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Original Article

FORMULATION AND PHARMACOKINETIC DETERMINATION OF GALLIC ACID IN *EMBLICA OFFICINALIS*

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ABSTRACT

Objective: The present work was to formulate oral herbal tablets of *Emblica officinalis* extract and also with pure gallic acid, further to determine the dosage frequency through pharmacokinetic profiles obtained for the same.

Methods: The *Emblica officinalis fruits* were suitably extracted and the concentration of gallic acid in *Emblica officinalis* extract was estimated by HPTLC (High-Performance Thin Layer Chromatography) with a comparison to pure form. Tablets were prepared with extract and synthetic form through direct compression technique by varying the process and formulation parameters. The formulated tablets were administered to rabbit models and their pharmacokinetic profile was studied after withdrawing blood samples through HPLC (High-Performance Liquid Chromatography).

Results: The concentration of gallic acid in *Emblica officinalis* was found to be 8.21%. The pre and post compression parameters evaluated for the formulated batches found to be within the pharmacopoeial limits. The *in vivo* pharmacokinetic studies conducted in rabbit models showed that there were no significant differences with p-value between the pharmacokinetic data obtained for pure and extract gallic acid tablets. The C_{max} was found to be 4.59±0.95 µg/ml in the extract form which was little low when compared to the pure form of 6.38±1.08 µg/ml. The $t_{1/2}$ in the extract form was 6.0±0.33 h, whereas it was 4.92±0.36 h in the pure form of gallic acid.

Conclusion: The *Emblica officinalis* extract tablet showed average $t_{1/2}$ of 6 h, so about every 6 h one tablet compared to 4 h of $t_{1/2}$ for pure gallic acid tablet can be the dosing frequency for the rabbit.

Keywords: *Emblica officinalis*, Gallic acid, Pharmacokinetics, dosing frequency.

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INTRODUCTION

Herbal drugs have been in use by different civilizations in different parts of the world for centuries to fight a large number of diseases. Many of these are in common use even today. With the emerging interest in the world to adopt and study the traditional system and to exploit their potentials based on different healthcare systems, the evaluation of the rich heritage of the traditional medicine is essential [1]. To reveal the active compounds of herbal medicines, in addition to chemical and pharmacological studies, pharmacokinetic study of herbal medicines is an important and necessary approach to elucidate the status and changes of active components in herbal medicines in the body, to explain and predict a series of events related to their efficacy and toxicity and finally to provide a firm basis for design of reasonable doses of clinical applications and pharmacological experiments [2]. So far, for most herbal medicines some basic and principal pharmacokinetic parameters of the isolated compounds have been reported but they were not linked or compared to the corresponding data in the whole herb and or herbal extract [3]. A significant shortcoming of this approach is that interactions among different ingredients cannot be observed only individual components are investigated, further, more pharmacokinetic data are usually available on only one or two ingredients which in most cases are markers rather than the main active principles in the investigated herbal medicines. This may mislead the interpretation of mechanisms of action, dosage design, and therapeutic monitoring during clinical applications of herbal medicines [4].

With the emerging interest in the world to adopt and study the traditional system and to exploit their potentials based on different healthcare systems, the evaluation of the rich heritage of the traditional medicine is essential. In conventional medicines, most remedies consist of synthetic drug preparation. Since herbal formulations consist of natural plant material and not a synthesized chemical, herbal remedies are less likely to cause unpleasant side effects than conventional pharmaceutical drugs. Thus, herbal remedies are précised safer, gentler and lower costing than conventional drugs [5-7].

Emblica Officinalis is a botanical that has been used since ancient times in Hindu and Ayurvedic traditional medicine. The fruit of the plant has been traditionally used for medicinal purposes and contains the active constituent gallic acid. The active constituent is an antimutagenic, anticarcinogenic and anti-inflammatory agent [8, 9].

This paper reports a comparative pharmacokinetic study on the formulation of oral herbal tablets of *Emblica officinalis* in extract form which was compared with the pharmacokinetic profile of the pure gallic acid formulation, which may be a reference to increase the efficacy, safety and quality for further research. Knowledge of herbal pharmacokinetics can provide valuable information to aid Practitioners in prescribing herbs safely and effectively. It may also enable useful predictions for dosing frequency based upon their half-life.

MATERIALS AND METHODS

Materials

Emblica officinalis fruit was purchased from Annai Agencies (voucher no: AA4621), Ooty, Nilgiri District, Tamilnadu and authenticated by a Botanist from Central Council for Research in Ayurveda and Siddha, Tirunelveli, Tamilnadu. Gallic acid was purchased from Preet Remedies (Baddi). All other chemicals were of analytical grade.

Extraction of gallic acid

The *Emblica officinalis* fruits obtained were washed cut into pieces and the seeds were removed. Then the fruit was dried in shade for about 15 d and powdered. The powdered *Emblica officinalis* (10 gm) was extracted for 24 h with 100 ml of methanol using a shaker at 25 °C and filtrated through 0.45 mm membrane filter paper. The residue was then extracted twice with 100 ml methanol. The combined methanolic extracts were concentrated by using a water

bath maintained at 40 °C. The residue was freeze-dried and then stored in an amber colored air-tight container at 40 °C, before further use [8, 9].

Quantification of the extract by HPTLC

The extract of gallic acid was quantified using standard drugs at 273λmax of (CAMAC Linomat, iv, Switzerland) after the development of pre coated plates of 4*10 cm size (silica gel 60F 254, 6. Merck).

Preparation of samples

The extract (100 mg) was weighed and dissolved in methanol. The flask was shaken for 30 min and then filtered through Whatman filter paper and the final volume was made up to 10 ml with methanol.

Preparation of standard solutions

Weighed 100 mg of extract was dissolved in 10 ml of methanol. From this 1.0 ml was diluted to 20 ml with methanol to produce 0.5 mg/ml. The standard drugs solution were also prepared at a concentration of 0.5 mg/ml with methanol in a similar manner and used for the analysis.

Application of standard and sample solutions

For the application of the solutions, pre-coated plates of 4 x 10 cm size (Silica gel 60 F 254, E. MERCK) were used. The standards and the sample solutions were applied on different tracks of the plate. A thin band of 6 mm width was applied using Linomat IV (automatic TLC applicator, CAMAG, Switzerland).

Chromatogram development and densitometric scanning

After the development of the chromatogram through twin-trough chamber, the plates were taken out, dried and observed under UV light. The suitable solvent system selected for the quantification of gallic acid was toluene: ethyl acetate: formic acid in the ratio of 7:5:1 v/v for the development of chromatogram. The developed plates were scanned using densitometer at 273 nm wavelength. The quantification of the gallic acid was calculated concerning standard solution [10].

Formulation and evaluation of tablets

Tablets of both synthetic gallic acid (300 mg) and the extract (equivalent to 3.2,8.4 mg of Gallic acid) were compressed (rotary tablet compressor, ten stations, Rimek, Ahmedabad, India) using 121 nm standard concave punches by direct compression technique with varying the process and formulation parameters. All the powder mass was passed through the BSS-80 mesh and geometrically mixed in a polyethylene bag for 10 min. Then lubricant (aerosil) was added and mixed for an additional 5 min and then compressed. Prior the compression, the powder mixture evaluated for angle of repose, bulk density, compressibility index and drug content. Table 1 gives the formula of different batches [11, 12].

Precompression parameters

The powder mixtures were studied for an angle of repose, bulk and tapped density, compressibility index, and drug content. The angle of repose was determined by funnel method using the below formula where h and r were the height and radius of the powder cone.

$$\text{Angle of repose} = \tan^{-1}(h/r) \quad (1)$$

Table 1: Formula for the formulation of *Emblica officinalis* extract and gallic acid tablets

S. No.	Ingredients	Pure gallic acid tablets (mg)	*Emblica officinalis* extract tablets (mg)
1	Gallic acid	300	-
2	*Emblica officinalis* Extract	-	400 (Equivalent to 32.84 mg of Gallic Acid)
3	Starch 1500	150	50
4	MCC	26	26
5	Croscarmellose	20	20
6	Aerosil	4	4

The bulk and tapped density were determined by taking the known quantity of slightly shaken powder mixture. These samples were, introduced to 50 ml measuring cylinder to record the bulk density. This is then allowed to fall under its weight onto a hard surface from the height of 2.5 cm at 2 sec interval. The tapping continued until no further change in volume was observed. The density was calculated based on the weight of powder to the volume occupied by it. The compressibility index was determined by analyzing the quantity of quinine extracted into phosphate buffer pH3 spectroscopically at λmax of 225 nm and expressed regarding percentage.

$$Compressibility\ index(\%) = 100(TD - BD) \div TD \quad (2)$$

Where TD and BD represent tapped and bulk density respectively.

Post-compression parameters

Post compression parameters like weight variation (n=20), drug content (n=10), friability (n=tablet to whole weight of 6.2g), disintegration time (n=6) and hardness was determined. The test for post compression parameters except hardness performed as per IP 2007. The drug content estimated for individual tablets. The hardness and friability were calculated using Monsanto hardness tester (Cadmach, Ahmedabad, India) and friability testing apparatus (Indian equipment, Mumbai, India). Then represents the number of tablets used for the test [13-15].

***In-vitro* drug release**

The dissol**u**tion medium consisted of 900 ml of phosphate buffer pH 7.2, and the study was carried out for 90 min for the developed formulation maintained at 37 °C±0.5 °C. The drug release at different time intervals was measured by HPLC (Shimadzu) at 225 λ max. It made clear that none of the ingredients used in the matrix formulations interfered with the assay. The release studies conducted in triplicate and the mean values plotted versus time [16-18].

Pharmacokinetic studies

Animals

Experiments were carried out on New-Zealand white rabbits of either sex 1.5±0.2 kg (mean±SD). The animals had overnight fasted before treatment but had free access to tap water. None subject was receiving any other drug at least two weeks before commencement of the study and no other drug permitted throughout the duration of the study. They randomly assigned into six groups (3 animals per group). Two groups received Gallic acid tablets, and two groups received *Emblica officinalis* extract tablets and one group as control. All experiments adhered to the institutional animal's ethics committee (JSSCP/IAEC/Projects/01/2008-09).

Administration and Collection of blood samples

The dose for the study taken was 35 mg and 70 mg of gallic acid from gallic acid tablets and extract tablets respectively calculated according to body weight and body surface area of rabbit with the help of conversion factor with the absolute human dose. The rabbits received the dose orally through an intragastric tube as 0.3% w/v CMC suspension. Blood samples (1 ml) were collected in heparinized tubes from the marginal ear vein at 0, 0.5, 1, 2, 4, 6, 8, 12, 24 h after the drug administration. The samples centrifuged at 3500 rpm for 10 min to separate the plasma and they were transferred into airtight containers and stored at-20±0.2 °C until analyzed [20].

Preparation of plasma samples

The gallic acid extracted from plasma samples (1 ml) obtained from study subjects by the addition of 200 µl of perchloric acid to precipitate plasma proteins. The resulting solution was vortexed for 5 min and centrifuged at 4000 rpm for 10 min. The supernatant layer was separated and analyzed by using Shimadzu gradient HPLC system [10].

Determination of gallic acid in plasma

The gallic acid extracted from plasma samples and the supernatant layer was separated and analyzed by using Shimadzu gradient HPLC system with LC-20 AD 230V Solvent delivery system (Pump), Manual Injector 25 µl (Rheodyne), SPD-M20A 230V Photo diode array detector and LC solutions data station. Separation achieved at room temperature on a Phenomenex Gemini C18 (250x4.6 mm i.d., 5µ) column. The mobile phase was a mixture of water and acetonitrile 97.5:2.5 v/v. The flow rate was 1.0 ml/min. The detection was done at 254 nm using SPD 20AD Diode Array Detector.

Statistics

All data expressed as mean value±standard deviation (SD). Statistical analysis was performed using ANOVA test (Tukey's test). Mean differences considered as statistically significant at a level of $p<0.05$.

RESULTS AND DISCUSSION

The extract of gallic acid from *Emblica officinalis* fruit done with methanol at 25 ^{0}C for 24h then filtered. The residue was then extracted twice with 100 ml methanol then the methanolic extracts were combined and concentrated at 40 ^{0}C, then freeze dried. The obtained extract was quantified for gallic acid by HPTLC with a comparison to the peak area obtained for 0.5 mg/ml methanolic solution of pure Gallic acid. The application volume of extract and the synthetic solution was 5 µl respectively.

The pre-coated plates developed using mobile phase consisting of toluene: ethyl acetate: formic acid in the ratio of 7:5:1 v/v was scanned by densitometer at the wavelength of 273 nm. The result is shown in table 2, with the obtained peak area at Rf value of 0.73±0.2 it estimated that 8.21% of the gallic acid is present in the Emblica officinalis extract.

Table 2: Quantification of gallic acid in the herbal extract by HPTLC

S. No.	Sample	Rf	Peak area	Gallic acid (%w/w)
1	Extract	0.73	1975.3	
2	Gallic acid	0.17	1741.5	8.21

Rf= Retention factor

The pure drug and the extract powder mixed with excipients in the geometrical pattern for 10 min and to confirm the uniform distribution of the drug the degree of mixing was carried. The drug content was 98.57 and 92.26% in case of pure drug and extract respectively. The further mixing led to demixing in the case of the pure drug, and no significant change was seen in the extract.

The angle of repose gives a qualitative assessment of internal and cohesive-frictional forces. All the batches had an angle of repose less than 31 ° indicating good flow potential. The size and shape of the particles reflect the density of the material. The density is directly proportional to the number of spherical particles present whereas inversely to the size of the particles**.** As the value of compressibility is less than 15% in all the cases, the granules produced the adequate flow and stable packing. Table 3 shows the results of precompression parameters.

Tablets of synthetic and extract were compressed by direct compression technique and the table 4 displaces their post compression parameters. The hardness of all the formulations was between 5.92 to 5.45±0.78 kg. The other parameters such as average weight, friability disintegration was found to be within limits. The drug content also showed more than 90% in both pure and extract tablets. MCC was used as binder cum diluent in the formulation as is widely used and croscarmellose used as the super disintegrant. The aerosil was used at the concentration of 2% as it can nullify the use of additional lubricant as it can serve both as glidant and lubricant in a case of direct compression. Various trials have been done, and only the optimized batch formula is given in table No 1. With the satisfactory post compression parameters, the *in vitro* release studies were carried out in 900 ml of Phosphate buffer pH 7.2. The *in vitro* dissolution study was carried out for 90 min and the drug release at different time intervals was measured by HPLC at 225 nm. The *in vitro* release graph is shown in fig. 1 [16-18]. It was observed at the end of 90 min the release was about 99% in pure gallic acid tablets and 88 % in extract tablets.

A single dose study, for two concentrations (drug equivalent to 35 mg and 70 mg) of *Emblica officinalis* extract and pure gallic acid, were carried out in five groups, containing three rabbits in each group, for each concentration of the formulations. The plasma samples were analyzed by reverse phase HPLC (Shimadzu UFLC LC20AD) with chromatographic conditions as water and acetonitrile in the ratio of 97.5:2.5 % v/v as mobile phase and phenomena.

Table 3: Precompression evaluations for *Emblica officinalis* Extract and pure gallic acid blend

S. No.	Parameters	Pure gallic acid blend	*Emblica officinalis* extract blend
1	Angle of repose (^{0} degree)	26.45±1.56	30.74±1.98
2	Bulk density(g/cm3)	0.48±0.05	0.52±0.07
3	Tapped density (g/cm3)	0.59±0.07	0.62±0.08
4	Compressibility (%)	13.49±1.45	14.58±1.94
5	Drug content (%)	98.57±1.78	94.26±1.53

Values represent mean±SD, n=3.

Table 4: Post compression evaluations for tablets

S. No.	Parameters	*Emblica officinalis* extract tablets	Pure gallic acid blend tablets
1	Average weight (mg)	499.25±2.96	497.12±2.56
2	Hardness (Kg/cm2)	5.92±0.25	5.45±0.78
3	Friability (%)	0.362±0.035	0.826±0.07
4	Disintegration (minutes)	10.33±0.82	3.45±0.69
5	Drug content (%)	90.45±1.39	97.72±1.83

Values represent mean±SD, n=3.

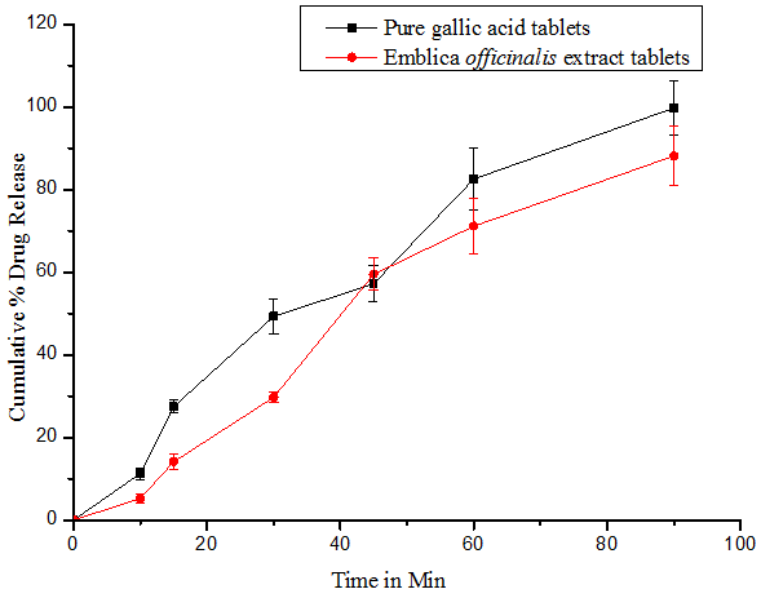

Fig. 1: *In vitro* dissolution plots of *Emblica officinalis* extract and Gallic acid tablets, Results are given in mean of triplicate

Table 5: Pharmacokinetic parameters of *Emblica officinalis* extract and pure gallic acid tablets

S. No.	Parameters	Average of two doses	
		***Emblica officinalis* extract**	**Pure gallic acid**
1	C_{max}(µg/ml)	4.59±0.95	6.38±1.08
2	T_{max} (h)	1.5±0.53	1.75±0.78
3	K_{eli} (h^{-1})	0.116±0.38	0.140±0.03
4	t ½(h)	6.0±0.33	4.92±0.36
5	$AUC_{(0-24)}$ (µg. h/ml)	29.65±1.01	79.80±1.75
6	$AUC_{(0-\infty)}$ (µg. h/ml)	32.60±1.02	82.38±1.40
7	Lag Time(t_0)	No	No

Values represent mean±SD, n=3, C_{max}-Peak plasma concentration, t_{max}-Time to attain C_{max}, k_{eli}-Elimination rate constant, $t_{1/2}$-Half-life AUC-Area Under Curve, (t_0)-Lag time

Gemini phase C18 (250x4.6 mm, i.d. 5µ) as a stationary phase. The flow rate of mobile phase set at 1 ml/min, and the samples detected by LC solutions as the data station at 225 nm. The quantification of the chromatogram was performed using peak area ratios (response factor) of the drug to the internal standard. Table 5 provides the various PK parameters estimated by PK1 and PK2 software. The values present in the table represent the average values of two doses. From the results, it observed that all the Pharmacokinetic parameters determined showed a slight increase with the pure gallic acid tablets, but half-life was found to be comparatively high in extract tablets. The pharmacokinetic data obtained for the pure and the extract showed no significant difference which confirmed by application of one-way ANOVA followed by Tukey test [19-22].

DISCUSSION

After the quantification of the *Emblica officinalis* extract, it was observed that 8.21% of the gallic acid is present in the *Emblica officinalis* extract. The preparation of tablets involves two basic techniques a) direct compression b) wet compression. The techniques have their advantages and disadvantages. The limitation of wet granulation is its cost. It is an expensive process because of labor, time, equipment, energy and space requirements, Loss of material during various stages of processing; Stability may be the major concern for moisture sensitive or thermo labile drugs, an inherent limitation of wet granulation is that any incompatibility between formulation components made us opts for direct compression. The leeway of the technique was minimized loss of mixing quantity for moisture sensitive material and improved disintegration since powder particles are not bonded together by a binder. The excipients in this study are common, used to formulate tablets. The MCC was used as a diluent, croscarmellose as the super disintegrant, aerosil as a glidant and lubricant. In the process of product development, some of the chemicals were added, omitted or varied in concentrations. The MCC is used as binder cum diluent in the formulation as is widely used in both the cases. But some researchers reported that MCC could sustain the release of the drug, to overcome this Croscarmellose used as the super disintegrant at the concentration of 5% w/w. At the concentration of 26 mg, the MCC provided the satisfactory post compression results in both pure and extract form. The aerosol was used at the concentration of 2%w/w which can nullify the use of additional lubricant as it can serve both as glidant and lubricant. The other post compression parameters like Average weight, friability, disintegration, and drug content were found to be within limits. As the hardness increased the disintegration time prolonged, the increase in hardness may be due to inbuilt nature of the extract. With the optimized batch, the *in vitro* release was found to be satisfactory. The pharmacokinetic parameters for both the extract and the pure formulation were, evaluated directly after oral administration of them into the stomach of rabbits. The study was, carried to evaluate the difference in the PK parameters between the two formulations. The pharmacokinetic data obtained for the pure and the extract showed no significant difference.

CONCLUSION

The pharmacokinetic data obtained for the pure and the extract had no significant difference which was confirmed by application of one-way ANOVA followed by Tukey test. The pharmacokinetic data obtained for pure and extract Gallic acid shows no significant difference in Cmax at Tmax. The *Emblica officinalis* extract tablets

showed an average $t_{1/2}$ of 6 h and about every 6h one tablet (equivalent to a min of 35 mg of gallic acid) compared to 4 h of t1/2 for pure Gallic acid tablet can be administered to the selected animal model as the dosing frequency. Further multiple dose studies are required to determine the exact dosage regimen.

CONFLICT OF INTERESTS

Declared none

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