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Ethanolic extract of *Parkia speciosa* Hassk leaves innovation of gastroretentive tablet: standardization and optimization

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ABSTRACT: *Parkia speciosa* ethanol leaves extract contains flavonoid, tannin, and terpen as ulcus peptic remedy. These compounds exhibit limited activity in the stomach due to the short gastric residence time following oral administration. The formulation of gastroretentive tablets can overcome this limitation. This research aims to control the prolonged release of drugs in the stomach to increase bioavailability and characterize the ethanol leaves extract. Extraction was carried out by maceration using ethanol, followed by standardization based on specific and non-specific parameters extract. Gastroretentive tablet was formulated with combination of HPMC-K4M and chitosan using factorial design 2^2. Effects of compositional factors and their interactions on gastroretentive tablet was observed on hardness, friability, floating lag/duration time, swelling index, and mucoadhesive time. Results standardization extract showed that extract met the required criteria for both specific parameters (organoleptic properties and phytochemical screening) and non-specific parameters (moisture content, loss on drying, water/ethanol-soluble extract content). Based on with DX®10 analysis, the optimum formulation was achieved with 20.25% of HPMC-K4M and 10.26% of chitosan. The analysis of the optimum formulation characteristics was as follows: friability (0.22%), hardness (29.53 N), mucoadhesive time (22.86 hours), floating lag/duration time (27.54 minutes; 12 hours), and swelling index (312.82%). Result revealed that gastroretentive tablets formulated with ethanol extract of *Parkia speciosa* leaves improve gastric residence duration and promote better bioavailability.

KEYWORDS: Extract; gastroretentive; phytopharmaceutics; screening phytochemistry; *Parkia Speciosa.*

INTRODUCTION

Parkia speciosa leaves often considered waste, are rich in bioactive compounds such as flavonoids, alkaloids, saponins, tannins, and terpenoids, which may confer health-promoting effects [1] . The extract of *Parkia speciosa* leaves exhibited antioxidant and antimicrobial activities and demonstrated potential in reducing peptic ulcers. Antioxidant activity was evaluated using the DPPH method, showing an IC_{50} value of 3.90 mg/L [1],[2]. Ethanol extract of *Parkia speciosa* (EPS) at 100 mg/kgBW dosage in test animals reduce the expansion of peptic ulcers by inhibition percentage of 75% almost the same as shown by omeprazole at a dosage of 20 mg/ kgBW. As a therapeutic agent of gastric ulcers, *Parkia speciosa* leaves ethanol extract is formulated into gastroretentive tablet dosage form to increase effectiveness in the use and effects of therapy [3],[4].

The pupose of gastroretentive system is to extend the residence time of drug in stomach and increase the bioavailability of the drug [5]. The combination is expected to overcome the weaknesses of each system on a single use [6]-[8].Weakness floating system enables the tablet to the pylorus are then removed from the hull when the number of gastric juices a little. The possibility of the tablet to be apart from the gastric mucosa due to peristalsis is the weakness of the mucoadhesive system [8],[9].

Chitosan and HPMC-K4M are polymers that can be used for floating or mucoadhesive system Mucoadhesive properties of HPMC-K4M is due to the formation of hydrogen bonds with the components of mucus, Owing to the slow penetration of the dissolution medium, HPMC K4M exhibits floating behavior

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and forms a gel matrix that prolongs drug release [9]. Mucoadhesive properties of chitosan is caused by the cationic nature of chitosan forming complex with negatively charged biomolecules so that interaction of the mucosal cells is more efficient. The floating nature of chitosan is to easily form swelling when interacting acid so it easily floats [6]. The factorial design method was employed to evaluate the effects of each polymer and their interactions on the floating ability, mucoadhesive properties, and release profile of the extract, in order to obtain a modified-release tablet dosage form that meets the required specification [5].

▪ MATERIALS AND METHODS

Materials

Materials used in this research were *Parkia speciosa* leaves were collected form Sukajaya, Oku Timur, Ogan Komering Ulu, South Sumatra, Indonesia. All chemicals used in this research were analytical grade.

Preparation of plant extract

Parkia speciosa Hassk leaves were collected from Suka Jaya Village, Buay Madang District, East Oku Regency, South Sumatra. Sampling was performed by cutting branches and selecting mature dark-green leaves. The collected leaves were sorted, air-dried, and subsequently identified ANDA Herbarium with register 015/K-ID/ANDA/II/2016. Parkia speciosa were extracted by maceration. The dried leaves parkia were add to the maceration vessel. The ethanol 96% was added in ratio 1:6 and soaked for 3x24 hours. Maserat obtained in concentrated by a rotary evaporator (Yamato®, RE301) at 70°C until it form a thick extract [4].

Characterization of extract

Organoleptic

Organoleptic characterization of the extract was conducted through sensory evaluation, including assessment of shape, odor, color, and taste.

Water-soluble extract content

A total of 0.5 g of extract was macerated with 10 mL of chloroform–aquadest (0,25%v/v) for 24. Followed by filtration. An aliquot of 2 mL of the filtrate was evaporated to dryness in a water bath and subsequently heated at 105 °C until a constant weight was obtained.

Ethanol-soluble extract content

A total of 0.5 g of extract was macerated with 10 mL of ethanol 96% for 24. Followed by filtration. An aliquot of 2 mL of the filtrate was evaporated to dryness in a water bath and subsequently heated at 105 °C until a constant weight was obtained.

Loss of drying and specific gravity

An aliquot of 1 g extract was accurately weighed into a pre-weighed dish, evenly spread, and dried at 105 °C to a constant weight.The extract was diluted to a 5% concentration. A pre-weighed pycnometer was filled with 10 mL of the diluted extract and weighed before and after filling. The same procedure was performed using 10 mL of distilled water.

Screening of phytochemistry

Phytochemical screening was conducted to identify secondary metabolites in *Parkia speciosa* leaf extract.

Table 1. Reagents for Screening of phytochemistry.

Phytochemical group	Reagents	Expected result
Alkaloids	Mayer's (HgI_2–KI),	Orange-brown
Flavonoids	Mg powder + HCl conc.	Red to pink coloration
Phenolics & Tannins	$FeCl_3$ 1–5%	Blue-black (219ydrolysable tannins), greenish-black (condensed tannins)
Saponins	Distilled water (vigorous shaking)	Persistent froth (≥1 cm, >10 min)
Terpenoids	Chloroform + H_2SO_4 conc.	Reddish-brown interface
Steroids	Acetic anhydride + H_2SO_4 conc.	Green to blue coloration

Formulation

This research used ethanol *parkia speciosa* leaves extract as active substance, HPMC-K4M as polimers. The rest of formulation consisted magnesium stearic 1%, talc 1%, Avicel q.s, PVP-K30 5%, Sodium bicarbonate 5%. The comparison of polimer at the formula design can be shown by Table 2. The tablets were made by wet granulation. The tablets is made by mixing EPS (Extract *Parkia specioa*) woth polimer (HPMC-K4M and chitosan), $NaHCO_3$, PCP K30 binder solution to form a mass that can be clenched. Massa sieved with a 12 Mesh sieve and dry in an oven at a temperature of 50 °C. Massa dry granules is sieved again with mesh sieve 14 (Retsch®). Add magnesium stearate and talc until it becomes homogeneous and molded into tablets with a weight of 500 mg.

Table 2. Comparisation polymer of Formulas of gastroretentive tablet.

Polimers	Amount (% w/w)			
	F1 (1)	F2(A)	F3(B)	F4(AB)
HPMC-K4M	10	25	10	27.5
Chitosan	5	5	20	22

Granul evaluation

All formulas obtained evaluation of granul test which the parameters were: water content, hausner ratio, compresibiltas, flow rate, repose angle.

Tablet evalution

Friability

A total of 20 tablets were placed into a friabilator (CS-1 *Friability Tester*) and rotated at 25 rpm for 4 minutes. The tablets were then removed, cleaned to eliminate dust, and reweighed.

Hardness

Hardness testing was performed by placing a single tablet into a hardness tester (YF-1 *Hardness Tester*) until fracture occurred. The test was conducted on six tablets.

Floating test

Tablets were placed in 100 mL of simulated gastric fluid (SGF) (pH 1.2; 37±0.5 °C). The time taken for a tablet to rise to the surface was recorded as the floating lag time, while the duration for which the tablet remained a float was recorded as the floating duration [10].

Swelling index

Tablets were placed in 100 mL SGF (pH 1.2; 37±0.5 °C). At the 2; 4; 6; 8th hours, the tablet was removed, blotted with filter paper to absorb excess water, and reweighed [11].

Muchoadhesive time

The mucoadhesive test was performed using goat gastric mucosa (abomasum section). The mucosa was washed with physiological saline and fixed to a glass beaker using cyanoacrylate adhesive. One side of the tablet was moistened with SGF (pH 1.2), placed on mucosa. The beaker was filled with 70 mL SGF (37 ± 0.5 °C), equipped with a magnetic stir bar set at 100 rpm. The time until the tablet detached from the mucosa was recorded as the mucoadhesive time [12].

Optimization formulas using factorial design

Results for friability, hardness, floating lag time, swelling index, floating duration, and mucoadhesive time were expressed as mean ± pvalue. Optimization was performed using Design Expert® 20 to generate contour plots for each response factor. These contour plots were overlaid to determine the optimum concentrations of HPMC-K4M and chitosan.

RESULTS

Characteristic extract

The extract characterization demonstrated that all evaluated parameters complied with the quality requirements outlined in the *Indonesian Herbal Pharmacopoeia*, covering organoleptic characteristics, loss on drying, moisture content, specific gravity, water-soluble extractives, and ethanol-soluble extractives. The phytochemical screening of the extract using specific reagents revealed that the ethanolic extract of *Parkia speciosa* leaves contains flavonoids, phenolic compounds, tannins, and terpenoids.The detailed evaluation results are shown in Table 2 & Table 3.

Table 2. Result characterization of extract EPE.

Parameter	Results (Mean ± SD)	Requirement
Organoleptic		
• Color	Dark brow	-
• Consistency	Viscous extract	-
• Odor	Characteristic	-
• Taste	Bitter	-
Loss on drying (%)	39.33±1.15	≤ 10%
Moisture content (%)	5.95±0.28	≤ 10%
Specific gravity (g/mL)	0.824±0.00	-
Water-soluble extract (%)	3.33±0.57	≤ 12%
Ethanol-soluble extract (%)	3.97±0.09	≤ 8%

Table 3. Results of phytochemical screening.

Phytochemical group	Method	Result
Alkaloids	Mayer's test	-
Flavonoids	Shinoda test	+
Phenolics & Tannins	Ferric chloride test	+
Saponins	Froth test	-
Terpenoids	Salkowski test.	+
Steroids	Liebermann–Burchard test.	-

Granul evaluation

The evaluation of the gastroretentive tablet granules was conducted in accordance with the requirements of the *Indonesian Pharmacopoeia*. The results showed that all formulations had a moisture content of less than 10%, a Hausner ratio below 1.25, a compressibility index of less than 1%, a flow rate of less than 1 g/s, and an angle of repose of less than 25°. The evaluation results of the tablet granules are presented in **Table 4**.

Table 4. Result of evalution granules gastroretentive tablet.

Evaluation	Result			
	F(1)	F(A)	F(B)	F(AB)
Water content (%)	4.17±0.05	5.63±0.64	5.64±1.28	6.38±1.13
Hausner ratio	1.08±0.00	1.10±0.00	1.04±0.02	1.08±0.01
Compresibiltas	0.008±0.00	0.09±0.00	0.04±0.02	0.06±0.01
Flow rate (g/s)	0.44±0.01	0.46±0.01	0.52±0.00	0.54±0.00
Reposa angle (°)	11.04±0.12	11.50±0.39	11.48±0.77	10.58±0.78

Tablet evaluation and optimizitation formulas

The Gastroretentive tablet of Ethanol extract formulations were designed using Design-Expert® 10 (Stat-Ease Inc.) with a 2^2 factorial design. A total of four formulations were prepared, and their characteristics are presented in Table 5 and Figure 1.

The results of the analysis of variance (ANOVA) for the nine formulations, obtained using Design-Expert® 10 (Stat-Ease Inc.), are expressed in the following equations:

Y = -0,032+8.88.10^{-3} X_A+0,013 X_B-3.11.10^{-4} X_{AB} .....(1)

Y = +35,344–0,07 X_A-0,333 X_B 4,04.$10^{-3}$$X_{AB}$.....(2)

Y = +18,37–0,89 X_A+0,32 X_B-0,059 X_{AB}.....(3)

Y = +250,51+0,21 X_A + 2,46 X_B+0,15 X_{AB}.....(4)

Y = +20,597–1,142 X_A+0,350 X_B+0,033 X_{AB}.....(5)

Remark:

Y = % friability (equation 1)
= Hardness (equation 2)
= Floating lag time (equation 3)
= Swelling index (equation 4)
= Mucoadhesive time (equation 5)

A = Proportion of HPMC-K4M X_B

B = Proportion of chitosan

Table 5. Analysis results of evalution tablets gastroretentive tablet.

Evaluation	Result			
	F(1)	F(A)	F(B)	F(AB)
Friability (%)	0.11±0.02	0.27±0.03	0.22±0.03	0.31±0.01
Hardness (N)	32.71±4.27	27.10±7.10	31.26±1.16	24.74±0.81
Floating lag time (minute)	26.00 ±5.29	22.00±1.00	35.00±3.51	17.67±1.52
Floating duration time (minute)	>12	>12	>12	>12
Sweeling index (%)	272.87±5.48	333.36±9.18	287.90±1.97	383.62±14.43
Mucoadhesive time (hour)	20.05±0.26	7.88±0.34	27.80±1.19	23.09±0.47

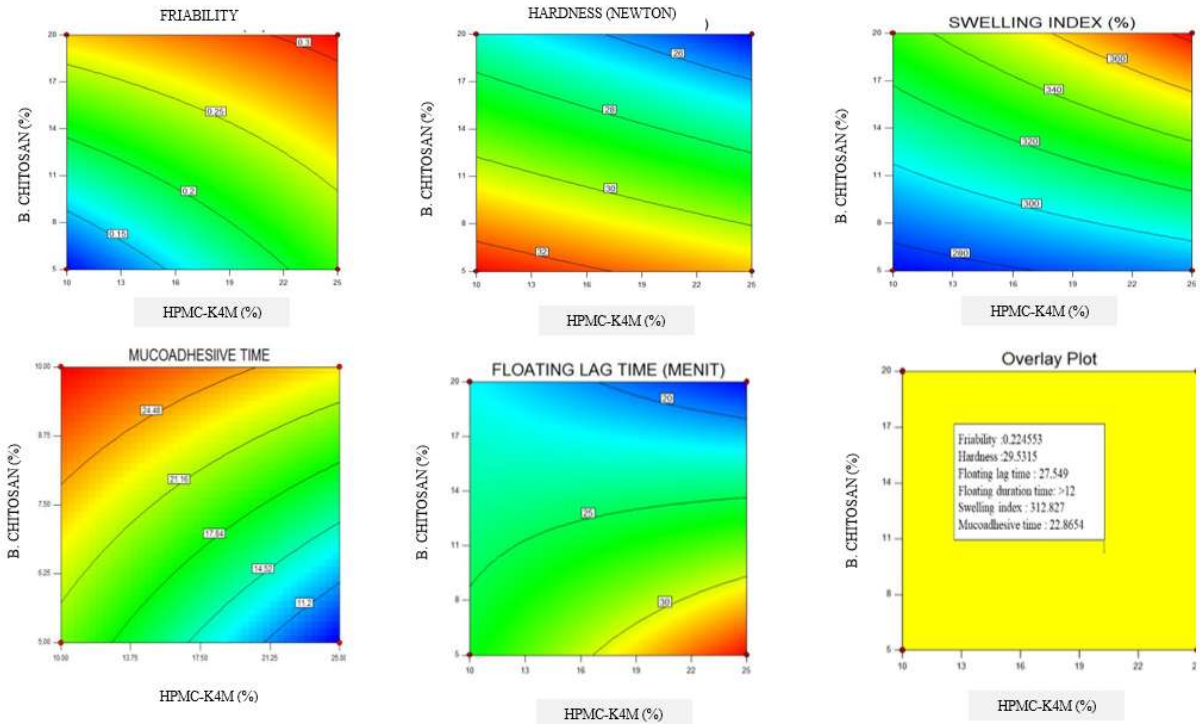

Figure 1. Countor plor of friability, hardness, swelling index, mucoadhesive floating lag time tablets and overlay plot of optimum formula.

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DISCUSSION

Characteristic extract

Characterization of the extract is essential to ensure consistency and quality uniformity, there by supporting the determination of its efficacy and safety. Based on Table 2, The moisture content of an extract is a critical parameter for stability and formulation, as excessive water promotes microbial growth and compromises quality. Ideally, the moisture content should not exceed 10%. A moisture content below 10% is desirable to prevent bacterial or fungal growth in the extract. The determination of loss on drying is intended to quantify volatile components released during heating. This parameter reflects not only the water content but also other volatile substances, such as essential oils and residual solvents.

Water and ethanol soluble extract values reflect the amount of active compounds extracted by polar and non-polar solvents, respectively. Water-soluble extractives represent polar constituents, whereas ethanol-soluble extractives indicate semi-polar to non-polar compounds. The ethanol-soluble extractive value of *Parkia speciosa* leaves extract was higher than the water-soluble fraction, indicating that most active compounds are semi-polar to non-polar in nature, and the results complied with the established requirements.

Based on Table 3, Phytochemical screening represents a qualitative method employed to detect bioactive compounds contributing to a plant's pharmacological activities. The ethanolic leaves extract of Parkia speciosa tested positive for flavonoids, phenols, tannins, and terpenoids during phytochemical screening, as evidenced by specific color changes. Flavonoid positivity was confirmed by an orange to red coloration of the extract solution (Shinoda test), which resulted from the hydrolysis of flavonoid glycosides into aglycones under strong acidic conditions and subsequent complexation with magnesium powder. Terpenoid positivity was carried out by adding chloroform, which serves to extract non-polar components, followed by the addition of concentrated H_2SO_4 to form a complex compound that produces a color change. A positive result for terpenoids was indicated by the development of a red coloration. Tannin positivity was conform when Fe^{3+} ions from $FeCl_3$ interact covalently with hydroxyl groups of tannins, leading to hydrogen displacement and complex formation that produces greenish-blue coloration.

Granul evaluation

Granule evaluation is presented in Table 4. The moisture content of all four formulations complied with the requirement of <10%. Excessive moisture (>10%) may lead to sticking and picking, while overly dry granules can cause compression defects such as cracking and lamination [5], [11].

Evaluation of Hausner ratio and compressibility index showed that all four tablet formulations exhibited excellent flow properties, with Hausner ratios of 1.0–1.1 and compressibility indices below 10%. The smaller the index value and the Hausner ratio the easier it is for granule compressibility to flow and solidify making it even easier to be felted [13].

All formulations exhibited good flowability, with flow rates of less than 1 second and angles of repose below 30°. Faster flow ensures more continuous die filling, thereby minimizing weight variation in the tablets. Four formulations showed excellent flow properties with repose angles below 25°. Smaller angles of repose indicate better flow characteristics, which are influenced by particle shape, size, and adhesion [14].

Tablet evaluation and optimizitation formulas

Equation 1 trough 5 indicates Chitosan factor increased hardness tablet and improve friability, floating lag time, swelling index, and mucoadhesive time meanwhile of HPMC-K4M factor increased hardness, floating lag time, and mucoadhesive time but increases friability, and the swelling index. Friability Based on friablity evaluation, In accordance with the results of the analysis of the effect of the friability HPMC-K4M factors have a positive effect +0.00775, chitosan 0.01275, the negatice effects of their interation -0.0325. Hygroscpic nature and size of HPMC-K4M. resembling fines lead HPMC-K4M to easily bind moisture from the air so it becomes moistand easily fragile [15], [16]. Chitosan is volumeus and there are cavities (pores) when it is in felts (compressed). Cavities (pores) result in tablets become brittle due the mechanical stresses (shock), the pressure when the packaging, storage, and distribution. Result of countor plot (Shown by Figure 1) stated more HPMC-K4M concentration and chitosan can increase friability tablet shown in red area.

The results of the analysis of the HPMC-K4M effect factors have an effect - 5.065, the effect of chitosan - 1.905 and interaction effects of both polymers – 0.455. As well as the evaluation of the friability of the above, HPMC-K4M and chitosan can increase the fragility as the harder the tablet is the smaller is its fragility.

[13]. The interaction effect can reduce the hardness but not for the effect of HPMC-K4M and chitosan. This is because, the combination of these two factors will form a more compact structure due to cavity caused by chitosan will be filled with the fines produced by PMC-K4M. Results of countor plot stated lesser HPMC K4M concentration and chitosan can increase the hardness of the tablet as shown in red areas.

Increasing concentrations of HPMC-K4M lowered floating lag time and increased cedar chitosan improving floating response lag time. In accordance with the analysis of the effects of HPMC-K4M is at -10.665, Chitosan at +2.335, and -6.665 of interaction effects. HPMC K4M is hydrophilic because thehydroksiprofil cluster and hydrogen bonding of the carboxyl group (COO) are soluble so that HPMC-K4M is hydrated and dispersed quickly in the medium. HPMC weight of 0.341 g/cm^3 less than the specific gravity of the hull 1.004 g/cm^3 results in dosage float. Therefore HPMC-K4M has the most influence on the floating lag time [12]. Chitosan is hydrated due to the formation of hydrogen bonding of the amine group of chitosan and hydrogen ions in the medium. Ionization of chitosan in acid medium causes the chitosan to expand along with the increasing volume of preparation [17]. Results of the countor plot stated the more concentration of HPMC K4M there is lesser chitosan can increase floating lag time as shown in the red area. Result countor plot of floating lag time shown at Figure 1.

Increased volume is due to tablet expanding by HPMC-K4M polymer and chitosan could prolong the retention of carbon dioxide gas due to the increased space of carbon dioxide [18]. The increasing volume can reduce the density as density (g/cm^3) is inversely proportional to the volume (cm^3). That's what causes the tablet density to decreases so that it can float and last longer in stomach [19]. From the results of the analysis factorial design of the influences HPMC-K4M and chitosan against brittleness the researcher failed to obtain an equation that states the effects of both polymers. This is because the results of the four formulas have the same value (>12 hours) so it is not known what is the influence of HPMC K4M and chitosan against floating response duration time [19].

Based on the observations, an increased concentration of HPMC-K4M can increase swelling index. The results of the analysis of the effect HPMC K4M and chitosan show that HPMC K4M increase swelling index by +78.105, chitosan amounted to + 32.645, and the effects of the interaction of both factors is +17.615. HPMC-K4M is a matrix that easily disperse and hydrate because the formation of hydrogen bonds and their hydroxypropyl group to form a thick gel layer which causes the tablet to develop and become large and heavy. Ionization of chitosan in acid medium causes the chitosan to expand along with the increasing volume of preparation. The interactions cause an increase in swelling index caused by more and more layers of gel produced by HPMC-K4M and chitosan which cause the tablet to swell and become large and heavy [20], [21]. Results of the countor plot stated more HPMC-K4M concentration and chitosan can increase swelling index as shown in the red area, and it shown at Figure 1.

Based on Figure 1, It shows that the addition of HPMC-K4M decrease the time and the addition of chitosan cause mucoadhesive time to increase. Based on the results of the analysis of the effects of the mucoadhesive time factor it also shows that the effect of chitosan factor increase +11.49 of mucoadhesive time, HPMC amounted to - 8.44 and the interaction of both factors of +3,73. The mechanism of the interaction of chitosan with the mucosa is through electrostatic interaction, hydrophobic bonding, and hydrogen bonding. Among the three bonds, elektrostatick has more frequent interaction. Electrostatic bonding occurred while experiencing protonated amine groups of chitosan into NH3 + and interact with carbohydrate mucosa chain COO [10], [11]. Hydrophobic bonding occurs on non deasetilated cluster residues with the acetyl group on the sialic acid. Hydrogen bonding occurs between nitrogen cluster on chitosan with the hydrogen cluster forming the mucosa. HPMC-K4M has a hydroxylgroup (OH-) that can interact with the mucosal mucin-K4M . HPMC is hydrated slowly so that the interpenetration of hydrophilic polymer chains which expands gradually will form a gel that provides the bonding strength [7], [8]. Results of the countor plot shown at Figure 1 stated more chitosan concentration and less HPMC- K4M increase the mucoadhesive time as shown in the red area.

Formula optimization using factorial design

Result of the countor plot of all responses is combined into an overlay of the plot in order to obtain the concentration of HPMC-K4M and chitosan which generate the best response. From the resulting overlay plot it is obtained that the concentration for HPMC K4M is 20.25% and 10.26% of chitosan. Overlay plot form all analysis shown by Figure 1.

CONCLUSION

Analysis indicated the presence of tannins, terpenoids, and flavonoids in the ethanolic extract, meeting all designated specific and non-specific parameters. Ethanol extract of *Parkia speciosa* formulated gastroretentive tablet with Optimum composition of HPMC-K4M (20.25%) and chitosan 10.26% polymers that provided the best response with increase the swelling index, mucoadhesive time and decrease friability, hardness, and floating lag time. The results indicate an increase in gastric residence time and improved drug bioavailability in the stomach.

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REFERENCES

[1] F. Fitrya, A. Amriani, R. P. Novita, A. Ahmadi, and R. Nabilah, "Efektifitas Ekstrak Etanol Polong Petai [Parkia speciosa Hassk.] sebagai Anti Ulcer Pada Tikus Wistar yang Diinduksi Etanol Absolut," *J. Sains Farm. Klin.*, vol. 9, no. 1, p. 64, 2022, doi: 10.25077/jsfk.9.1.64-70.2022.

[2] N. A. Fithri, Fitrya, T. Shabrina, A. Akbari, and D. Yulanri, "Antioxidant Activity Analysis and Standardization of Parkia speciosa (Petai) Pods Ethanol Extract," *Sci. Technol. Indones.*, vol. 4, no. 1, pp. 5–10, 2019, doi: 10.26554/sti.2019.4.1.5-10.

[3] T. Samrit *et al.*, "Ethanolic extract of Parkia speciosa pods exhibits antioxidant and anti-inflammatory properties in lipopolysaccharide-induced murine macrophages by inhibiting the p38 MAPK pathway," *Heliyon*, vol. 10, no. 20, p. e39641, 2024, doi: 10.1016/j.heliyon.2024.e39641.

[4] A. K. Azemi, M. L. Nordin, K. A. Hambali, N. A. Noralidin, S. S. Mokhtar, and A. H. G. Rasool, "Phytochemical Contents and Pharmacological Potential of Parkia speciosa Hassk. for Diabetic Vasculopathy: A Review," *Antioxidants*, vol. 11, no. 2, pp. 1–14, 2022, doi: 10.3390/antiox11020431.

[5] S. S. Y. H. R. Kehar Singh, "A Review On Gastro Retentive Drug Delivery System: Novel Approach With The Future Perspectives," *Int. J. Pharm. Sci.*, vol. 02, no. 06, pp. 606–621, 2024, doi: 10.5281/zenodo.11550881.

[6] E. V. Blynskaya, S. V. Tishkov, V. P. Vinogradov, K. V. Alekseev, A. I. Marakhova, and A. A. Vetcher, "Polymeric Excipients in the Technology of Floating Drug Delivery Systems," *Pharmaceutics*, vol. 14, no. 12, pp. 1–25, 2022, doi: 10.3390/pharmaceutics14122779.

[7] N. Nurhalifah, P. D. Sundawan, S. C. Veronita, S. I. Puji Destria, S. Nuryamah, and N. Yuniarsih, "Literature Review Article: Drug Delivery System Held in the Stomach (Gastroretentive)," *J. Soc. Res.*, vol. 2, no. 1, pp. 126–133, 2022, doi: 10.55324/josr.v2i1.472.

[8] A. Ainurofiq *et al.*, "Chitosan as floating-mucoadhesive polymers in gastroretentive drug delivery," *Sci. Eng. Heal. Stud.*, vol. 17, 2023, doi: 10.69598/sehs.17.23010002.

[9] V. Kumar, S. Somkuwar, and A. K. Singhai, "A recent update on gastro retentive drug delivery systems," vol. 27, no. February, pp. 125–144, 2024.

[10] M. A. D. S. S. and P. F. Iqbal, "World Journal of Pharmaceutical research FORMULATION," *SJIF J.*, vol. 2, no. 5, pp. 1685–1703, 2021, doi: 10.20959/wjpr202415-33309.

[11] G. Anusha, R. Sunayana, M. Ponnam, and B. A. Kumar, "Asian Journal of Pharmaceutical Research and Development," *Asian J. Pharm. Res. Dev.*, vol. 8, no. 6, pp. 77–80, 2020.

[12] S. Chauhan, S. Tyagi, P. Maan, G. Noida, and U. Pradesh, "International Journal of Newgen Research in Pharmacy & Healthcare Volume-1, Issue-2, December 2023 www.ijnrph.com," no. 2, pp. 129–134, 2023.

[13] K. Vinchurkar, J. Sainy, M. A. Khan, S. Mane, D. K. Mishra, and P. Dixit, "Features and Facts of a Gastroretentive Drug Delivery System-A Review," *Turkish J. Pharm. Sci.*, vol. 19, no. 4, pp. 476–487, 2022, doi: 10.4274/tjps.galenos.2021.44959.

[14] J. Riyanto, L. Lutojo, and S. Sunarto, "Aplikasi Penggunaan Konsentrat Pemacu Pertumbuhan untuk Penggemukan Sapi Potong di Karanganyar," *PRIMA J. Community Empower. Serv.*, vol. 4, no. 1, p. 7, 2020, doi: 10.20961/prima.v4i1.37988.

[15] S. A. Nitave, V. A. Patil, and A. A. Kagalkar, "Review on gastro retentive drug delivery system (GRDDS)," *Int. J. Pharm. Sci. Rev. Res.*, vol. 27, no. 2, pp. 90–95, 2014, doi: 10.33772/pharmauho.v7i1.11693.

[16] S. Jain and B. Srinivasan, "An Insight on the Strategical Approach of Gastro-retentive Drug Delivery System," *Pharm. Sci*, vol. 3, no. 2, pp. 34–54, 2023.

[17] N. Nurfitriyana, H. Harmita, and I. Iskandarsyah, "In vitro study of a transfersomal gel preparation containing lynestrenol as a transdermal drug delivery system," *Int. J. Appl. Pharm.*, vol. 12, no. Special Issue 1, pp. 242–244, 2020, doi: 10.22159/ijap.2020.v12s1.FF052.

[18] R. Malasiya and T. P. Shukla, "Formulation development and evaluation of gastroretentive mucoadhesive tablets of glimepiride using natural polymers," *J. Drug Deliv. Ther.*, vol. 10, no. 4-s, pp. 153–159, 2020, doi: 10.22270/jddt.v10i4-s.4264.

[19] R. Khan, "Int J Pharm Bio Sci 2013 Apr; 4(2): (P) 630-646 Gastroretentıve Drug Delıvery System-A Revıew," vol. 4, no. 2, pp. 630–646, 2013, [Online]. Available: www.ijpbs.net

[20] H. Chinthaginjala, G. C. Barghav, C. M. Reddy, B. Pradeepkumar, and H. Abdul Ahad, "Formulation and in vitro Evaluation of Floating Tablets of Dicloxacillin Sodium Using Different Polymers," *J. Young Pharm.*, vol. 11, no. 3, pp. 247–253, 2019, doi: 10.5530/jyp.2019.11.51.

[21] M. Rahamathulla, N. Alam, U. Hani, Q. Ibrahim, and Y. Alhamhoom, "Development and in vitro evaluation of effervescent floating matrix tablet of neritinib: An anticancer drug," *Pak. J. Pharm. Sci.*, vol. 34, no. 4, pp. 1297–1303, 2021, doi: 10.36721/PJPS.2021.34.4.REG.1297-1303.1.