should not be less than 75% - 125% but if out of these 10 patches 3 patches contain content range 75% - 125% then another 20 patches add for the determination on content uniformity and if these newly tested formulations show range from 85% - 115% then it suggests that patches have definite content uniformity [21].

Table 1. Preliminary trials of Buspirone HCl patch

Batch	BH (mg)	Guar gum (mg)	Karaya gum (mg)	Gellan gum (mg)	Xanthan gum (mg)	SA (mg)	Glycerin %	PEG 400 %	PG %	Water (ml)
F1	128	400	-	-	-	-	10	10	10	20
F2	128	400	-	-	-	-	10	10	10	20
F3	128	400	-	-	-	-	10	10	10	20
F4	128	-	400	-	-	-	10	10	10	20
F5	128	-	400	-	-	-	10	10	10	20
F6	128	-	400	-	-	-	10	10	10	20
F7	128	-	-	400	-	-	10	10	10	20
F8	128	-	-	400	-	-	10	10	10	20
F9	128	-	-	400	-	-	10	10	10	20
F10	128	-	-	-	400	520	10	10	10	20
F11	128	-	-	-	400	520	10	10	10	20
F12	128	-	-	-	400	520	10	10	10	20

ISSN: 2458 - 8806

2.5.4. Determination of drug content

A drug content determination study was done to check drug distribution in the formulated patch and for this, it must be dissolved in a solvent in which the drug is soluble. Drug content was measured by dissolving the 100 mg of film into the drug completely in water of a patch size 2*2 cms. About 100 mg of a weighed portion of the patch was dissolved in 100 ml of water. After that solution was continuously shaken in an incubator for 24 hr following by sonication. Then solution was filtered and drug content was measured by UV-VIS spectroscopy at wavelength 303 nm with appropriate dilution [22].

2.5.5. % Moisture content

For the determination of moisture content, all the prepared films were accurately weighed individually and then kept in a calcium chloride-containing desiccator for 24 h at room temperature. Then the films were again weighed after 24 hr until the finding of constant weight after the moisture loss. The percentage of moisture content is calculated with the use of the formula given below [23].

% Moisture content= (Initial weight – Final weight)/ (Final weight) ×100

2.5.6. % Moisture Uptake

To determine moisture uptake by patch prepared films accurately weighed and kept for 24 hr in a desiccator. Then all films were removed from the desiccator and all were exposed to relative humidity of about 84% These are then taken out and exposed to 84% relative humidity in a desiccator containing saturated potassium chloride (KCl) solution till their constant weight was obtained. Following formula was used to calculate the % Moisture uptake by patch [24].

% Moisture content= (Final weight – Initial weight)/ (Initial weight) ×100

2.5.7. Percentage flatness study (%F)

The transdermal patch must have a smooth surface and it should not be constricted with time and this could be confirmed by a percentage flatness study. For the determination of flatness, a strip was cut from the center of the f patch and another two strips were cut from the patch. Then the percentage (%) of constriction was calculated on the basis of the measurement the of length of each strip [25]. If the percentage of constriction is zero percent, then it is equal to the flatness of 100% and it is calculated with the use of a formula which is given below:

$\%\ \text{constriction}=(I_1-I_2)/I_2\times 100$

I_2 = Final length of each strip

I_1 = Initial length of each strip

2.5.8. Folding Endurance

Evaluation parameter folding endurance was done to determine the folding capacity of prepared films for this it was given the folding at an extreme level. The folding endurance value of the film is the number of folding without breaking at the same place. Determination of folding endurance is carried out by repeated folding of film on the same place every time until the films are broken [26].

2.6. In Vitro Permeability or Diffusion Study

The in vitro assessment of Buspirone Hydrochloride permeation through various transdermal patches was conducted using a locally fabricated Franz-type diffusion cell. This diffusion cell comprises two components: the upper part, referred to as the donor compartment, which contains the active ingredient and the patch, and the lower part housing the receptor solution, a temperature-controlling water jacket, and the sampling port [27]. The effective permeation area of the diffusion cell and the volume of the receptor and cell were 2.5 cm^2 and 35 milliliters, respectively and patch having 2 cm diameter was placed at the dialysis membrane. The temperature was maintained at 37±2°C. In the receptor compartment, 20 milliliters of phosphate buffer with a pH of 7.2 (IP) were stirred using a magnetic stirrer. The fluid of the receptor was stirred with the use of a Remi magnetic stirrer which is fitted with a Teflon-coated magnetic bead. Then 1 ml sample was withdrawn and it was replaced with the fresh receptor of equal volume during each sampling to maintain the constant volume of the receptor it was diluted up to the 10 ml mark which was then analyzed spectrophotometrically with a UV-VIS spectrophotometer for the determination of drug content present in formulation (Shimanzu UV 1800) at 303 nm [28].

Diffusion rate, in vitro flux (Jss), and permeability coefficient were assessed for all formulations (Kp). Fick's law of diffusion, which views the movement of medicines through the epidermal barrier as a pas-

sive diffusion process, was used to calculate the in vitro flux (Js). The slope of the linear part of the cumulative amount penetrated per unit area vs. time plot was used to calculate the skin flux (g/cm^2/hr).

The amount of medication that diffused across the membrane one milligramme at a time was utilized to calculate the diffusion rate (hr).

Dr=Q/T

Here,

Dr = Diffusion rate

Q = Amount of drug passing through the skin

T = Drug permeable through the skin per unit of time

The skin flux can be experimentally determined from the following equation:

Jss=dQ/dT×1/T

Here,

dQ/dt = Amount of drug which passes through the skin per unit time (µg/hr)

A = Area of skin tissue (cm^2) through drug permeation takes place

Jss = Steady-state flux (mg/cm^2/ hr)

From the equation given below, the permeability coefficient (Kp) (cm/hr) was determined:

Kp=Jss/Cd

Here, Cd = Drug concentration in the donor compartment. [12]

3. Results and Discussion

3.1. Analytical Method for Estimation of Buspirone Hydrochloride

The UV maxima of Buspirone HCl was found at 303nm in water. The linearity graph of buspirone HCl shows a good linearity R^2 value of 0.9975.

The validation data (interday, intraday, precision, accuracy and % RSD) of buspirone HCl has shown in the Table 2.

These results indicates that the analytical method is well-suited for its intended purpose. It demonstrates good linearity, sensitivity, precision, and accuracy within the specified concentration range. The low % RSD values for both interday and intraday measurements indicate that the method is stable and reproducible over time and within a single day. However, the slightly higher accuracy (101.98%) might require further investigation to understand and possibly correct the systematic bias in the measurements.

3.2. Drug-Excipient Compatibility Study

3.2.1. FTIR study

The drug-excipient compatibility study was carried out by FTIR spectroscopy. In order to find out the

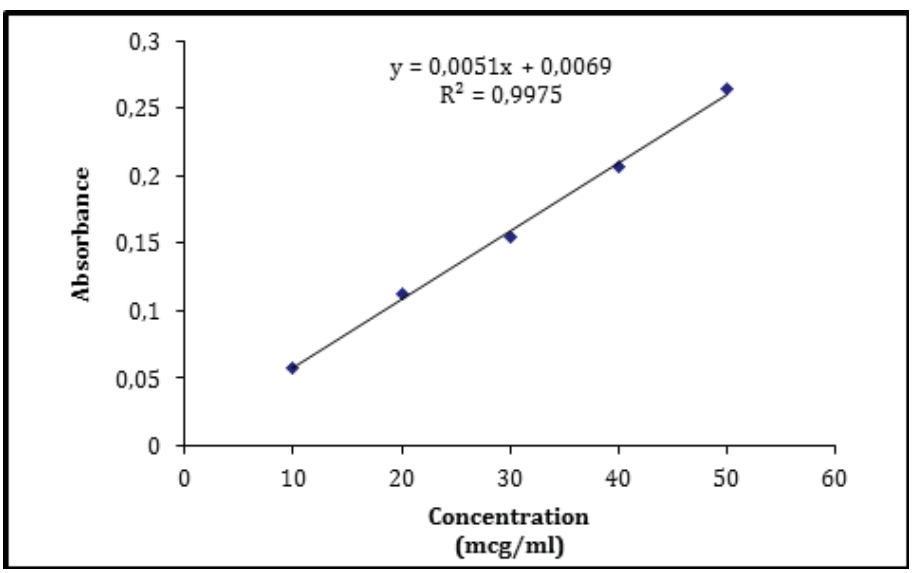

Figure 1. Calibration Curve of Buspirone HCl

ISSN: 2458 - 8806

Table 2. Validation parameters of Buspirone HCl

Sr.No	Parameters		Results
1	λmax		303nm
2	Linearity range(µg/ml)		10-50µg/ml
3	Intercept		0.0051
4	Slope		0.0069
5	r^2		0.9975
6	Standard deviation		0.0145
7	% RSD (linearity)		0.6520
8	Interday (% RSD)	10 µg/ml	1.056
		20 µg/ml	0.513
		30 µg/ml	0.977
9	Intraday (% RSD)	10 µg/ml	1.018
		20 µg/ml	0.509
		30 µg/ml	0.784
10	Accuracy (%)		101.98
11	Precision (% RSD)		0.98

possibility of an interaction of buspirone HCl with the excipients The physical mixture's and the drug's FTIR spectra were recorded in the 4000-400 cm-1 region.

Buspirone HCl, Guar gum, Gellan Gum, and the Physical mixtures of both formulations displayed some notable and recognizable peaks. The peak of the drug at 3489 cm^{-1} was due to stretching vibrations of the N-H bond respectively. Peaks at 1650 cm^{-1}, 1250 cm^{-1}, and 700 cm^{-1} could be assigned to C=O bend, C-N stretching, and C-Cl bond respectively. The peak of Guar gum at 3200 cm^{-1} was due to stretching vibrations of the O-H bond respectively. Peaks at 1635 cm^{-1}, 1350 cm^{-1}, and 1050 cm^{-1} could be assigned to C=O bend, CH_2 stretching, and C-O bond respectively. The peak of Gellan gum at 3370 cm^{-1} was due to stretching vibrations of the O-H bond respectively. Peaks at 1650 cm^{-1}, 1450 cm^{-1}, and 1200 cm^{-1} could be assigned to C=O bend, O-H stretching, and C-O bond respectively. There was no interaction between the drug and the excipients in Figure 2 as indicated by the availability of all the Buspirone HCl, Guar gum, and Gellan gum shows characteristic peaks in the formulation that was optimized.

3.2.2. Differential Scanning Calorimetry study

The DSC thermograms of pure buspirone HCl powder the formulation of guar gum and the formulation of gellan gum are shown in the Figure 3.

The drug Buspirone HCl subjected to the DSC study, started melting at 180ºC and completed at 210ºC, suggesting that this narrow range of melting points is due to the presence of a single compound in the pure form. Formulation DSC thermograms show a buspirone HCl endothermic peak at 191.79ºC, so it can be concluded that Buspirone HCl was a complex form in the patch. These results imply that polymers used for the preparation of patches are compatible with the drug.

3.3. Preliminary Trails of Formulation

In the formulation of the patch polymers and plasticizer used were varied and the "effect on folding endurance" and "moisture content" was studied.

Different types of polymers guar gum, gellan gum,

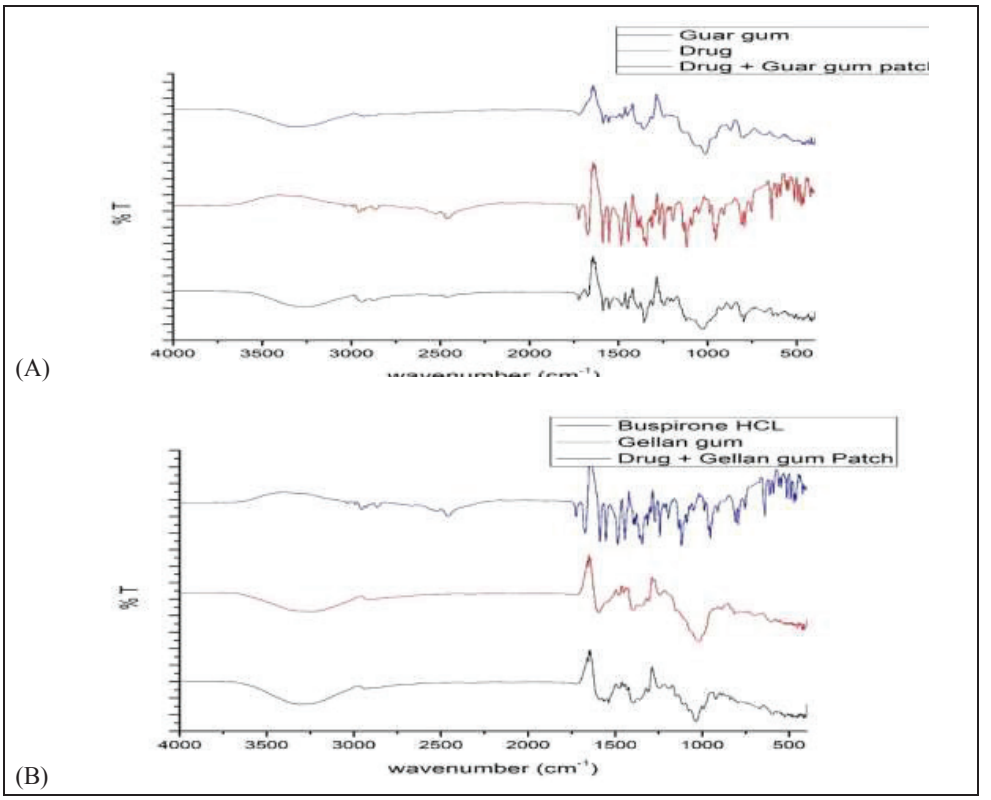

Figure 2. FTIR data (A) Buspirone HCL, Guar gum, and Formulation (B) Buspirone HCl, Gellan gum and Formulation.

xanthan gum, and sodium alginate were used and the effect on folding and moisture content was evaluated, whereas in case of karaya gum the film/ patch was not formed. Among all these polymers guar gum and gellan gum show greater folding endurance compared to other polymers so, guar gum and gellan gum using different concentrations were selected for the further preparation of buspirone HCL transdermal patches.

3.4. Preparation of Transdermal Patches of Buspirone HCl

Guar gum and Gellan gum using different concentrations were selected for the further preparation of buspirone HCl transdermal patches.

3.5. Characterization of the Transdermal Patches

Buspirone Hydrochloride loaded patches were formulated using different polymers by keeping the drug weight constant using the solvent casting method. All the prepared drug-loaded patches were smooth, transparent, thin, and flexible. The prepared patches were subjected to folding endurance, thickness, moisture content, moisture uptake, uniformity of weight, drug content, and flatness, in vitro diffusion study was studied and their values are given in Tables 6. All the Buspirone Hydrochloride loaded patches were obtained and showed that an increase in the concentration of polymer leads to an increase in thickness and percentage flatness. Also, the weight of patches increased with an increase in the concentration of polymer.

The folding endurance for all guar gum and gellan gum batches was greater than 100. The percentage moisture content of the Guar gum patch was in the range of 8.89 % to 13.23 % and Gellan gum was in the range of 8.68 % to 11.95 %. The moisture uptake data was in the range of 17.39 % to 20.37 % and 8.13 % to 10.62 % of Guar gum and Gellan gum respectively. Studies of moisture content and moisture absorption revealed that the hygroscopic properties of the polymer-glycerol composite patches may be responsible for the increase in moisture absorption. In the prepared patches drug content analysis, it was found that Guar gum ranged between 92.67% to

ISSN: 2458 - 8806

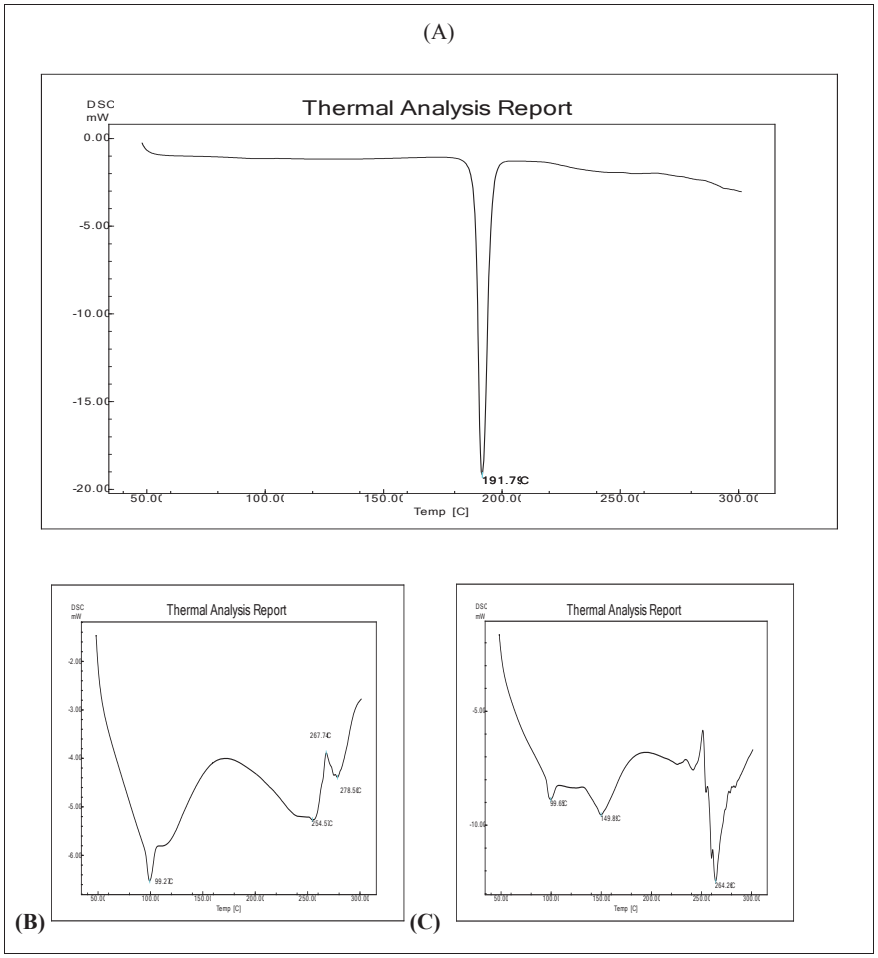

Figure 3. DSC data (A) Buspirone HCl (B) Guar gum (C) Gellan gum

Table 3. Evaluation of preliminary trails

BATCH	POLYMER	FOLDING ENDURANCE	MOISTURE CONTENT
F1	Guar gum	> 100	18.83%
F2		> 100	13.47%
F3		> 100	11.91%
F4	Karaya gum	Film/ patch not formed	
F5		Film/ patch not formed	
F6		Film/ patch not formed	
F7	Gellan gum	> 100	13.73%
F8		> 100	21.66%
F9		> 100	18.42%
F10	Xanthan gum +Sodium alginate	> 100	18.80%
F11		1	12.52%
F12		28	18.78%

Table 4. Composition of transdermal patches using different concentration

Ingredients	G1	G2	G3	L1	L2	L3
Buspirone HCl	128 mg	128 mg	128 mg	128 mg	128 mg	128 mg
Guar gum	400 mg	600 mg	800 mg	-	-	-
Gellan gum	-	-	-	400 mg	600 mg	800 mg
Glycerin	10 %	10 %	10 %	10 %	10 %	10 %
Water	40 ml	40 ml	40 ml	40 ml	40 ml	40 ml

Table 5. Physico-chemical evaluation data of Buspirone HCl transdermal Patches

Batch	*Thickness (Mm)	*Folding Endurance	*Moisture Content (%)	*Moisture Uptake(%)	Uniformity Of Weight (Mg ± SD)	Flatness	Drug Content % ± Sd
G1	0.1±0.04	144±04	08.89±0.49	17.39±1.078	0.037 ± 0.0037	100 %	92.67 ± 0.69
G2	0.1±0.03	150±08	11.94±0.68	18.19±0.971	0.045 ± 0.0028	100 %	99.56 ± 0.31
G3	0.2±0.09	148±03	13.23± 0.59	20.37± 1.014	0.071 ± 0.002	100 %	98.95 ± 0.35
L1	0.2±0.07	127±02	08.68±0.98	08.13±0.854	0.044 ± 0.004	100 %	68.05 ± 0.45
L2	0.2±0.06	137±04	09.61±0.71	09.28±0.768	0.077 ± 0.0028	100 %	72.78 ± 0.52
L3	0.3±0.028	123±05	11.95±0.58	10.62±1.029	0.191 ± 0.0057	100 %	68.05 ± 0.67

99.56% and Gellan gum ranged between 68.05% to 72.78%.

3.6. In-Vitro Diffusion Study

The Comparitively % drug diffusion study of all the batches is shown in Table 6.

The % drug diffusion study of the gellan gum formulation shows less release compared to the guar gum formulation Gellan gum % diffusion release is up to 70% and guar gum shows the release of up to 99% at 24 hrs. In gellan gum G2 batch shows release in controlled and uniform manner.As the guar gum shows a more moisture uptake compare to gellan gum due to entrapment of water in the patches guar gum shows the more drug release.

The provided results appear to represent data related to the diffusion rate, flux, and permeability coefficient for different batches or groups (G1, G2, G3) and formulations (L1, L2, L3).

This parameter measures the rate at which a substance (presumably a drug or solute) diffuses through a specific membrane or material per unit of time (hour).Among the batches and formulations, G2 exhibits the highest diffusion rate (0.2593 mg/hr), followed closely by G3 (0.2587 mg/hr). This suggests that these batches release the drug at a relatively faster rate compared to the others.L3 has the lowest diffusion rate (0.1801 mg/hr), indicating slower drug release. Similar to the diffusion rate, G2 and G3 have the highest flux values (8.2596×10^{-2} mg/cm² hr^{-1} and 8.2413×10^{-2} mg/cm² hr^{-1}, respectively). This confirms their relatively faster drug release rates.L3 has the lowest flux (5.7371×10^{-2} mg/cm² hr^{-1}), indicating slower drug transport through this formulation. The values provided are in the range of 1.2108×10^{-2} to 1.3152×10^{-2}, with G2 having the highest permeability coefficient and L3 the lowest.A higher permeability coefficient suggests greater ease of drug transport through the material.

ISSN: 2458 - 8806

Table 6. In-vitro diffusion studies of transdermal patches

		% Drug Diffusion					
SR NO	**Time (hr)**	**G1**	**G2**	**G3**	**L1**	**L2**	**L3**
1	0	0	0	0	0	0	0
2	0.5	9.94	24.15	11.03	23.05	15.4	13.22
3	1	19.77	36.17	14.31	25.24	20.87	14.31
4	2	26.33	43.82	24.15	28.52	27.42	16.5
5	3	32.89	51.47	27.42	32.89	32.89	21.96
6	4	39.44	55.84	33.98	41.63	35.89	26.33
7	5	46.00	58.02	40.54	46.00	38.35	28.52
8	6	54.74	60.21	44.91	51.47	41.35	32.89
9	7	59.12	63.49	48.19	55.84	43.82	37.26
10	24	91.24	99.11	98.89	70.04	71.14	68.84

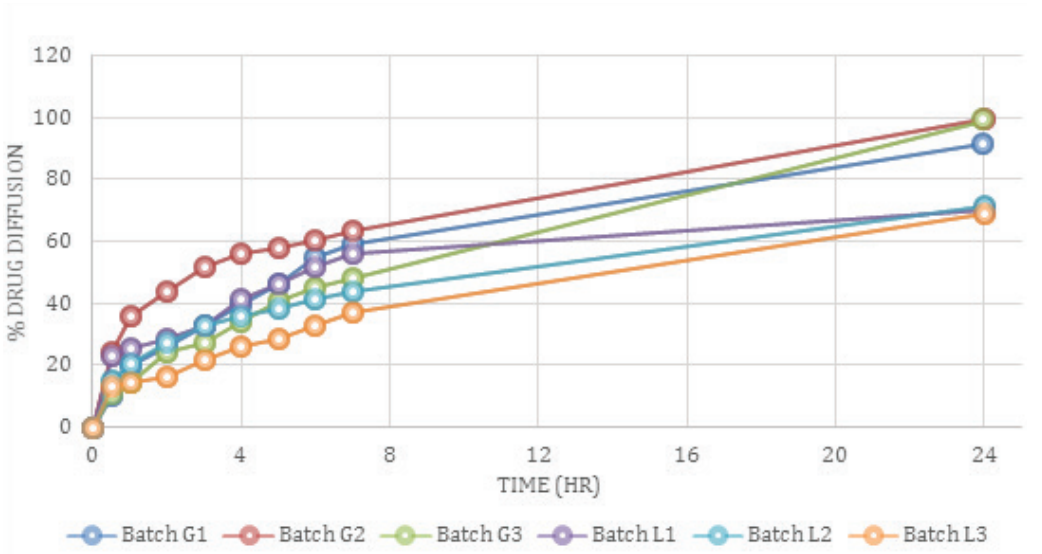

Figure 4. In-vitro diffusion of transdermal patches

4. Conclusions

In the present research studies, an attempt was given to design and develop Transdermal Drug Delivery route using Natural polymers such as Guar gum, Xanthan gum Kraya gum and Gellan gum were used as natural polymers for the preparation of the patch using solvent casting method. Karaya gum and Xanthan gum patches were not used for the further study because the patches were not formed well on the bases of folding endurance and percentage moisture content. After that, patches were prepared using different amount of Guar gum and Gallen gum (400mg, 600mg and 800mg respectively). The patch of 3 × 3 cm containing 2mg/cm^2 was evaluated on the basis of different parameters like folding endurance, percentage moisture content, thickness, percentage

Table 7. Evaluation of in-vitro permeation of Buspirone HCl

Batch	Diffusion rate (mg/hr)	Flux (mg/cm^2 hr^{-1})	Permeability coefficient
G1	0.2387	7.6039×10^{-2}	1.2108×10^{-2}
G2	0.2593	8.2596×10^{-2}	1.3152×10^{-2}
G3	0.2587	8.2413×10^{-2}	1.3123×10^{-2}
L1	0.1832	5.8373×10^{-2}	0.9295×10^{-2}
L2	0.1861	5.9283×10^{-2}	0.9440×10^{-2}
L3	0.1801	5.7371×10^{-2}	0.9135×10^{-2}

moisture uptake, uniformity of weight, flatness drug content, and in vitro diffusion study. From the result of evaluation parameter, it was concluded that G3 batch was selected as best patch containing buspirone hydrochloride, 800mg Guar gum, The result of diffusion study shows that G3 batch had 98.89% drug released in increasing manner which indicated higher drug diffusion through the skin within 24 hours. It is suggested that Natural Polymers can be good for preparation of transdermal patch.

Acknowledgments

The author are thankful to the Faculty of Pharmacy, Dharmsinh Desai University, Nadiad

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Statement of Contribution of Researchers

Concept – M.P., V.P.; Design – M.P, T.S; Supervision – M.P, T.S, B.S; Resources – M.P., T.S., B.S.; Materials – K.P,M.P., V.P., T.S., M.P., B.S.; Data Collection and/or Processing – K.P., M.P., V.P., T.S., M.P., B.S; Analysis and/or Interpretation – A.D., S.O., M.S.Y., H.S., Y.N.; Literature Search – K.P.,M.P., V.P; Writing – K.P.,M.P., V.P., M.P.; Critical Reviews – K.P, M.P, T.S, B.S.

References

1. Bhatia C, Sachdeva M, Bajpai M. Formulation and evaluation of transdermal patch of pregabalin. International Journal of Pharmaceutical Sciences and Research. 2012;3(2):569. http://dx.doi.org/10.13040/IJPSR.0975-8232.3(2).569-75
2. Jain NK. Controlled and novel drug delivery. CBS publishers & distributors New Delhi; 1997.
3. Fox LM. Remington: the science and practice of pharmacy. American Journal of Pharmaceutical Education. 2006;70(3):X3.
4. Troy DB. Remington: The science and practice of pharmacy. (No Title). 2005;
5. Zhang Y, Cun D, Kong X, Fang L. Design and evaluation of a novel transdermal patch containing diclofenac and teriflunomide for rheumatoid arthritis therapy. Asian Journal of pharmaceutical sciences. 2014;9(5):251–9. http://doi.org/10.1016/j.ajps.2014.07.007
6. Jamakandi VG, Mulla JS, Vinay BL, Shivkumar HN. Formulation, Characterisation, and Evaluation of matix type transdermal patches of Anti-hypertensive Drugs. Drug Del. 2009;1–7. http://doi.org/10.4103/0973-8398.49177
7. Tyagi RK, Chandra A, Singh D, Rahman MA. Transdermal drug delivery system (TDDS): an overview. International journal of pharmaceutical sciences and research. 2011;2(6):1379. http://dx.doi.org/10.13040/IJPSR.0975-8232.2(6).1379-88
8. Garala KC, Shinde AJ, Shah PH. Formulation and in-vitro characterization of monolithic matrix transdermal systems using HPMC/Eudragit S 100 polymer blends. Int J Pharm Pharm Sci. 2009;1(1):108–20.
9. Patel H, Panchal DR, Patel U, Brahmbhatt T, Suthar M. Matrix type drug delivery system: A review. J Pharm Sci Biosci Res. 2011;1(3):143–51.
10. Kulkarni Vishakha S, Butte Kishor D, Rathod Sudha S. Natural polymers–A comprehensive review. International jour-

ISSN: 2458 - 8806

nal of research in pharmaceutical and biomedical sciences. 2012;3(4):1597–613.

11. Patel H, Patel U, BHIMANI B, DASLANIYA D. Transdermal drug delivery system as prominent dosage forms for the highly lipophilic drugs. The International Journal of Pharmaceutical Research and Bio-Science. 2012;1(3).
12. George A, Shah PA, Shrivastav PS. Guar gum: Versatile natural polymer for drug delivery applications. European Polymer Journal. 2019;112:722–35. http://doi.org/10.1016/j.eurpolymj.2018.10.042
13. Bharti K, Mittal P, Mishra B. Formulation and characterization of fast dissolving oral films containing buspirone hydrochloride nanoparticles using design of experiment. Journal of Drug Delivery Science and Technology. 2019;49:420–32. 10.1016/J.JDDST.2018.12.013
14. Nagaich U, Chaudhary V, Nagaich J. Development and Statistical Optimisation of Buspirone Hydrochloride Buccoadhesive Films. International Scholarly Research Notices. 2014;2014. http://dx.doi.org/10.1155/2014/214026
15. Dhandapani H, Hemamrutha S, Lakshmi Sravanthi K, Swetha J. Spectrophotometric estimation of buspirone hydrochloride in bulk and its pharmaceutical formulation. Int J of Pharma Sciences and Research. 2010;1(4).
16. Joshi GV, Kevadiya BD, Bajaj HC. Design and evaluation of controlled drug delivery system of buspirone using inorganic layered clay mineral. Microporous and Mesoporous Materials. 2010;132(3):526–30.
17. Takka S, Sakr A, Goldberg A. Development and validation of an in vitro–in vivo correlation for buspirone hydrochloride extended release tablets. Journal of controlled release. 2003;88(1):147–57. https://doi.org/10.1016/S0168-3659(02)00490-X
18. Sheikhzadeh M, Rohani S, Jutan A, Manifar T, Murthy K, Horne S. Solid-state characterization of buspirone hydrochloride polymorphs. Pharmaceutical research. 2006;23:1043–50. https://doi.org/10.1007/s11095-006-9779-6
19. Saxena M, Mutalik S, Reddy MS. Formulation and evaluation of transdermal patches of metoclopramide hydrochloride. Indian drugs. 2006;43(9):740–5.
20. Dhamecha DL, Rathi AA, Saifee M, Lahoti SR, Dehghan MHG. Drug vehicle based approaches of penetration enhancement. Int J Pharm Pharm Sci. 2009;1(1):24–46.
21. Bharkatiya M, Nema RK, Bhatnagar M. Development and characterization of transdermal patches of metoprolol tartrate. Asian J Pharm Clin Res. 2010;3(2):130–4.
22. Mahajan NM, Zode GH, Mahapatra DK, Thakre S, Dumore N, Gangane PS. Formulation development and evaluation of transdermal patch of piroxicam for treating dysmenorrhoea. Journal of Applied Pharmaceutical Science. 2018;8(11):035–41. 10.7324/JAPS.2018.81105
23. Darwhekar G, Jain DK, Patidar VK. Formulation and evaluation of transdermal drug delivery system of clopidogrel bisulfate. Asian J Pharm Life Sci ISSN. 2011;2231:4423.
24. Dahodwala STS, Sheikh A. Formulation and evaluation of transdermal film of promethazine hydrochloride. Journal of Advanced Pharmacy Education & Research Oct-Dec. 2013;3(4). https://doi.org/10.4103/2230-973X.176468
25. Sathyapriya LS, Jayaprakash S, Prabhu RS, Abirami A, Subramanian K, Nagarajan M. An approach to the formulation and evaluation of transdermal DDS of isoxsuprine HCL. Int J Pharm Sci Tech. 2008;1:22–8.
26. Bangale GS, Rathinaraj BS, Rajesh KS, Shinde GV, Umalkar DG, Rajveer CH, et al. Design and evaluation of transdermal films of Atenolol. J Chem Pharm Res. 2010;2(3):593–604.
27. Allena RT, Yadav HK, Sandina S, Sarat Chandra Prasad M. Preparation and evaluation of transdermal patches of metformin hydrochloride using natural polymer for sustained release. Int J Pharm Pharm Sci. 2012;4(3):297–305.
28. Sheth NS, Mistry RB. Formulation and evaluation of transdermal patches and to study permeation enhancement effect of eugenol. Journal of Applied Pharmaceutical Science. 2011;(Issue):96–101.