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FORMULATION AND EVALUATION OF IBUPROFEN AND CHLORZOXAZONE SUSPENSION USING NATURAL AND SYNTHETIC SUSPENDING AGENTS

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ABSTRACT

The present study was undertaken to formulate and evaluate an oral suspension of Ibuprofen and Chlorzoxazone using natural and synthetic suspending agents, with the objective of comparing their influence on physicochemical properties and suspension stability. Ibuprofen, a non-steroidal anti-inflammatory drug, and Chlorzoxazone, a centrally acting muscle relaxant, are widely prescribed in musculoskeletal disorders but exhibit poor aqueous solubility, making suspension formulation a suitable approach for improving patient compliance. Four formulations (F1–F4) were prepared by the trituration method using methylcellulose as a synthetic suspending agent and fenugreek (Trigonella foenum-graecum) seed powder as a natural suspending agent at different concentrations. Preformulation studies, including melting point determination and FTIR spectroscopy, confirmed the identity and purity of both drugs. The prepared suspensions were evaluated for particle size, sedimentation volume, viscosity, flow rate, pH, swelling index, and phytochemical characteristics. Among the formulations, F2 exhibited the highest viscosity and sedimentation volume with the lowest flow rate, indicating superior physical stability, while F4 demonstrated acceptable stability with improved homogeneity using a natural suspending agent. All formulations showed pH values within an acceptable range for oral administration. The swelling index and phytochemical screening confirmed the presence of mucilage and other bioactive constituents in fenugreek seed powder, supporting its role as an effective natural suspending agent. The study demonstrates that natural suspending agents can serve as promising alternatives to synthetic polymers in suspension formulations.

Keywords: *Ibuprofen, Chlorzoxazone, Oral suspension, Fenugreek seed powder, Methylcellulose, Natural suspending agent.*

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INTRODUCTION

Oral liquid dosage forms play a crucial role in drug delivery, particularly for pediatric, geriatric, and dysphagic patients who experience difficulty in swallowing solid dosage forms. Pharmaceutical suspensions are biphasic systems consisting of finely divided insoluble solid particles dispersed uniformly in a liquid vehicle with the aid of suitable suspending agents. They are especially useful for drugs that are poorly soluble in aqueous media and require flexibility in dose adjustment [1-4]. Ibuprofen is a widely used non-steroidal anti-inflammatory drug (NSAID) possessing analgesic, antipyretic, and anti-inflammatory properties. It is commonly prescribed for the management of mild to moderate pain, inflammation, and fever. Chlorzoxazone is a centrally acting skeletal muscle relaxant used in combination with analgesics to relieve painful muscle spasms associated with musculoskeletal disorders. Despite their therapeutic effectiveness, both drugs exhibit limited aqueous solubility, which can affect formulation stability and bioavailability when administered in liquid form [5]. Suspension formulations overcome these limitations by dispersing the drug in a suitable vehicle, improving palatability and ease of administration. However, the major challenge in suspension formulation is maintaining physical stability, particularly preventing sedimentation and caking while ensuring easy redispersibility. This stability is primarily governed by the choice and concentration of suspending agents [6,7]. Synthetic suspending agents such as methylcellulose are widely used due to their reproducibility and predictable behavior. However, increasing interest in natural excipients

has encouraged the exploration of plant-based materials owing to their biocompatibility, low toxicity, cost-effectiveness, and environmental acceptability. Fenugreek (Trigonella foenum-graecum) seed powder has demonstrated promising swelling and viscosity-enhancing properties, making it a potential natural suspending agent [8-10]. The present study was therefore undertaken to formulate ibuprofen and chlorzoxazone oral suspensions using both natural (fenugreek seed powder) and synthetic (methylcellulose) suspending agents and to evaluate and compare their physicochemical characteristics and stability.

MATERIALS AND METHODS

Materials

Ibuprofen and chlorzoxazone were obtained as gift samples from a pharmaceutical supplier. Fenugreek seeds were procured from a local market and authenticated. Methylcellulose was used as a synthetic suspending agent. Other excipients such as glycerin, preservatives, sweetening agents, flavouring agents, and purified water were of pharmaceutical grade and used as received.

Preparation of Fenugreek Seed Powder

Fenugreek seeds were cleaned, dried, and finely powdered using a mechanical grinder. The powder was passed through a suitable sieve to obtain uniform particle size and stored in an airtight container until further use.

Formulation of Ibuprofen and Chlorzoxazone Suspension

Four formulations (F1–F4) were prepared using different concentrations of natural and synthetic suspending agents. The suspensions were prepared by the trituration method. The accurately weighed quantities of ibuprofen and chlorzoxazone were triturated with the suspending agent in a mortar to form a smooth paste. Glycerin was added as a wetting agent, followed by gradual addition of the aqueous vehicle containing preservatives and sweetening agents. The final volume was adjusted with purified water, and the suspension was transferred into suitable containers.

Preformulation Studies

Preformulation studies were conducted to confirm the identity, purity, and compatibility of the selected drugs before formulation development [11-14].

Identification of Drugs

The identity of Ibuprofen and Chlorzoxazone was confirmed by melting point determination and Fourier Transform Infrared (FTIR) spectroscopy.

Melting Point Determination

Melting point analysis was performed using a Veego melting point apparatus. A small quantity of each drug was filled into a capillary tube, and the temperature range at which the drug melted was recorded. The observed melting points were compared with reported literature values to confirm the purity and identity of the drugs [15].

Fourier Transform Infrared Spectroscopic Study

FTIR analysis was carried out using the KBr pellet technique. Drug samples were mixed with spectroscopic-grade potassium bromide and compressed under a hydraulic press at a pressure of 7–10 tons to form pellets. The spectra were recorded in the range of 400–4000 cm^{-1}. The obtained spectra were compared with standard reference spectra to confirm the presence of characteristic functional groups and the chemical integrity of the drugs [16,17].

Formulation of Ibuprofen and Chlorzoxazone Suspension

Ibuprofen and Chlorzoxazone suspensions were prepared by the trituration method using both natural and synthetic suspending agents. Accurately weighed quantities of Ibuprofen and Chlorzoxazone were transferred into a dry mortar and triturated to obtain a fine and uniform powder. Tween 80 was added as a wetting agent and triturated thoroughly to ensure uniform wetting of drug particles. The selected suspending agent, either methyl cellulose or fenugreek seed powder depending on the formulation, was added gradually with continuous trituration to form a smooth suspension.

Glycerin was added to the mixture to enhance viscosity and improve dispersibility. Simple syrup was then incorporated as a sweetening agent. Sodium benzoate, previously dissolved in a small quantity of purified water, was added as a preservative. The resulting suspension was transferred into a measuring cylinder, and the final volume was adjusted to 100 mL with purified water. The suspension was mixed thoroughly to ensure uniformity.

Evaluation of Ibuprofen and Chlorzoxazone Suspension

Preparation of Calibration Curves

Calibration curves for Ibuprofen and Chlorzoxazone were prepared using UV-Visible spectrophotometry. Stock solutions of each drug were prepared by dissolving 100 mg of the drug in 100 mL of distilled water to obtain a concentration of 1000 µg/mL. Further dilutions were made to obtain concentrations ranging from 2 to 10 µg/mL [18,19]

Particle Size Analysis

Particle size analysis was carried out using the optical microscopy method. The eyepiece micrometre was calibrated using a stage micrometer before analysis. A drop of each suspension was placed on a glass slide and examined under a microscope. The diameters of 300 particles were measured, and the mean particle size was calculated.[20]

Determination of Sedimentation Volume

Sedimentation volume was determined by transferring the prepared suspension into a graduated measuring cylinder and allowing it to stand undisturbed at room temperature. The height of sediment formed was measured at regular time intervals, and sedimentation volume was calculated as the ratio of sediment height to the original height of the suspension [21].

Viscosity Measurement

The viscosity of the suspensions was measured using a Brookfield viscometer. The suspension sample was placed in a 600 mL beaker, and viscosity readings were recorded at different rotational speeds at room temperature.

Determination of Flow Rate

The flow rate of the suspension was determined by measuring the time required for a fixed volume of suspension to flow through a 10 mL pipette. The flow rate was calculated by dividing the volume by the time taken for the flow.

pH Determination

The pH of each suspension formulation was measured using a calibrated digital pH meter at room temperature [22,24].

Swelling Index of Fenugreek Seed Powder

The swelling index of fenugreek seed powder was determined by placing 1 g of powder in a China dish and adding 10 mL of

distilled water. After allowing the mixture to stand for one-hour, excess water was removed, and the increase in weight was recorded to calculate the swelling index [25-27].

Phytochemical Evaluation of Fenugreek Seed Powder

Preliminary phytochemical screening of fenugreek seed powder was carried out using standard qualitative tests to detect carbohydrates, proteins, alkaloids, mucilage, and flavonoids.

RESULTS AND DISCUSSION

Identification of Drugs

The identity of Chlorzoxazone and Ibuprofen was confirmed by melting point determination and Fourier Transform Infrared (FTIR) spectroscopic analysis. These Preformulation studies were carried out to ensure the authenticity, purity, and suitability of the drugs for further formulation development.

Melting Point Determination

The observed melting points were compared with reported literature values to confirm the identity and purity of the drugs in Table 1.

Table 1: Melting Point Determination of Ibuprofen and Chlorzoxazone

Name of Drug	Reported Melting Point (°C)	Observed Melting Point (°C)
Chlorzoxazone	191–191.5	191–193
Ibuprofen	75–77	75–78

Infrared Spectroscopic Study

The presence of characteristic peaks corresponding to C–Cl, C–N, C=O, and N–H functional groups confirm the chemical structure of Chlorzoxazone (Table 2, Figure 1).The observed FTIR peaks correspond to the characteristic functional groups of Ibuprofen, including hydroxyl, carbonyl, and aliphatic hydrocarbon groups (Table 3, Figure 2).

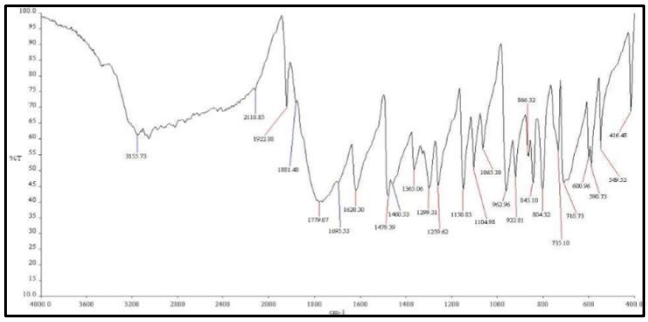

Figure 1: FTIR Interpretation of Chlorzoxazone

Table 2: IR Correlation of Chlorzoxazone

Sr. No.	Wave Number (cm^{-1})	Interpretation
1	710.73	C–Cl stretching
2	1299.31, 1259.62	C–N stretching
3	1779.07	C=O stretching (aromatic ring)
4	3155.73	N–H stretching

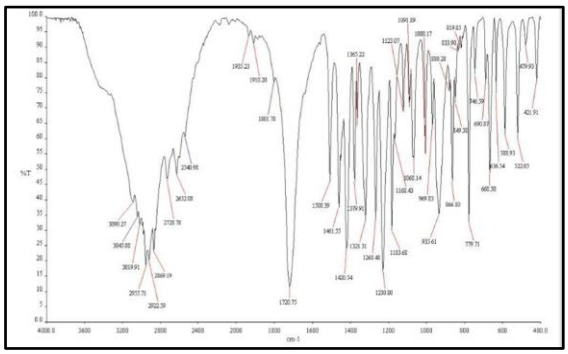

Figure 2: FTIR Interpretation of Ibuprofen

Table 3: IR Correlation of Ibuprofen

Sr. No.	Wave Number (cm^{-1})	Interpretation
1	3390.27	Aliphatic O–H stretching (broad)
2	2955.71	Aliphatic C–H stretching
3	1720.75	Aliphatic C=O stretching
4	1379.91	Aliphatic C–H bending

Formulation of Ibuprofen and Chlorzoxazone Suspension

Four formulations (F1–F4) were prepared by varying the type and concentration of the suspending agents.

Table 4: Ingredients Used in the Formulation of Ibuprofen and Chlorzoxazone Suspension

Ingredients	F1	F2	F3	F4
Ibuprofen	2 g	2 g	2 g	2 g
Chlorzoxazone	1 g	1 g	1 g	1 g
Methyl cellulose	1 g	2 g	–	–
Fenugreek seed powder	–	–	1 g	2 g
Simple syrup	10 mL	10 mL	10 mL	10 mL
Sodium benzoate	0.1 g	0.1 g	0.1 g	0.1 g
Tween 80	0.1 g	0.1 g	0.1 g	0.1 g
Glycerin	10 mL	10 mL	10 mL	10 mL
Purified water	q.s.	q.s.	q.s.	q.s.

Figure 3: Formulation of Ibuprofen and Chlorzoxazone Suspension (F1, F2, F3 and F4)

Calibration Curve of Ibuprofen and Chlorzoxazone

Absorbance was measured at 238 nm for Ibuprofen and 218 nm for Chlorzoxazone, and calibration curves were constructed by plotting concentration versus absorbance(Figure 4).

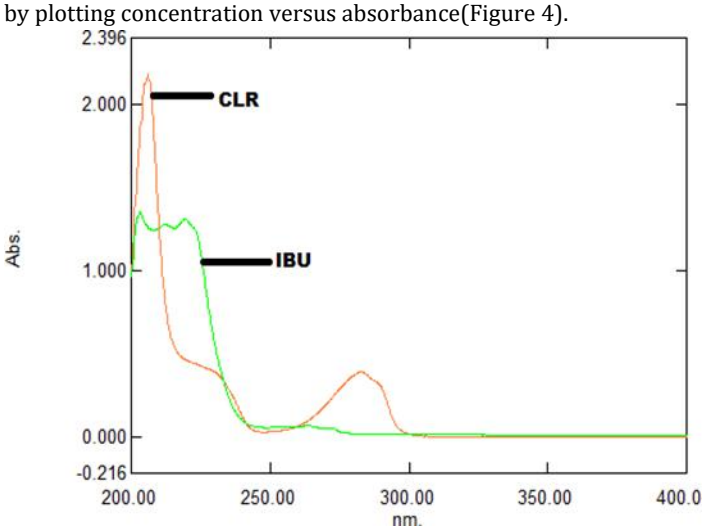

Figure 4:Absorbance spectra of CLR (10 µg/ml) and IBU (10 µg/ml) in methanol

Calibration Curve Data of Chlorzoxazone and Ibuprofen

The calibration data for Chlorzoxazone and Ibuprofen are presented in Table 5, showing a linear increase in absorbance with increasing concentration in the range of 2–10 µg/mL. The corresponding calibration curves are illustrated in Figure 5 (Chlorzoxazone) and Figure 6 (Ibuprofen). Both drugs exhibited excellent linearity, with correlation coefficients (R^2) of 0.9974 for Chlorzoxazone and 0.9983 for Ibuprofen, confirming the suitability of the UV–visible spectrophotometric method for quantitative analysis.

Table 5: Calibration Curve of Chlorzoxazone and Ibuprofen

Concentration (µg/mL)	Absorbance of Chlorzoxazone (218 nm)	Absorbance of Ibuprofen (238 nm)
2	0.076167	0.077
4	0.121667	0.140
6	0.173500	0.179
8	0.284167	0.230
10	0.234667	0.300

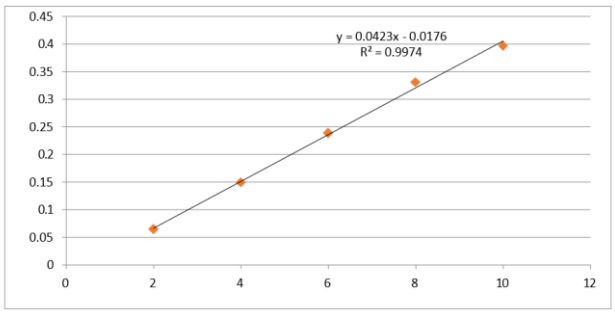

Figure 5: Calibration Curve of CLR (2-10 ug/ml)

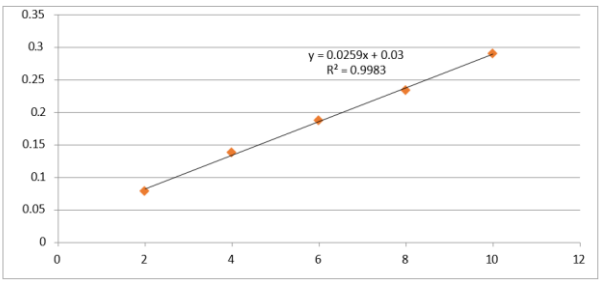

Figure 6: Calibration Curve of IBU (2-10 ug/ml)

Particle Size Analysis

The mean particle size values of formulations F1–F4 are summarised in Table 6. Among all formulations, F2 exhibited the smallest mean particle size, indicating better dispersion and uniformity of drug particles. Reduced particle size contributes to improved physical stability and dissolution characteristics, making F2 comparatively more homogeneous than the other formulations.

Table 6: Mean Particle Size of Ibuprofen and Chlorzoxazone Suspension Formulations

Formulation	Mean Particle Size (µm)
F1	4.56
F2	4.01
F3	4.33
F4	4.43

Sedimentation Volume

The sedimentation volume profiles of all formulations over a period of 60 minutes are presented in Table 7. Formulation F2 showed the highest sedimentation volume throughout the study, indicating superior suspendability and resistance to rapid particle settling. Higher sedimentation volume reflects better physical stability of the suspension system compared to F1, F3, and F4.

Table 7: Sedimentation Volume (Hu/Ho) of Formulations Over Time

Time (min)	F1	F2	F3	F4
0	1.00	1.00	1.00	1.00
5	0.99	1.00	0.96	0.98
10	0.98	0.99	0.95	0.97
15	0.96	0.99	0.94	0.96
20	0.96	0.98	0.93	0.95
25	0.95	0.98	0.91	0.95
30	0.93	0.97	0.90	0.94
40	0.92	0.96	0.88	0.93
50	0.91	0.95	0.86	0.91
60	0.90	0.94	0.84	0.88

Viscosity, Flow Rate, and pH of Ibuprofen and Chlorzoxazone Suspension Formulations

The combined rheological and physicochemical properties of the formulations are summarised in Table 8. Formulation F2 exhibited the highest viscosity and lowest flow rate, indicating superior suspension stability due to reduced particle mobility, while all formulations-maintained pH values within an acceptable range for oral administration. The inverse relationship between viscosity and flow rate further supports the improved physical stability of F2.

Table 8: Viscosity, Flow Rate, and pH of Ibuprofen and Chlorzoxazone Suspension Formulations

Formulation	Viscosity (mPa·s)	Flow Rate (mL/sec)	pH
F1	217.6	0.40	4.96
F2	347.4	0.067	4.36
F3	40.2	3.33	4.40
F4	124.7	1.42	4.57

Swelling Index

The swelling index of fenugreek seed powder is presented in Table 9. A swelling index of 120% indicates high water absorption capacity due to the presence of mucilage. This swelling behaviour contributes to increased viscosity and improved suspension stability when fenugreek seed powder is used as a natural suspending agent.

Table 9: Swelling Index of Fenugreek Seed Powder

Parameter	Value
Initial weight (W_1)	10 g
Final weight (W_2)	22 g
Swelling Index (%)	120

Phytochemical Screening

The results of phytochemical screening of fenugreek seed powder are shown in Table 10. The presence of carbohydrates, proteins, alkaloids, mucilage, and flavonoids confirms the natural polymeric nature of fenugreek mucilage. These constituents support its effectiveness as a natural suspending agent by enhancing hydration and viscosity.

Table 7: Phytochemical Screening of Fenugreek Seed Powder

Test	Observation
Carbohydrates (Molisch's test)	Positive
Tannins (Ferric chloride test)	Negative
Proteins (Biuret test)	Positive
Alkaloids (Wagner's test)	Positive
Mucilage (Ruthenium red test)	Positive
Flavonoids (Alkaline reagent test)	Positive
Reducing sugars (Fehling's test)	Negative

CONCLUSION

Ibuprofen and Chlorzoxazone oral suspensions were successfully formulated using both natural and synthetic suspending agents. Preformulation studies confirmed the purity and compatibility of the drugs. Among all formulations, F2 showed superior physical stability due to higher viscosity and sedimentation volume, while F4 demonstrated good homogeneity and acceptable stability using fenugreek seed powder as a natural suspending agent. The results indicate that fenugreek seed powder possesses excellent swelling and viscosity-enhancing properties and can be effectively used as a natural, economical, and biocompatible alternative to synthetic suspending agents in oral suspension formulations.

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Nil

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper. Acknowledgment

AUTHOR CONTRIBUTIONS

K. Sushma conceived and supervised the study and drafted the manuscript. Konatham Teja Kumar Reddy contributed to data collection, analysis, and manuscript preparation. All authors reviewed and approved the final manuscript.

REFERENCES

1. Ponnada VNL. Formulation and evaluation of ibuprofen suspension using natural and synthetic suspending agents. 2017.
2. Subramanyam CVS. Textbook of Physical Pharmaceutics. 2nd ed. New Delhi: Vallabh Prakashan; 2002. p. 374–387.
3. Kumar RS, Yagnesh TNS. Pharmaceutical suspensions: patient compliance oral dosage forms. World J Pharm Pharm Sci. 2016;5(12):1471–1537.
4. Jahnavi P., Kumar A. K., Prema S., Ramana Singamaneni V., Vidiyala N., Sunkishala P., Rani S., Shankar Gupta P. Recent Progress in Heterogeneous Catalysis for Sustainable Chemical Processes. J. Chem. Rev., 2026; 8(2): 154-179. doi: 10.48309/jcr.2026.535464.1482
5. Vodeti R, Rejili M, Singamaneni VR, Hani U, Fatima F, Kumar Gupta J, et al. Gamma irradiation crosslinked fluorescent nanocarbon based biodegradable hydrogel for controlled release of antibiotics. Singha NR, editor. PLOS One. 2026 Jan 16;21(1):e0340351.
6. Ansel HC, Popovich NG, Allen LV Jr. Pharmaceutical Dosage Forms and Drug Delivery Systems. 10th ed. Philadelphia: Lippincott Williams & Wilkins; 2020.
7. Martin A, Swarbrick J, Cammarata A, editors. Physical Pharmacy. 3rd ed. Philadelphia: Lea and Febiger; 1983. p. 544.
8. Nutan MT, Reddy IK. General principles of suspensions. In: Pharmaceutical Suspensions. New York: Springer; 2010. p. 39–65.
9. Cooper J, Gunn C. Tutorial Pharmacy. 6th ed. New Delhi: CBS Publishers; 1987. p. 75–78.
10. Sushma G, Kumar KM, Ajay B, Ruchi T. Advancements and patents in pharmaceutical suspension technologies. J Biol Sci Opin. 2013;1(4):1–9.
11. Patel RM. Parenteral suspension: an overview. Int J Curr Pharm Res. 2010;2:4–13.
12. Doye PAKP, Mena T, Das N. Formulation and bioavailability parameters of pharmaceutical suspension. Int J Curr Pharm Res. 2017;9(3):8–14.

13. Chukka S, Puligilla S, Yamsani MR. New formulation and evaluation of domperidone suspension. World J Pharm Pharm Sci. 2014;3:1867–1884.
14. Aulton ME. Pharmaceutics: The Science of Dosage Form Design. 2nd ed. Edinburgh: Churchill Livingstone; 2002. p. 84–86, 273.
15. Martin A. Physical Pharmacy. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2001. p. 479–481.
16. Matalqah SM, Singamaneni VR, Jahnavi P, Hani U, Fatima F, Vodeti R, et al. Bio-waste derived fluorescent carbon dots based biodegradable mechanically strong hydrogel for stimuli-responsive nonsteroidal anti-inflammatory drug (NSAID) delivery. Singha NR, editor. PLOS One. 2026 Jan 23;21(1):e0340974.
17. Dhole RS; Singamaneni VR; Chhabra GS; Taru PP; Pathare SS; Pathare YS; Ram BLGPR; Sakat SS, Formulation and Evaluation of Xanthan Gum-Based Naproxen Matrix Tablets for Controlled Drug Release. Int J Drug Deliv Technol. 2025;15(4): 1794-1804, DOI: 10.25258/ijddt.15.4.32
18. Kulshreshtha AK, Singh ON, Wall GM, editors. Pharmaceutical Suspensions: From Formulation Development to Manufacturing. New York: Springer; 2009.
19. Kellaway IW, Najib NM. Hydrophilic polymers as stabilizers and flocculants of sulphadimidine suspensions. Int J Pharm. 1981;9:59–66.
20. Irvine J, Afrose A, Islam N. Formulation and delivery strategies of ibuprofen: challenges and opportunities. Drug Dev Ind Pharm. 2018;44(2):173–183.
21. Parojčić J, Corrigan OI. Rationale for ibuprofen co-administration with antacids: potential interaction mechanisms affecting drug absorption. Eur J Pharm Biopharm. 2008;69(2):640–647.
22. Moore RA, Derry S, Straube S, Ireson-Paine J, Wiffen PJ. Faster, higher, stronger? Evidence for formulation and efficacy for ibuprofen in acute pain. Pain. 2014;155(1):14–21.
23. Barbagallo M, Sacerdote P. Ibuprofen in the treatment of children's inflammatory pain: a clinical and pharmacological overview. Minerva Pediatr. 2019;71(1):82–99.
24. Yang Z, Hu Y, Tang G, Dong M, Liu Q, Lin X. Development of ibuprofen dry suspensions by hot melt extrusion: characterization, physical stability and pharmacokinetic studies. J Drug Deliv Sci Technol. 2019;54:101313.
25. Kocbek P, Baumgartner S, Kristl J. Preparation and evaluation of nanosuspensions for enhancing the dissolution of poorly soluble drugs. Int J Pharm. 2006;312(1–2):179–186.
26. Helin-Tanninen M, Autio K, Keski-Rahkonen P, Naaranlahti T, Järvinen K. Comparison of six different suspension vehicles in compounding of oral extemporaneous nifedipine suspension for paediatric patients. Eur J Hosp Pharm Sci Pract. 2012;19(5):432–437.
27. Moqbel HA, ElMeshad AN, El-Nabarawi MA. A pharmaceutical study on chlorzoxazone orodispersible tablets: formulation, in-vitro and in-vivo evaluation. Drug Deliv. 2016;23(8):2998–3007.