

Comparative spectrophotometric evaluation and forced degradation study of caffeine in tablet and green tea extract

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ABSTRACT

Caffeine is used in worldwide as a central nervous system stimulant and its natural herbal source such as green tea also act as a central nervous system stimulant due to presence of caffeine. The present study aimed to perform a comparative UV spectrophotometric analysis of caffeine in a marketed tablet (cafergot) containing caffeine and ergotamine and in green tea extract. Absorbance were measured at 273 nm using UV spectrophotometer, with distilled water as blank and 1cm path length of cuvette. The absorbance of green tea extract was found to be higher than that of tablet solution under identical experimental conditions . This increased absorption maybe due to caffeine or to the presence of other UV absorbing phytochemicals, which are abundant in green tea and show absorption in the same wavelength region. Forced degradation studies were performed to evaluate the stability of caffeine under acidic , basic and heat conditions. The result demonstrate that caffeine remains stable in acidic conditions and thermal conditions showing no significance change in absorbance for both tablet and green tea extract samples . however under alkaline conditions , a slight decrease in absorbance was observed in tablet samples, indicating partial degradation . while tea extract showed higher absorbance due to possible matrix interference . These findings confirm that caffeine exhibits greater stability in acidic medium compared to alkaline medium. This study demonstrate that UV spectrophotometry is a simple , rapid, and cost effective method for comparative analysis of caffeine in pharmaceutical and herbal. The findings highlights the importance of considering phytochemical interference when analyzing herbal products and support the applicability of spectrophotometric methods in comparative study between herbal source and its marketed tablet form.

Keywords: caffeine , herbal source, UV spectroscopy .

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INTRODUCTION

Caffeine is a naturally occurring alkaloid which is used for its central nervous system stimulant effects. It is present in various natural sources such as tea, coffee, and green tea and also used in pharmaceutical formulations such as in the management of migraine, fatigue, and some related conditions. In pharmaceutical preparations caffeine is often combined with other active ingredients, such as ergotamine, to enhance therapeutic efficacy. due to its pharmacological importance and vast use, caffeine shows its absorbance at 273nm in spectrophotometry. [1-3]

Green tea, obtained from the leaves of *Camellia sinensis* is a commonly used herbal product which contain caffeine along with other naturally occurring constituents like polyphenolic compounds etc. it is use due to its health benefits in dietary and therapeutic applications.[4-10]

UV-Visible spectrophotometry is a most common analytical technique in pharmaceutical analysis due to its simplicity, rapidity, and cost effectiveness. it is based on the beer-lambert law, which correlates absorbance with concentration. Caffeine show its absorbance in the ultraviolet region,

around 272-273 nm, which makes UV spectrophotometry suitable for its detection and comparative estimation. This technique is commonly use in daily routine of pharmaceutical quality control and laboratory analysis [11]. Stability studies or Forced degradation studies are important to evaluate the chemical behaviors of compounds under various stress conditions, including acidic, alkaline and thermal conditions. Caffeine, considered chemically stable, however, its stability maybe affected by PH and temperature variations. Forced degradation studies which include acid and basic hydrolysis and thermal stress, provide important information regarding the stability profile and degradation behavior. Thermal stress helps to get the effect of temperature on compounds stability, which is important for appropriate storage and handling conditions determination. These studies are particularly important when comparing caffeine in pure pharmaceutical formulations and natural sources such as tea extracts, as plant matrices which is complex than tablet formulations, may influence the analytical response. Therefore, stability assessment of caffeine under acidic, alkaline and heat stress

conditions was performed to ensure stability of caffeine in these conditions [12].

The present study perform a comparative spectrophotometric analysis of caffeine by using marketed pharmaceutical tablet formulation and green tea extract from herbal source which is green tea leaves using UV-Visible spectrophotometry . This study aims to evaluate and compare the analytical response of caffeine from pharmaceutical and herbal sources under identical experimental conditions [13-16] .

METHODOLOGY

Caffeine tablet contain 100mg caffeine and 1mg ergotamine (brand name :cafergot)

Dried Green tea leaves obtained from herbal source

Chemicals and reagents were used (0.1 N HCL and 0.1N NAOH and distilled water)

All these equipment were used [UV –Visible spectrophotometer,volumetric flask , pipettes , water bath, Filter paper(Whatman No. 1)]

Sample preparation

Tablet Sample :

1 tablet which contain 100mg caffeine and 1gram ergotamine crushed and dissolved in 100ml distilled water, its concentration is 0.1% w/v as (1gram in 100ml) then this

solution was filtered through Whatman no.1 filter paper . then 10ml were taken and dissolved in 100ml volumetric flask and volume was makeup by distilled water , now its concentration is 0.01% , then to make 0.001% again 1 ml was taken from previous dilution of 0.01% and dissolved in 10ml volumetric flask and make up the volume by distilled water. [13, 17]

Green tea sample :

3.5 gram of green tea leaves were weighed and added to 100 ml distilled water in beaker then this mixture is heated for 15 minutes on medium flame to facilitate extraction of caffeine ,after heating this solution is filtered to get extraction from green tea leaves . 10 ml were taken from this extracted solution and added to 100ml distilled water , then 1 ml were taken from this dilution and added in 10ml distilled water to make 0.001% solution [18, 19]

UV –spectrophotometric analysis :

The absorbance of both solutions was measured by using UV – spectrophotometer at wavelength of 273nm which is wavelength of caffeine . for both samples distilled water were used as Blank and for reference . with their absorbance values of their previous solutions initial dilutions were also recorded for comparison [19, 20].

Forced degradation / stability studies :

This study is performed to evaluate caffeine stability under acid stress , basic stress and thermal stress conditions [21].

Acidic stress:

1ml of both samples were taken from the dilution of 0.01% and added into 10ml volumetric flask and makeup the volume by 0.1N HCL for both , tablet sample and tea extract sample and then these solutions were kept for 30 minutes at room temperature [22].

Basic stress:

1ml of samples of tea extract and tablets sample were taken from their 0.01 % dilution and added into 0.1N NaOH in 10 ml volumetric flask . [23]

Thermal stress :

10 ml from the 0.001% dilution was placed in water bath for at 60°C for 30 minutes .After cooling to room temperature , its absorbance were measured in 273nm

After keeping All solutions (for acid stress and basic stress) for 30minutes at room temperature then their absorbance were noted .[24]

higher extractable caffeine concentration in sample of green tea or maybe the presence of additional UV absorbing phytochemical like catechins, polyphenols, and flavonoids . In comparison of tablet which has pure caffeine , green tea extract is a complex matrix which contain many chromophoric compounds that shows their wavelength in this analysis.

Table 1:Absorbance of sample and standard

	S.NO	Tablet sample (0.001%)	Green tea extract sample (0.001%)
Absorbance at 273nm	1	0.418	0.58
	2	0.412	0.572
	3	0.424	0.588
Mean	0.418		0.58
S.D	0.006		0.008

Table 2:In forced degradation study :

Condition	Sample	Reading 1	Reading 2	Reading 3	Mean	S.D
For Acidic stress	Tablet	0.511	0.505	0.517	0.511	0.006
	Green tea	0.58	0.572	0.588	0.58	0.008
For Basic Stress	Tablet	0.401	0.395	0.407	0.401	0.006
	Green tea	0.786	0.774	0.798	0.786	0.012
For Thermal stress	Tablet	0.411	0.405	0.417	0.411	0.006
	Green tea	0.521	0.513	0.529	0.521	0.008

RESULTS

In this initial analysis

green tea extract showed higher caffeine absorbance than tablet .it maybe due to

Under acidic condition:

Both sample showed similar absorbance as of initial absorbance which show no degradation in samples and caffeine

remained stable in acidic condition. Caffeine has a ring structure which resist acid hydrolysis. this observation confirms excellent acid stability of caffeine in both samples[25].

Under basic condition

Tablet sample showed almost no degradation but slightly decrease in absorbance which means caffeine showed slightly degradation in alkaline conditions and for green tea extract , it showed higher absorbance than initial absorbance . the larger rise in this sample suggest that plant matrix compound either release more caffeine or generate chromophoric degradation products when exposed to base or maybe due to additional alkaline soluble compound in extract that also absorbed at same wavelength released from plant matrix . In green tea ,phenolic and some other compounds also present so maybe ionization of those compounds increased its absorbance or their structural changes can also lead to higher absorbance[26].

Under thermal condition

both samples showed no degradation in absorbance means caffeine indicating good thermal stability

CONCLUSION

This study successfully carried out the comparative evaluation of caffeine tablet with its herbal source by spectrophotometric analysis along with its stability studies under different stress conditions . UV visible spectrophotometry at wavelength 273nm proved to be rapid, simple and reliable method for detection and comparative analysis of caffeine . The results confirms the presence of caffeine in both samples but slightly higher in Tea sample under normal conditions . Forced degenerative study shows that caffeine exhibit good stability under acidic condition . under alkaline conditions, tablet sample remains stable while green tea extract shows higher absorbance which maybe due to chromophoric degradation substance or matrix relative effects . overall study demonstrates that caffeine is chemically stable under tested conditions and UV spectrophotometry can be applied for comparative analysis because it is simple , rapid, and cost effective, although selective quantification in herbal samples may require more specific techniques such as high performance liquid chromatography (HPLC). The findings highlights the importance of considering phytochemical or matrix interference when analyzing herbal products

or natural products .This method can be utilized for quality control and stability assessment of caffeine containing products.

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