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Fabrication, Characterization and Evaluation of Vaginal Suppositories Containing *Angelica sinensis* L. Polysaccharide

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ABSTRACT:

This study investigated the formulation and characterization of suppositories loaded with *Angelica sinensis* polysaccharide (ASP) for potential therapeutic applications. The results revealed valuable insights into various formulation parameters, including displacement factor, base amount, mean weight, hardness, disintegration time, melting point, content uniformity, and *in vitro* drug release kinetics. The displacement factor varied among formulations, indicating differences in base amount requirements. Suppositories exhibited consistent mean weights but varied in hardness values, potentially influencing mechanical stability. Disintegration times ranged from approximately 16 to 28 minutes, with notable variability within formulations. Melting points varied between 38.78°C and 42.46°C, demonstrating consistency across formulations. Content uniformity showed moderate variability, suggesting formulation-specific drug distribution. *In vitro* drug release studies revealed significant differences in release kinetics among formulations, with formulations SF2 and SF5 exhibiting comparatively higher release rates. Understanding these parameters is crucial for optimizing suppository formulations and achieving desired therapeutic outcomes.

Keywords: Suppositories, *Angelica sinensis* polysaccharide (ASP), Dang Qui, Drug release kinetics, Women ginseng

1. INTRODUCTION

Suppositories are solid dosage forms that are inserted into body orifices, typically the rectum or vagina, where they melt, dissolve, or disperse, releasing the active ingredients they contain. They are often used for the systemic or local delivery of drugs, providing several advantages over other dosage forms. In this article, we will explore suppositories in detail, including their composition, types, advantages, and applications (Yoshimatsu et al., 1964, Ham and Buckheit Jr, 2017). Suppositories consist of both active and inactive ingredients. The active ingredients can be drugs or other therapeutic agents intended to produce a desired effect. The inactive ingredients, also known as excipients, provide the suppository's structure, stability, and release characteristics. Common excipients include fatty bases, such as cocoa butter or polyethylene glycol, which melt at body temperature, facilitating drug release. Suppositories can be classified based on their composition, route of administration, or intended use (Ham and

Buckheit Jr, 2017, Melnyk et al., 2020). The most common types include (Bergogne-Bérézin and Bryskier, 1999, Shan et al., 2023):

Rectal Suppositories: These are inserted into the rectum and are used for systemic drug delivery or local treatment of conditions such as constipation, hemorrhoids, or inflammatory bowel disease.

- *Vaginal Suppositories:* These are inserted into the vagina and are used for local treatment of conditions such as vaginal infections, hormonal imbalances, or contraception.
- *Urethral Suppositories:* These are inserted into the urethra and are used for the treatment of urinary tract infections or erectile dysfunction.

Suppositories offer several advantages over other dosage forms, making them a preferred choice in certain situations (Shan et al., 2023, Thushara et al., 2023):

- Localized Drug Delivery: Suppositories allow for targeted delivery of drugs to specific anatomical sites, such as the rectum or vagina, minimizing systemic side effects and maximizing therapeutic efficacy.
- Avoidance of First-Pass Metabolism: Drugs absorbed through the rectal or vaginal mucosa bypass the liver's first-pass metabolism, resulting in higher bioavailability compared to oral administration.
- Enhanced Patient Compliance: Suppositories are easy to administer and do not require swallowing, making them suitable for patients who have difficulty swallowing tablets or capsules.
- Prolonged Drug Release: Suppositories can be formulated to provide sustained or controlled release of drugs over an extended period, reducing dosing frequency and improving patient convenience.
- Stability of Active Ingredients: Some drugs are unstable in the acidic environment of the stomach or undergo degradation in the gastrointestinal tract. Suppositories protect these drugs from degradation, ensuring their stability and potency.
- Rapid Onset of Action: Suppositories often provide faster onset of action compared to oral dosage forms, as they bypass the gastrointestinal tract and are directly absorbed into the bloodstream or target tissue.
- Alternative Route of Administration: Suppositories offer an alternative route of administration for patients who cannot take medications orally or intravenously due to vomiting, unconsciousness, or other medical conditions.

Suppositories have a wide range of applications in various medical fields, including (Thushara et al., 2023):

- Gastroenterology: Rectal suppositories are used for the treatment of constipation, inflammatory bowel disease, or hemorrhoids.
- Obstetrics and Gynecology: Vaginal suppositories are used for the treatment of vaginal infections, hormonal imbalances, or contraception.
- Urology: Urethral suppositories are used for the treatment of urinary tract infections or erectile dysfunction.
- Palliative Care: Suppositories are used for the management of pain, nausea, or other symptoms in palliative care patients who cannot take medications orally.

In summary, suppositories are versatile dosage forms that offer several advantages, including localized drug delivery, avoidance of first-pass metabolism, enhanced patient compliance, and rapid onset of action. They have applications in various medical fields and play an important role in patient care. As pharmaceutical technology continues to advance, suppositories will remain an important option for drug delivery and treatment (Thushara et al., 2023, Yasmitha et al., 2023).

The rationale for using natural polysaccharides in suppository preparation is multifaceted and encompasses various pharmaceutical, therapeutic, and patient-related considerations. Natural polysaccharides, such as agar, alginate, carrageenan, cellulose derivatives, and starches, are derived from renewable plant or microbial sources (Yasmitha et al., 2023, Kumar et al., 2023). They are inherently biocompatible and biodegradable, making them safe for use in pharmaceutical formulations. Their natural origin reduces the risk of adverse reactions or toxicity, making them suitable for sensitive mucosal tissues, such as the rectum or vagina. Suppositories formulated with natural polysaccharides are often perceived as more natural and gentler compared to synthetic alternatives. This can improve patient acceptance and compliance, particularly in individuals who prefer or require natural or organic products. Many natural polysaccharides exhibit bioadhesive properties, allowing them to adhere to mucosal surfaces and prolong contact with the absorption site (Kumar et al., 2023). This enhances drug absorption and retention, leading to improved therapeutic outcomes. Bioadhesive suppositories are particularly advantageous for drugs with poor mucosal penetration or short residence times. Natural polysaccharides can be modified or cross-linked to modulate drug release kinetics (Kumar et al., 2023, Baral et al., 2021). By altering factors such as polymer concentration, molecular weight, or degree of cross-linking, it is possible to achieve sustained, controlled, or targeted drug release from suppositories. This is beneficial for drugs requiring prolonged therapeutic action or those with narrow therapeutic windows. Some natural polysaccharides, such as hyaluronic acid or sodium alginate, have inherent moisture-retaining properties. When incorporated into suppositories, they help maintain tissue hydration and lubrication, reducing irritation and discomfort associated with suppository insertion. This is particularly relevant for rectal or vaginal applications, where tissue hydration can influence patient comfort and compliance.

Natural polysaccharides are generally compatible with a wide range of active pharmaceutical ingredients (APIs), including hydrophilic and hydrophobic compounds. They can serve as carriers, stabilizers, or matrices for drug incorporation, providing uniform dispersion and controlled release of the API within the suppository matrix. This versatility facilitates the formulation of diverse suppository products for different therapeutic indications (Hou et al., 2020, Yi et al., 2020). Natural polysaccharides are derived from renewable resources and are biodegradable, contributing to environmental sustainability. Their use reduces reliance on synthetic polymers derived from petrochemicals, which may have environmental implications during production, use, and disposal. In a nutshell, the use of natural polysaccharides in suppository preparation offers several advantages, including biocompatibility, enhanced patient acceptance, bioadhesive properties, controlled drug release, tissue hydration, compatibility with active ingredients, and environmental sustainability. These factors contribute to the development of safe, effective, and patient-friendly suppository formulations for various therapeutic applications (Dos Santos et al., 2021, Xue et al., 2023).

Angelica sinensis polysaccharide (ASP) is a biologically active compound extracted from the roots of *Angelica sinensis*, also known as Dong Quai or Chinese *Angelica*. ASP has gained attention in traditional Chinese medicine and modern pharmacology due to its potential therapeutic properties (Nai et al., 2021). ASP is a complex carbohydrate composed of various sugar units, including glucose, arabinose, galactose, and xylose, among others. It exhibits a range of biological activities, including immunomodulatory, antioxidant, anti-inflammatory, and anticancer effects. Research suggests that ASP can enhance immune function by stimulating the production and activity of immune cells, such as T cells, B cells, and natural killer cells (Bi et al., 2021, Shen et al., 2024, kataki and Kakoti, 2015). Additionally, ASP's antioxidant properties help protect cells from oxidative damage caused by free radicals, thereby reducing inflammation and oxidative stress. Furthermore, ASP has shown promise in cancer therapy by inhibiting tumor growth and metastasis, inducing apoptosis (programmed cell

death) in cancer cells, and enhancing the efficacy of chemotherapy drugs. *Angelica sinensis* polysaccharide holds significant potential as a therapeutic agent for various health conditions, and further research is warranted to fully elucidate its mechanisms of action and clinical applications (Shen et al., 2024, kataki and Kakoti, 2015). Furthermore, vaginal suppositories containing *Angelica sinensis* polysaccharide hold promise as a natural remedy for various gynaecological conditions and may offer benefits related to menopausal symptom relief, urogenital health, anti-inflammatory effects, wound healing, immune modulation, antioxidant activity, and potential anticancer effects. Therefore, considering all these facts, the present study was designed to extract the polysaccharide from roots of *Angelica sinensis* (ASP) followed by the preparation of suppositories using ASP.

2. MATERIAL AND METHODS

Materials

Polyethylene glycol (PEG) 400, PEG 2000, PEG 6000, glycerine, n-hexane, and gelatin were procured from Merck, a reputable supplier based in Germany, renowned for its high-quality chemical products. PEG, available in various molecular weights such as 400, 2000, and 6000, is widely utilized in pharmaceuticals, cosmetics, and industrial applications due to its versatility and non-toxic nature. By sourcing these chemicals from Merck, known for its adherence to stringent quality standards, the integrity and reliability of the materials are ensured, thereby contributing to the efficacy and safety of the end products.

Plant material: *Angelica sinensis* Polysaccharide (ASP)

Fresh roots of *A sinensis* L. were sourced from the Kullu district of Himachal Pradesh, India, in November-December 2022. Identification of the species was conducted at the Herbarium of the Department of Pharmacognosy, School of Pharmacy, AU, Himachal Pradesh, India, and a voucher specimen (MK/33-2023/39) was deposited. Subsequently, the fresh roots underwent drying in an oven at 40°C, followed by crushing and weighing.

Polysaccharides extraction

Two hundred grams (200 g) of dry-milled *A sinensis* roots underwent sieving through a 5 mm sieve, followed by soaking in 1 L of purified water and agitation for 20 minutes. The resulting mixture was filtered, and the filtrate was subjected to precipitation using 97% ethanol. The residue obtained was further treated with 80% ethanol (v/v), followed by centrifugation and vacuum drying. The sediment obtained, designated as ASP, was subsequently dissolved in purified water and subjected to freeze-drying. The percentage yield of the extracted ASP was determined using the gravimetric method.

Swelling index determination

The swelling index (S.I.) represents the increase in sample volume after it has been swollen in an aqueous solution. To determine the swelling index, one gram of ASP was added to 30 mL of distilled water in a sealed glass flask. The flask was vigorously shaken every ten minutes for an hour and then allowed to stand for an additional three hours. The final volume was recorded in millilitres, and the swelling index was calculated using the following equation:

The swelling index (S.I.) = [Ws – Wd/Wd] X 100

where Ws represents the weight of the swollen plant material and Wd represents the weight of the dry plant material.

Displacement factor

The displacement values were determined using the following equation:

$$f = \left[\frac{100(E-G)}{G.X}\right] + 1$$

Where, f is the displacement factor, E is the weight of the suppository base without medicinal product (ASP), G is the weight of the suppository containing medicinal product and X is the percentage of the medicinal product content.

Preparation of suppositories

Glycerinated gelatin base suppositories

A glycerinated gelatin base was prepared using a ratio of 70% glycerine, 20% gelatin, and 10% water. Initially, glycerine and water were combined in a water bath at 45°C. Subsequently, gelatin powder was slowly added to the mixture while stirring continuously. Accurate quantities of the ASP at concentrations of 10%, 20%, and 35% (w/w) were then blended with their respective glycerinated gelatin bases. Following thorough dispersion of the active ingredient into the base, the mixture was poured into 2-gram moulds, previously lubricated with light mineral oil, and transferred to the refrigerator for further processing.

Polyethylene glycol base suppositories

Various formulations of polyethylene glycol (PEG)-based suppositories were prepared as per table 1. Different types of PEG were accurately weighed, melted, and blended uniformly at 50°C. Subsequently, 25% and 50% (w/w) of the medicinal product (ASP) were added to the PEG base and thoroughly mixed. Upon achieving homogeneity of the medicinal product in the base, the resulting mixture was poured into 2-gram moulds, which were lubricated with light mineral oil, and then transferred to the refrigerator for a duration of half an hour (Allen Jr, 1997).

Oleaginous base suppositories

Oleaginous base suppositories were prepared using Theobroma oil. The lipid base was melted in a water bath at 40°C and blended uniformly with 25% and 50% (w/w) ASP to create SF5 and SF6 formulations, respectively. Following thorough mixing, the resulting mixture was moulded into 2-gram moulds, which were lubricated with glycerine, and then placed into the refrigerator for the specified duration (Allen Jr, 1997, Mollel, 2006).

Table 1. Composition of different suppository formulations

	Suppository Formulation Ingredients (%)				
Formulation	**PEG 2000 (%)**	**PEG 6000 (%)**	**PEG 400 (%)**	**Theobroma oil (%)**	**ASP* (%)**
SF1	15	45	15	-	25
SF2	15	30	30	-	25
SF3	10	30	10	-	50
SF4	10	20	20	-	50
SF5	-	-	-	75	25
SF6	-	-	-	50	50

*ASP = *Angelica sinensis* polysaccharide

Weight uniformity test, hardness test and content uniformity test

The weight uniformity test was conducted in accordance with the British Pharmacopoeia (BP, 2011). Twenty suppositories from each formulation were randomly selected, and their mean weight and standard deviation were determined (Hargoli et al., 2013). The hardness of the suppositories was assessed using a suppository hardness tester at room temperature (25±0.5°C). Ten randomly chosen suppositories from each formulation were subjected to varying progressive weights (Abbaspour et al., 2022). The weight required for each suppository to collapse was recorded in kilograms-force to evaluate resistance to crushing. To analyse the impact of ASP addition on mechanical strength, base suppositories (without ASP) were also prepared, and their hardness was assessed. For the content uniformity test, a gravimetric method was employed. Ten randomly selected suppositories from each batch were weighed

and individually placed in test tubes, which were then heated in a water bath at 50°C to melt the contents. Ten millilitres of distilled water were added to each tube, followed by the addition of 4 ml of 96% ethanol to precipitate the ASP content. The tubes were centrifuged at 1000 rpm for 2 minutes. Subsequently, 2 mL of hexane were added to each tube, and after shaking for two minutes at 55°C, the tubes were centrifuged again to separate the lipophilic phase of the suppositories. The supernatant containing the lipophilic base was discarded, and the residue containing the ASP was dried at 45-50°C and weighed. The mean weight was determined and used to quantify the ASP content of each suppository (Matsumoto et al., 2017).

Determination of disintegration time

Five randomly selected suppositories from each formulation were subjected to the disintegration test using the disintegration test apparatus. The test tubes were filled with distilled water adjusted to pH 4.5 by adding citric acid/phosphate buffer and were then immersed in a water bath maintained at 37±1°C. A plastic disc was inserted into each tube to prevent the suppositories from floating (U.S.P., 2018). The disintegration time, i.e., the time required for complete separation or dissolution of the suppository components, was recorded.

Determination of softening and melting points

The melting point of the ASP suppositories was determined following the procedure outlined in the U.S.P. 41-NF36, utilizing a melting point apparatus. A straight capillary tube with both ends open was filled with an adequate amount of the suppository base (approximately 1 cm). The filled capillary tube was then placed in the melting point apparatus alongside a thermometer. The melting point was recorded when the contents of the capillary tube began to melt.

In-vitro release test

The in-vitro release test was conducted following the method described elsewhere (Matsumoto et al., 2017, Hargoli et al., 2013) with some modifications. Three randomly selected suppositories from each formulation were immersed in Falcon tubes containing 10 ml of distilled water as the dissolution medium, adjusted to achieve a pH of 4.5 with phosphate buffer solution to simulate vaginal pH. These Falcon tubes were then placed in a shaker water bath at a constant temperature of 37°C. Samples of 2 mL were withdrawn at specified time intervals (0, 5, 15, 25, 35, and 45 minutes). To maintain a constant volume throughout the study, an equal volume of fresh medium was added back into the dissolution medium after each sampling. After withdrawal, 4 ml of 96% ethanol was added to each tube, which was then centrifuged at 1000 rpm for 2 minutes. Subsequently, 2 ml of hexane was added to each test tube. The supernatant containing the lipophilic base was carefully removed, and the residue containing the medicinal product (ASP) was dried at 40-45°C and weighed. The mean weight and release percentage were calculated for each suppository based on the amount of ASP released over time.

Statistical analysis

The obtained results were subjected to statistical analysis using GraphPad Prism 7 statistical software (GraphPad, Inc. CA, U.S.A.). An unpaired T-test was employed to compare each sample group with its corresponding base group. For comparisons of means among different groups, a one-way ANOVA test followed by Tukey's multiple comparisons test was conducted. A significance level of $P < 0.05$ was considered statistically significant.

3. RESULTS AND DISCUSSION

Displacement factor, base amount, mean weight, hardness and weight

The table 2 provides valuable insights into the displacement factor, base amount required, mean weight of suppositories without the drug, hardness of suppositories, hardness of suppository bases, and weight across different formulations of suppositories. Firstly, the displacement

factor, which represents the ratio of the base amount required to the mean weight of suppositories without the drug, varied among the formulations. Formulation SF5 exhibited the highest displacement factor of 0.811, indicating a relatively higher base amount required to achieve the desired suppository weight compared to other formulations. On the other hand, formulations SF2 and SF4 had a displacement factor of 0.601, suggesting a lower base amount requirement for these formulations. The base amount required ranged from 1.32 g to 2.08 g across the formulations. Formulations SF2 and SF4 required a higher base amount of 2.08 g, while SF6 required the lowest amount at 1.32 g. This variation in base amount reflects differences in the formulation composition and efficiency of drug incorporation. The mean weight of suppositories without the drug was relatively consistent among the formulations, ranging from 3.03 g to 3.15 g. This uniformity in suppository weight indicates consistent manufacturing processes and formulation precision. Hardness measurements revealed variation among the formulations, with mean values ranging from 3.01 kg to 3.08 kg for suppositories and 2.64 kg to 5.11 kg for suppository bases. Formulations SF5 and SF6 exhibited lower hardness values compared to others, potentially affecting their mechanical stability and handling characteristics. Overall, the data highlight the importance of optimizing formulation parameters to achieve desired suppository characteristics, including weight, hardness, and drug content uniformity.

Table 2. Displacement factor, hardness and weight of selected suppositories

Parameters	SF1	SF2	SF3	SF4	SF5	SF6
Displacement Factor	0.715	0.601	0.715	0.601	0.811	0.804
Base Amount Required (g)	2.01	2.08	2.05	2.06	2.04	2.41
Mean Weight of Suppositories (g)	3.15	3.12	3.15	3.12	3.03	2.06
Hardness of Suppositories (kg)	3.01 ± 0.41	3.02 ± 0.31	3.02 ± 0.42	3.03 ± 0.33	3.04 ± 0.31	3.08 ± 0.43
Hardness of Suppository Bases (kg)	3.04 ± 0.522	4.03 ± 0.392	5.09 ± 0.302	5.11 ± 0.302	3.21 ± 0.209	3.55 ± 0.41
Weight (g) Mean ± SD	3.621 ± 0.094	3.401 ± 0.087	3.511 ± 0.091	3.544 ± 0.088	3.287 ± 0.191	3.301 ± 0.07
RSD (%)	4.3	3.5	3.8	3.2	5.8	3.8

Disintegration Timem **Melting Point and Content Uniformity**

The table presents data on the disintegration time, melting point, and content uniformity of six different suppository formulations (SF1 to SF6). The mean disintegration time of the ASP suppositories ranges from approximately 16 to 28 minutes. SF2 has the shortest mean disintegration time of 16.21 minutes, while SF6 has the longest mean disintegration time of 28.51 minutes. There is variability within formulations, as indicated by the standard deviation (SD) values. For example, SF4 and SF6 exhibit relatively higher SD values, suggesting greater variability in disintegration time within these formulations. The melting point of the MP suppositories ranges from approximately 38.78 to 42.46°C. SF5 has the lowest melting point at 38.78°C, while SF2 has the highest melting point at 42.46°C. The relative standard deviation (RSD) values for the melting point of MP suppositories are relatively low, indicating consistency in melting point across formulations.

The mean content of the MP in the suppositories ranges from approximately 0.457 to 1.224 grams. SF3 has the highest mean content of MP at 1.224 grams, while SF5 has the lowest mean

content at 0.457 grams. The percentage of mean content ranges from approximately 76.56% to 112.79%, indicating variations in content uniformity across formulations. The RSD values for content uniformity range from 10.81% to 16.95%, suggesting moderate variability in content uniformity among formulations. Overall, the data suggest significant variability in disintegration time, melting point, and content uniformity among the different suppository formulations. Understanding these parameters is crucial for ensuring the efficacy and consistency of suppository-based drug delivery systems.

Table 3. Disintegration time, melting point, and content uniformity of suppositories

Formulations / Parameters	**SF1**	**SF2**	**SF3**	**SF4**	**SF5**	**SF6**
Disintegration Time of ASP Suppositories (min)	26.65 ± 0.011	16.21 ± 0.019	21.71 ± 0.011	23.21 ± 0.031	26.11 ± 0.021	28.51 ± 0.023
Disintegration Time of Bases (min)	13.37 ± 0.142	11.10 ± 0.098	13.34 ± 0.133	11.31 ± 0.089	09.22 ± 0.51	09.18 ± 0.035
Melting Point of MP Suppositories (°C)	40.66 ± 1.643	42.46 ± 1.24	41.21 ± 1.11	41.34 ± 0.99	38.78 ± 0.491	38.87 ± 0.587
Melting Point of Bases (°C)	41.68 ± 0.611	43.57 ± 0.511	41.91 ± 0.554	43.46 ± 0.471	38.54 ± 0.561	38.25 ± 0.509
ASP Content (g)	0.687 ± 0.065	0.647 ± 0.064	1.224 ± 0.216	0.989 ± 0.101	0.457 ± 0.048	0.912 ± 0.089
Percentage of Mean Content	107.46	107.36	112.79	90.88	76.56	84.12
RSD (%)	11.91	10.81	15.88	11.75	16.95	12.064

The *in vitro* drug release study

The in vitro drug release study conducted over 45 minutes provides valuable insights into the release kinetics of six different formulations (SF1 to SF6). At the onset of the study (0 min), no drug release was detected across all formulations, as indicated by the uniform value of 0. This initial observation suggests that the drug release process initiates after a certain lag time, characteristic of the formulations under investigation. As time progresses, drug release becomes evident in all formulations, with the amount of released drug steadily increasing at each time point. Notably, formulations SF2 and SF5 exhibit comparatively higher drug release rates at every interval, implying potentially faster drug release kinetics compared to the other formulations. For instance, at 45 minutes, SF5 demonstrates the highest drug release at 82.73±1.21, while SF6 shows the lowest release at 50.91±1.34. Throughout the study duration, noticeable differences in drug release profiles are observed among the formulations. These variations may be attributed to differences in formulation composition, including excipients and drug loading. Additionally, the standard deviation values provided alongside the mean drug release values offer insights into the variability within each formulation. Higher standard deviation values indicate greater variability in drug release kinetics within a formulation, whereas lower values suggest more consistent release profiles over time. Understanding the drug release profiles of these formulations is crucial for optimizing drug delivery systems to achieve desired therapeutic outcomes, such as sustained or controlled drug release. Further analysis and characterization are warranted to elucidate the factors influencing the observed differences in drug release behaviour among the formulations and to inform future formulation development and optimization efforts.

Table 4. Results of the *In vitro* drug release study

Time (min)	SF1	SF2	SF3	SF4	SF5	SF6
0	0	0	0	0	0	0
5	10.34±1.01	12.22±1.01	8.37±0.99	11.32±1.02	14.44±0.99	9.12±0.99
15	18.48±1.02	22.45±1.01	14.79±0.99	20.76±1.02	26.89±1.11	16.33±1.09
25	26.67±1.11	32.76±1,02	20.78±1.03	28.39±1.03	37.49±1.03	23.24±1.22
35	37.99±1.20	45.76±1,03	27.77±1.21	39.47±1.03	62.79±1.09	34.67±1.09
45	52.39±1.13	67.49±1.21	40.68±1.22	58.58±1.25	82.73±1.21	50.91±1.34

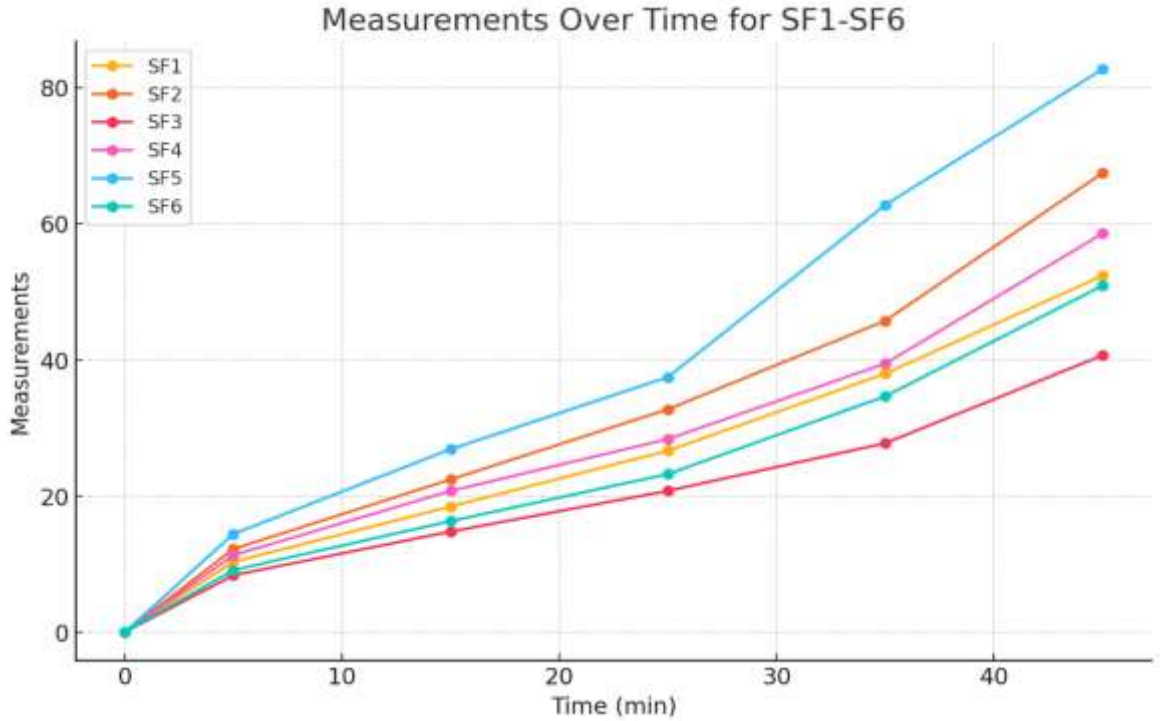

Figure 1. Presenting the results of the *In vitro* drug release study as a concentration vs time profile

4. CONCLUSIONS

In conclusion, the formulation and characterization of ASP-loaded suppositories offer promising insights into potential therapeutic applications. The observed variability in formulation parameters underscores the importance of optimizing formulation composition and processing parameters to achieve desired suppository characteristics, including weight, hardness, and drug release kinetics. Despite differences among formulations, consistent mean weights and melting points indicated formulation precision and reproducibility. However, variability in disintegration times and content uniformity highlights the need for further optimization and standardization. The significant differences in drug release kinetics among formulations emphasized the importance of understanding release profiles for optimizing drug delivery systems. Overall, this study contributed valuable knowledge to the development of suppository-based drug delivery systems and underscored the potential of ASP-loaded suppositories for various therapeutic applications. Further research is warranted to elucidate the underlying mechanisms influencing formulation parameters and to optimize suppository formulations for enhanced therapeutic efficacy.

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