Original Research Article

UV-SPECTROPHOTOMETRIC AND FIRST-ORDER DERIVATIVE METHODS SIMULTANEOUS DETERMINATION OF PARACETAMOL, IBUPROFEN, AND CAFFEINE IN BULK AND CAPSULES

ABSTRACT

Aims: this work is to develop accurate and simple spectrophotometric methods with the first derivative for estimation of Ibuprofen (IBU), Caffeine (CAF) and Paracetamol (PAR) in bulk and pharmaceutical preparation.
Method: the methods use ethanol 90%: 0.1 N sodium hydroxide (25:75) as a solvent for analysis work. The wavelengths were determined for each drug in the range of 200-400 nm in spectrum mode. UV-spectrophotometer-equipment used to calculate the first derivatives through which IBU, CAF, and PAR were evaluated for simultaneous assay. The validity of the methods is established on the basis of linearity, accuracy and precision, limit of detection and limit of quantification. The methods applied to estimate the level of PAR, IBU, and CAF in a capsule dosage form.
Results: The linearity of the methods was in the range of (1 - 15) µg /ml at λ max 220 nm for IBU, for CAF was (1-10) µg /ml at λ max 272 nm, and for PAR was (1-16.5) µg /ml at λ max 257 nm. In the second method, by application of first derivatives, IBU has an absorbance at 212 NM (in contrast CAF and PAR have zero value at is this wavelength) whereas, CAF absorbed at 272 nm (in contract IBU and PAR have zero value at this wavelength) whereas PAR has absorbance at 230 nm (in contrast IBU and CAF has zero value). Upon derivative assay, the amount was 98.58 %, 98.15% and 98.66% for PAR, IBU, and CAF, respectively.
Conclusion: the suggested methods can be effectively applied for simultaneous determination of IBU, CAF and PAR in the bulk and capsule dosage form with good precision, recovery and less percentage of error.

Keywords: Ibuprofen, Paracetamol, Caffeine, First order derivative, UV- spectrophotometry.

1. INTRODUCTION

Ibuprofen (IBU) is (RS) – 2-(4-(2 methyl propyl) phenyl) propionic acid [1] (Fig.1), non-steroidal anti-inflammatory drug (NSAIDs).it acts by inhibition of cyclooxygenase 2 (COX-2), therefore, It is recommended in many conditions such as controlling of mild to moderate pain and inflammation as in dysmenorrhoea, migraine, dental pain, postoperative pain, muscle and joint syndrome [2].

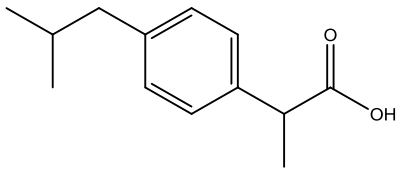

Fig. 1: Chemical structure of Ibuprofen (IBU)

Paracetamol or Acetaminophen (PAR), is an N-(4-hydroxyphenyl) acetamide (Fig. 2). It is classified as a non- steroidal anti-inflammatory drug as a result of its inhibition of prostaglandin production [3]. It has analgesic and antipyretic activity. It is frequently presented in combination with other drugs, for example, in cough medications [4]. Or in opioid analgesic medication [5, 6], PAR is typically given orally or rectally, but is also accessible intravenously.

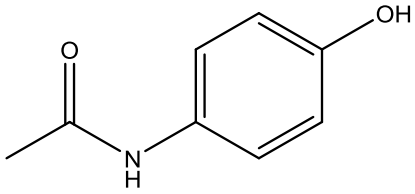

Fig.2: Chemical structure of paracetamol (PAR)

Caffeine (CAF) is a trimethylxanthine derivative (Fig. 3). It is naturally standing up from several plants, including coffee beans, cocoa beans, and tea. CAF is considered as a central nervous stimulant that produces a state of wakefulness and raises the mental activity [7]. It also increases the incidence and depth of respiration by stimulation of the respiratory center [8]. These three ingredients (PAR, IBU and CAF) have been introduced in combination dosage form to meliorate the analgesic activity [9] or used separately with other pharmaceutical components.

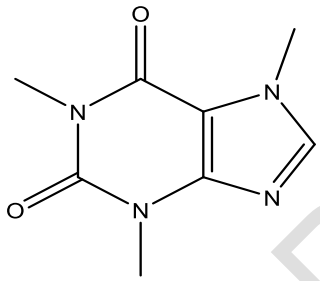

Fig.3: Chemical structure of Caffeine (CAF)

Numerous analytical methods have been described for estimation of IBU, PAR, and CAF alone or in combination with other active ingredient, such as HPLC [10- 22], electrochemical method [23- 27], volumetry [28], GC-MS [29- 31], UV - visible spectrophotometric analytical methods [32-37].

Moreover, there are limited works which based on chemometric analysis for simultaneous determination of these three drugs in pharmaceutical dosage forms using UV-visible spectrophotometry [38, 39]. In recent times, the determination of binary or ternary mixture that has been accomplished by derivative spectrophotometry was lunched to be a useful method in determination of drugs without the interference effect of the formulation matrix by employing the zero-crossing method [40- 42].

So, the aim of this work is to develop a reliable, precise, simple, linear, accurate, sensitive and effective method for simultaneous determination of Ibuprofen, Caffeine and Paracetamol in the ternary mixture and multi-component dosage form.

2. MATERIAL AND METHODS

2.1 Chemicals and Reagents

2.1.1 Pure Drugs

Active therapeutic ingredients of PAR (purity 99.5%), IBU (purity 99.5%), CAF (purity 99.5%) were kindly offered by Sammara drug industries SDI, Sammara, Iraq.

2.1.2 The solvents

Ethanol solvent 90% and sodium hydroxide NaOH 100% were supplied by HIMEDIA, India. Ethanol 90 % and 0.1 M NaOH (25:75) was selected as a solvent for developing spectral characteristics of drugs. . Distilled water was prepared in laboratories of the faculty of pharmacy.

2.1.3 NO Pain® Capsules

Pharmaceutical dosage form NO Pain® Capsules (Vitane Pharmaceuticals, Inc) containing paracetamol 325 mg, Ibuprofen 200 mg, and caffeine 30 mg was obtained from the local market.

2.2 Instrumentations

SHIMADZU- 1800 UV-visible spectrophotometry (Kyoto, Japan) equipped with a 1.0 cm quartz cell, supported by UV Probe 2.32 software has been used for spectrophotometric measurements. Analytical balance for weightings (Germany).

2.2 Preparation of Standard Stock Solution

A standard stock solution of (100 µg/ml) for each pure PAR, IBU, and CAF were prepared separately by accurately weighing about 0.01 g of each drug, then dissolving in 25 ml of 95% Ethanol solvent, transferring into 100 ml volumetric flask and diluting to the mark with the 0.1 M NaOH. These solutions were employed as working standard stock solutions used for further study.

2.3 Preparation of Sodium Hydroxide Solution (0.1 M)

NaOH solution 0.1 M was prepared by weighing 2.0 g of the reagent and dissolving in 500 ml volumetric flask using distilled water.

2.4 Preparation of the Powder Mixture

Starting from the previous standard stock solutions (100 µg/ml), standard solutions containing (10 µg/ml, 1.5 µg/ml and 16.5 µg/ml, ,) were prepared in 50 ml volumetric flask by diluting three volumes (5 ml , 0.75 ml, and 8.25 ml) of IBU, CAF, and PAR, respectively. Then, these solutions made up to the mark with the solvent (25 ml of 95 % Ethanol and 75ml of 0.1 M NaOH). These diluted solutions were employed for further analysis.

2.5 Procedure for Pharmaceutical Preparation

Ten commercial capsules (No Pain capsules), containing IBU 200 mg, CAF and PAR 325 mg, 30 mg, were weighted and grounded well to produce a powder. An accurately weighed amount of this powder equivalent to, 1.0 mg of IBU and 0.15 mg of CAF, 1.625 mg of PAR dissolved in solvent (25 ml of 95 % Ethanol and 75 ml of 0.1 M NaOH), mixed well and transfer to 100 ml volumetric flask and complete to the mark with the same solvent. the resulting solution was filtered using Whatman filter paper No. 41, to eliminate any insoluble material, then , the filtrate was transmitted to 100 ml volumetric flask and the solution made up to the mark with the previous solvent. The sample solution of the final concentration of 10.0 µg/ml of IBU, 1.5 µg/ml of CAF and 16.5 µg/ml of PAR was scanned between 200 nm and 400 nm against a reagent blank (25 ml of 95% Ethanol and 75 ml of 0.1M NaOH). The first derivative spectrum was recorded and the absorbance was measured at 212 nm, 230 nm, 272 nm for IBU, CAF, and PAR, respectively. The concentration of each analyte was determined by the equations generated from the calibration curves of corresponding drugs.

3. RESULTS AND DISCUSSION

3.1 Selection of Analytical Wavelength

Via suitable dilutions of the working standard stock solution, the solutions were scanned separately in the wavelength region of 400-200 nm versus the reagent blank. It was found that the λ max was 220 nm, 272 nm and 257 nm for IBU, CAF, and PAR, respectively.

The absorption spectrum adapted to first -order derivative using the spectrum mode at (200-400 nm) and it was observed that IBU was absorbed at 212 nm whereas PAR and CAF show absorbance at 230 nm and 272 nm, respectively. The absorbance of PAR and CAF was zero at wavelength 212 nm. Thus, 230 nm and 272 nm were selected as working wavelengths for PAR and CAF and for IBU, working wavelength selected was 212 nm for first derivative spectroscopy. The results are shown in (Fig. 4-11).

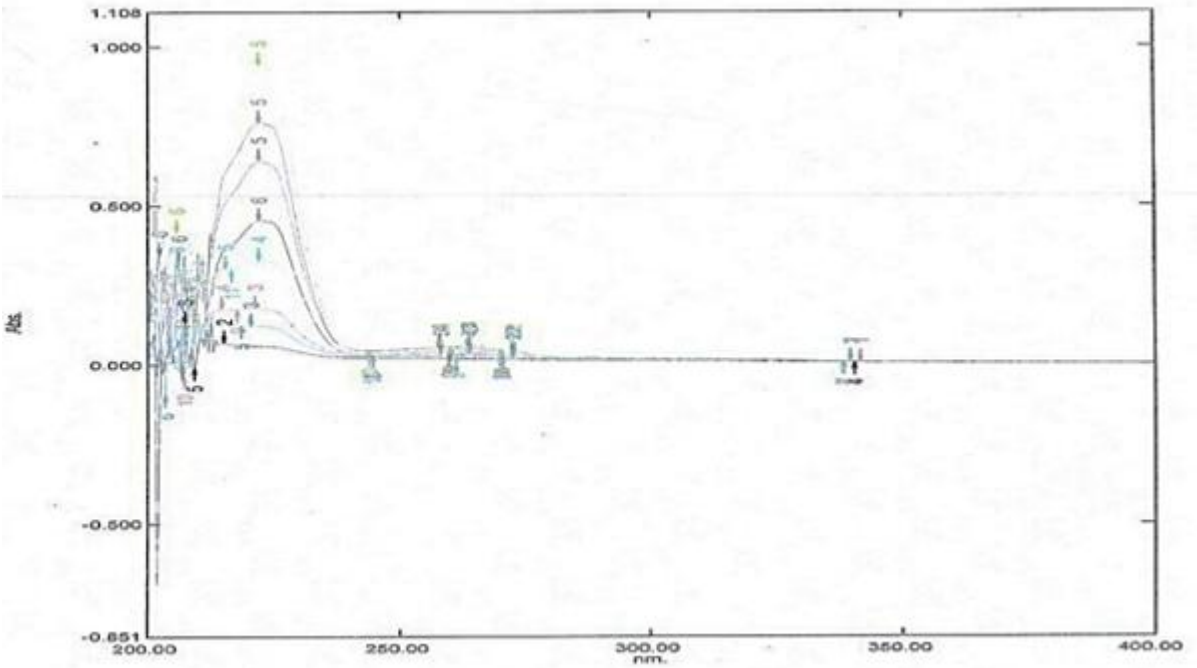

Fig. 4. UV absorption spectra of series of IBU at λmax= 220 nm

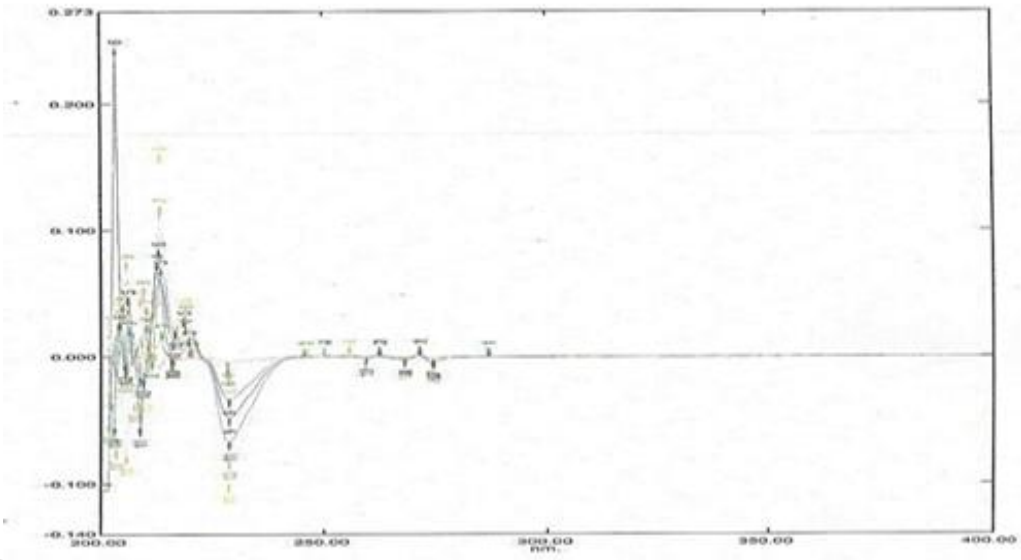

Fig. 5:.First order derivative absorption spectra of IBU at λ max= 212 nm

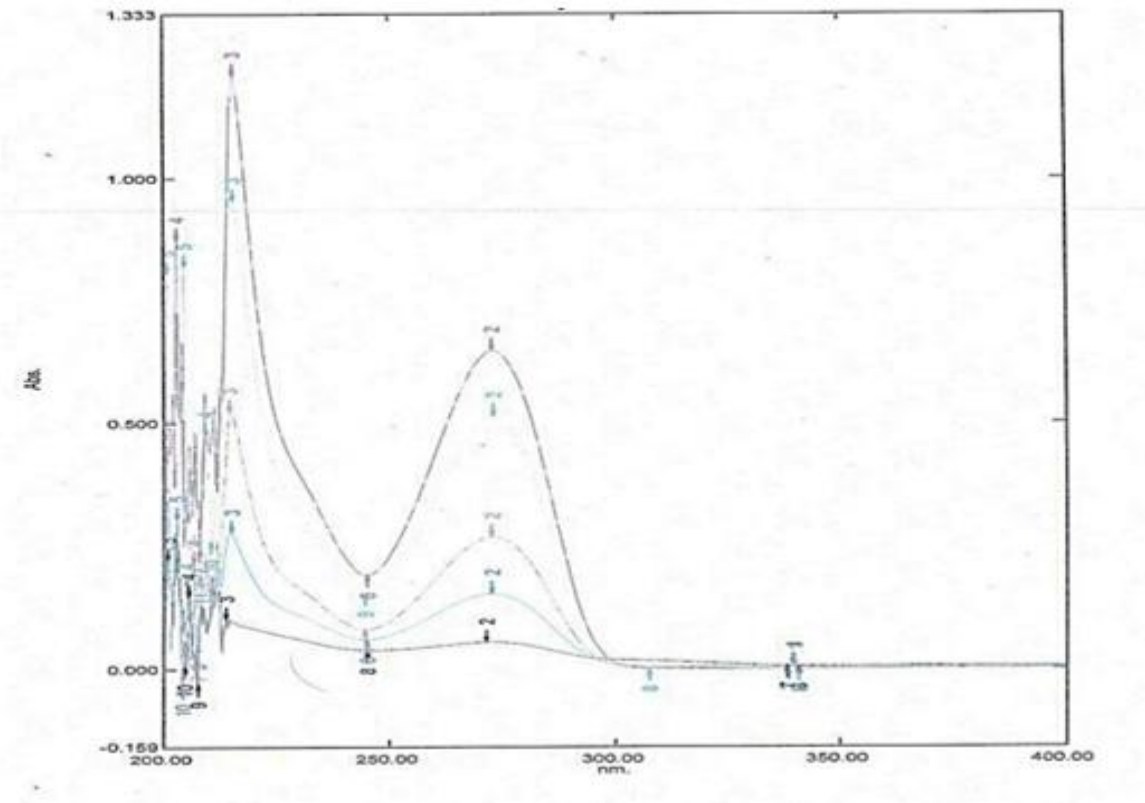

Fig. 6: UV absorption spectra of CAF at λmax= 272 nm

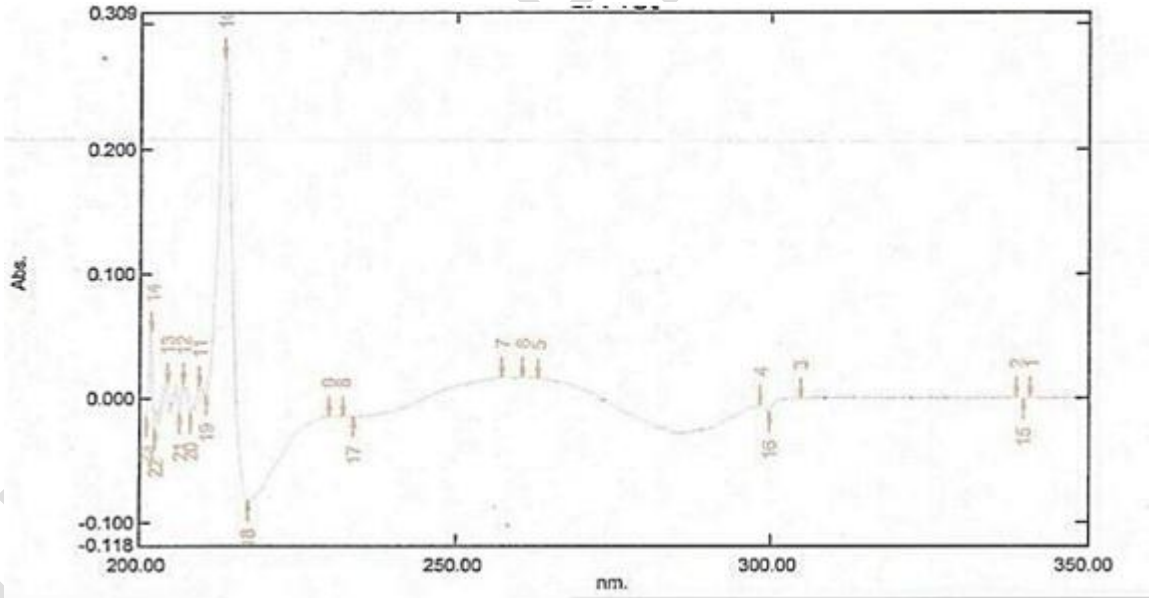

Fig. 7: First order derivative absorption spectra of CAF at λmax= 272 nm

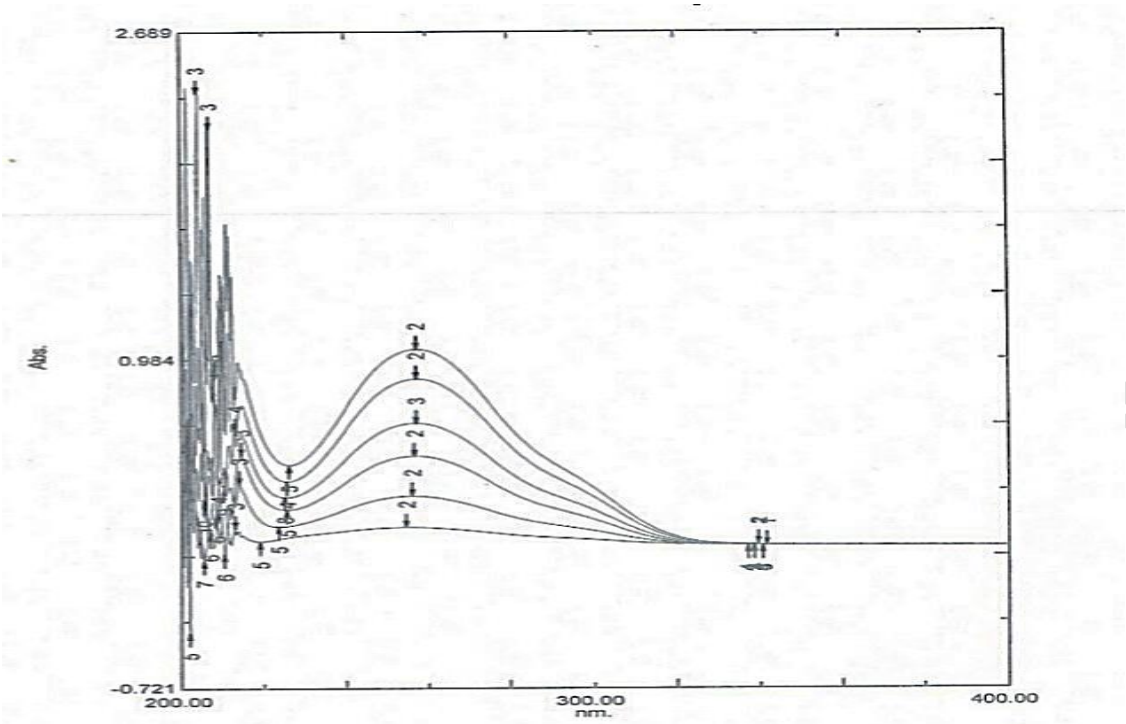

Fig. 8: UV absorption spectra of PAR at λmax= 257 nm

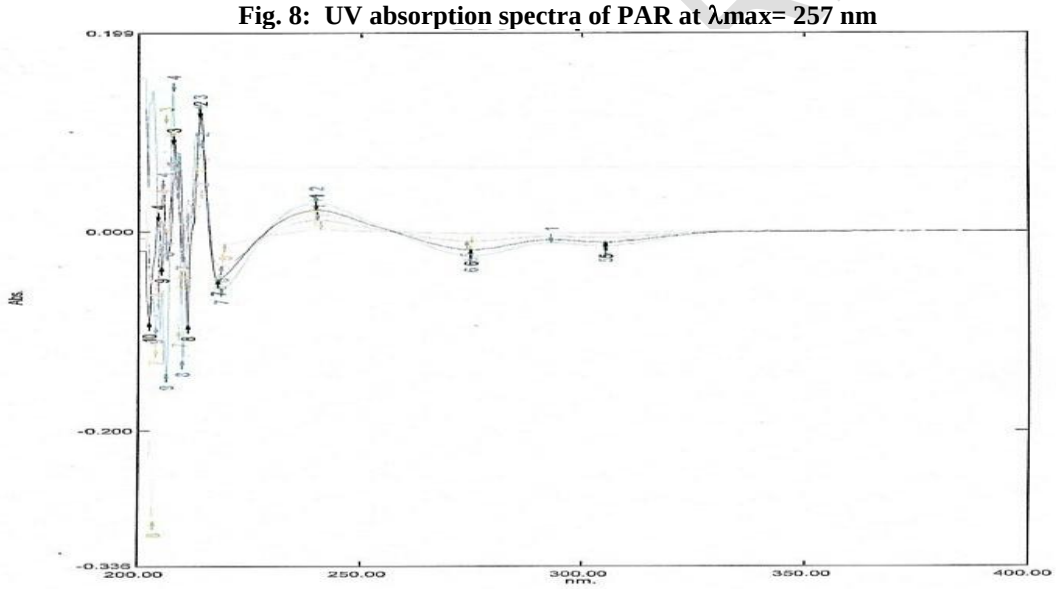

Fig. 9: First order derivative absorption spectra of PAR at λmax= 230 nm

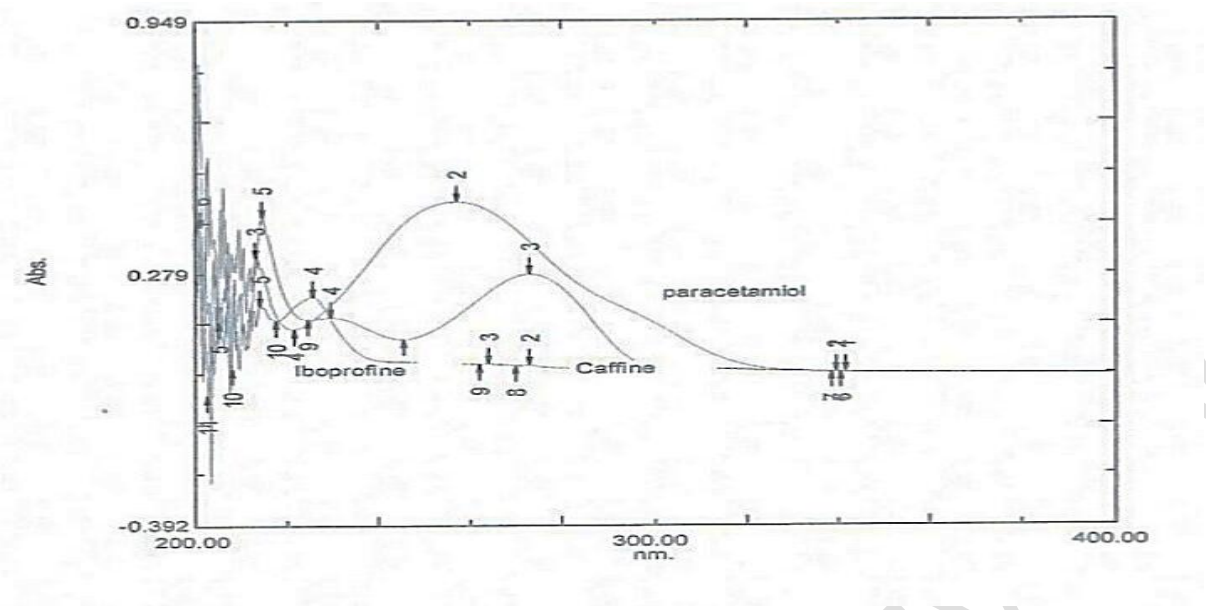

Fig.10: The overlay UV spectrum 10.0 µg/ml IBU, 1.5 µg/ml CAF and 16.5 µg/ml PAR

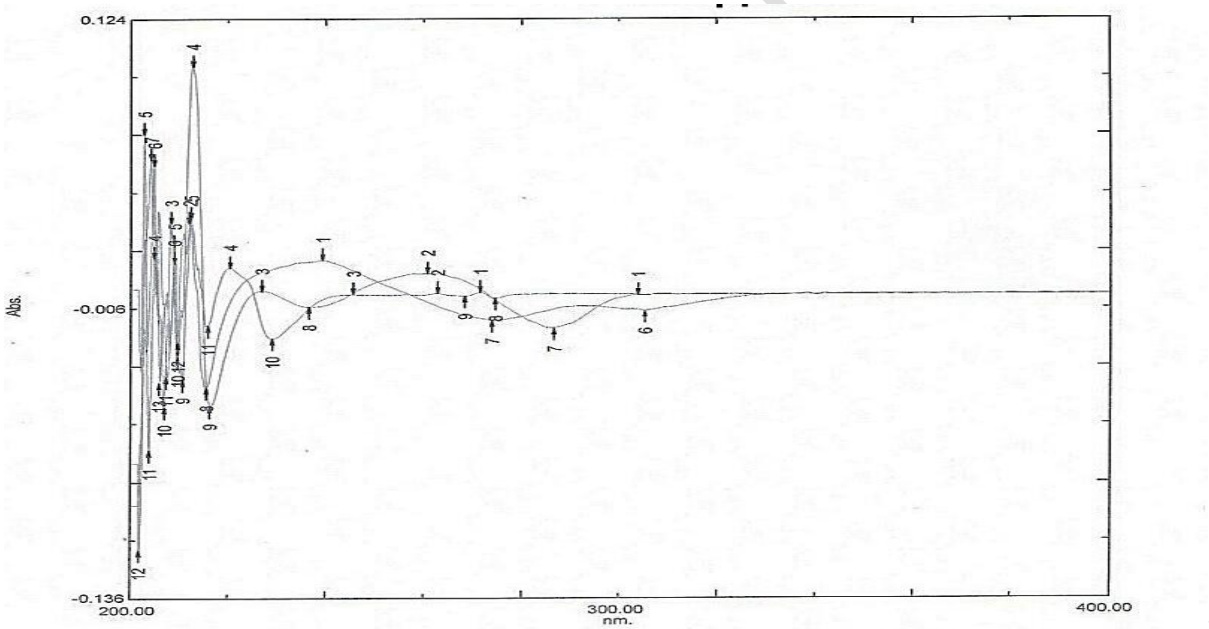

Fig. 11: First order derivative overly of UV spectra of 10.0 µg/ml IBU, 1.5 µg/ml CAF and 16.5 µg/ml PAR

3.2 Calibration Graph

The linearity was obtained by diluting an accurate volume of stock solution (100 µg/ml) of each drug to make a different concentration set of IBU (1-15 µg/ml), CAF (1-10 µg/ml) and PAR (1-16.5 µg/ml). The absorbance was measured at a range of 200-400 nm, and the first derivative of the spectrum was taken. The derivative was measured for each of these solutions at the working wavelength and plotted against concentration to obtain the calibration curve as shown in (Fig.12, 13, 14, 15, 16 and 17).

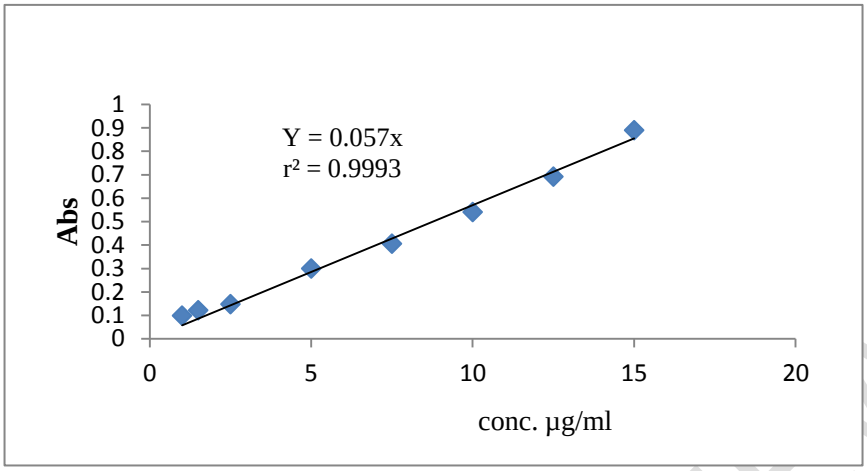

Fig. 12: Calibration curve of IBU at 220 nm

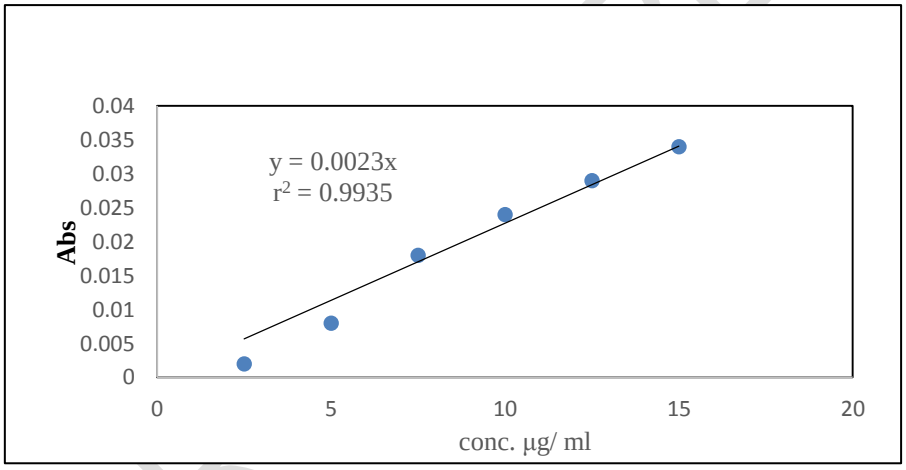

Fig. 13: First order derivative calibration curve of IBU at 212 nm

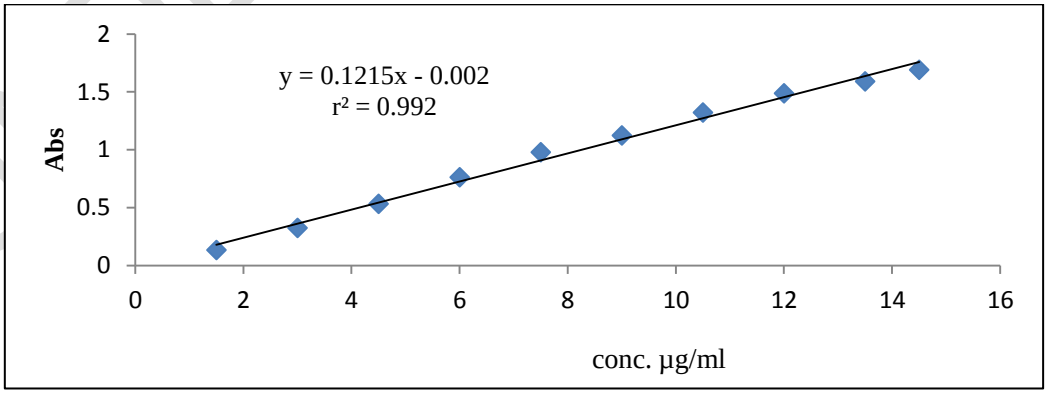

Fig. 14: Calibration curve of CAF at 272 nm

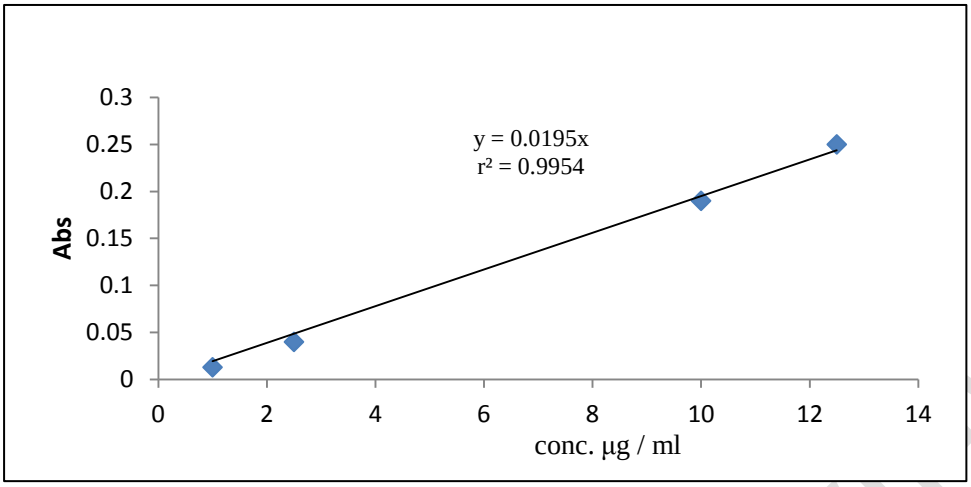

Fig.15: First order derivative calibration curve of CAF at 213 nm

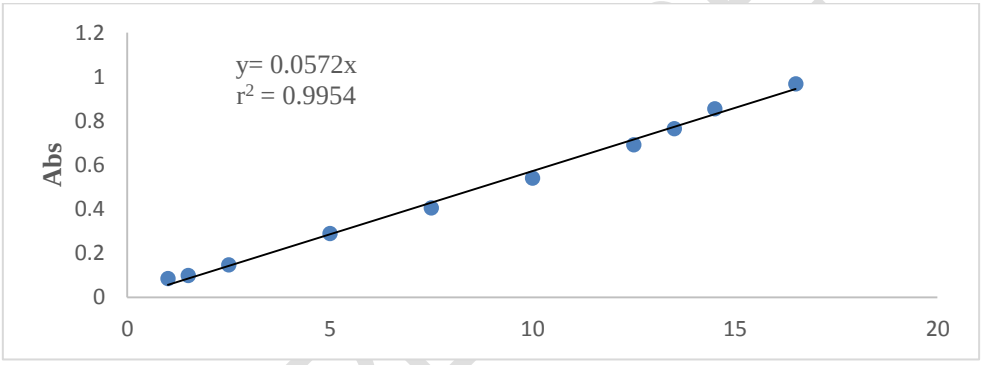

Fig. 16: Calibration curve of PAR at 257 nm

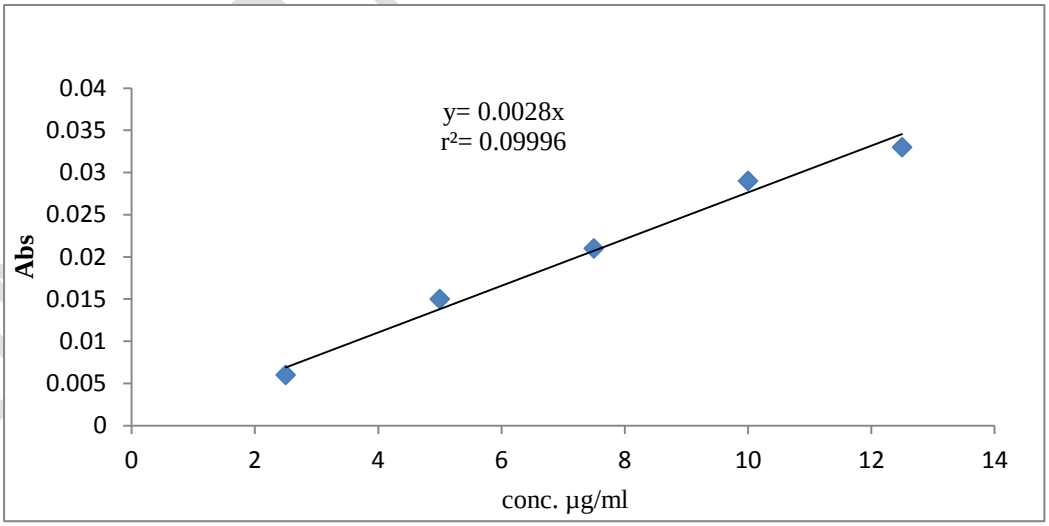

Fig. 17: First order derivative calibration curve of PAR at 230 nm

3.3 The Validation of the Methods

Parameter	IBU	CAF	PAR

Method validation parameter's like linearity, accuracy, precision, limit of detection and limit of quantification were accomplished for pure powder mixture and capsule dosage form.

3.3.1 Linearity

The linearity of the anticipated methods was estimated by regression analysis of the calibration graphs. The results acquired from zero and first-order derivative explain that the methods applied were linear within concentrations range in construction of the calibration curve, with their regression coefficient (r^2) all nearly to one. Based on the standard deviation SD and the slop of the calibration curve, Limit of quantification LOQ and limit of detection LOD were calculated. The results are listed in Table 1.

Table 1: optical analytical parameters of proposed methods

λ max.(nm) **First method** **First-order derivative**	**220** **212**	**272** **272**	**257** **230**
Linearity (μg/mL) **First method** **First-order derivative**	**1-15** **1-15**	**1-10** **1-13**	**1-16.5** **2-13**
Regression equation **First method** **First-order derivative**	**Y=0.057x** **Y=0.0023x**	**Y=0.1215x-0.0022** **Y= 0.0195x**	**Y=0.0572x** **Y=0.0028x**
Correlation coefficient (r^2) **First method** **First-order derivative**	**0.9993** **0.9935**	**0.9920** **0.9954**	**0.9954** **0.9996**
Slope **First method** **First-order derivative**	**0.057** **0.0023**	**0.1215** **0.0195**	**0.0572** **0.0028**
Intercept **First method** **First-order derivative**	**000** **000**	**-0.002** **000**	**000** **000**
LOQ (μg/mL)	**2.105**	**0.987**	**2.097**
LOD (μg/mL)	**0.631**	**0.2962**	**0.629**
Recovery %	**99.13**	**100.18**	**99.7**
RSD %	**1.27**	**1.15**	**0.91**

3.3.2

Accuracy and precision

The accuracy of these proposed methods was estimated by recovery studies. The accuracy of the analytical method was measured for a series of seven replicates of three levels of concentration PAR, CAF, and IBU. The recovery percentage (98-99.6 %) and (98-100%) for the first method and second method, respectively indicate that these methods are accurate with an acceptable error. The precision was signified by the percent relative standard deviation RSD %. The RSD % calculated is less than 2 which show that the methods used are highly precise for estimation of these ingredients in pure form and in the pure mixture. The results are summarized in Table 2, 3, 4 and 5.

Table 2: Statistical validation for Paracetamol at different levels of concentrations

Conc. Taken μg/mL	Conc. Found* μg/mL	Error%*	R.S.D%*	Recovery%*
2	1.98	1%	0.97	99%
6	5.95	0.83%	0.94	99.16%
10	10.1	1%	0.89	101%

*: mean of seven determinations, RSD: relative standard deviation

Table 3: Statistical validation for Ibuprofen at different levels of concentrations

Conc. Taken μg/mL	Conc. Found* μg/mL	Error%*	R.S.D%*	Recovery%*
2.0	1.98	1%	1.21	99%
8.0	7.94	0.75%	1.31	99.25%
14.0	13.88	0.85%	1.29	99.14%

*: mean of seven determinations, RSD: relative standard deviation

Table 4: Statistical Validation for the Caffeine at different levels of concentrations

Conc. Taken μg/mL	Conc. Found* μg/mL	Error%*	R.S.D%*	Recovery%*
2.0	2.01	0.5%	1.12	100.5
6.0	5.99	0.17%	1.13	99.83
9.0	9.02	0.22%	1.21	100.22

*: mean of seven determinations, RSD: relative standard deviation

Table 5: Statistical validation for the standard mixture

Conc. Taken μg/mL	Conc. Found* μg/mL	Error%*	R.S.D%*	Recovery%*
Ibuprofen				
1.5	1.49	0.77	0.9	99.33
6.0	5.89	1.83	1.1	98.16
Caffine				
1.5	1.48	1.33	0.87	98.66
6.5	6.44	0.92	1.12	99.07

Paracetamol				
2.5	2.47	1.2	0.98	98.8
8.5	8.42	0.94	1.23	99.09

3.3.3 Limit of detection and limit of quantitation

On the basis of standard deviation, intercept and slope, limit of detection LOD and Limit of quantitation LOQ were estimated using formula LOQ= 10 σ /S and LOD= 3.3 σ/S, where, σ is the standard deviation of the response and S is the slope of the calibration curve of a sample. Analysis of the LOQ and LOD values which are shown in Table 1 for the proposed methods was indicated a good precision.

3.4 Application

The accuracy of the formulated product was confirmed by recovery studies from capsules at different concentration levels, the mean percentage recoveries were found (98.00-100 %) as shown in Tables 4 and 5. These methods were successfully applied to the analysis of No pain capsule.

3.4.1 Analysis of (No pain)® capsules formulation:

A sample solution of final concentration containing 10.0 µg /ml of IBU, 1.5 µg/ml of CAF and 16.25 µg/ml of PAR, were analysed using suggested methods and the absorbance was measured at 230 nm, 212 nm and 272 nm for PAR, IBU, and CAF, respectively (Fig.18 and Fig.19). The concentrations of PAR, IBU and CAF were estimated using calibration curve. The results are shown in Table 6.

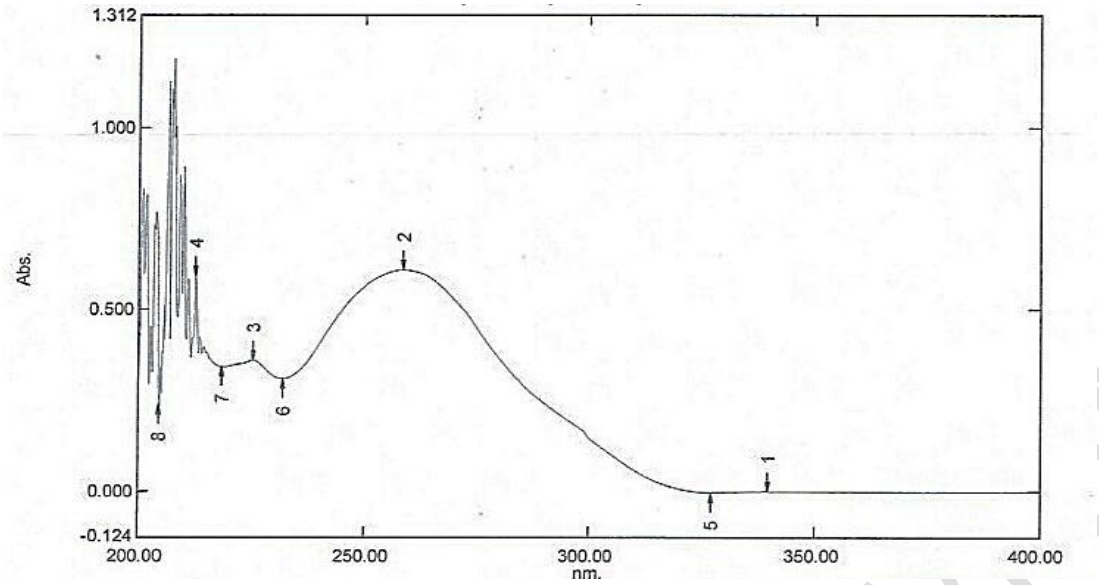

Fig.18: Absorption UV spectra of sample No Pain the UV spectrum of (16.5 µg/ml, 10.0 µg/ml and 1.5 µg/ml) of PAR, IBU and CAF, respectively

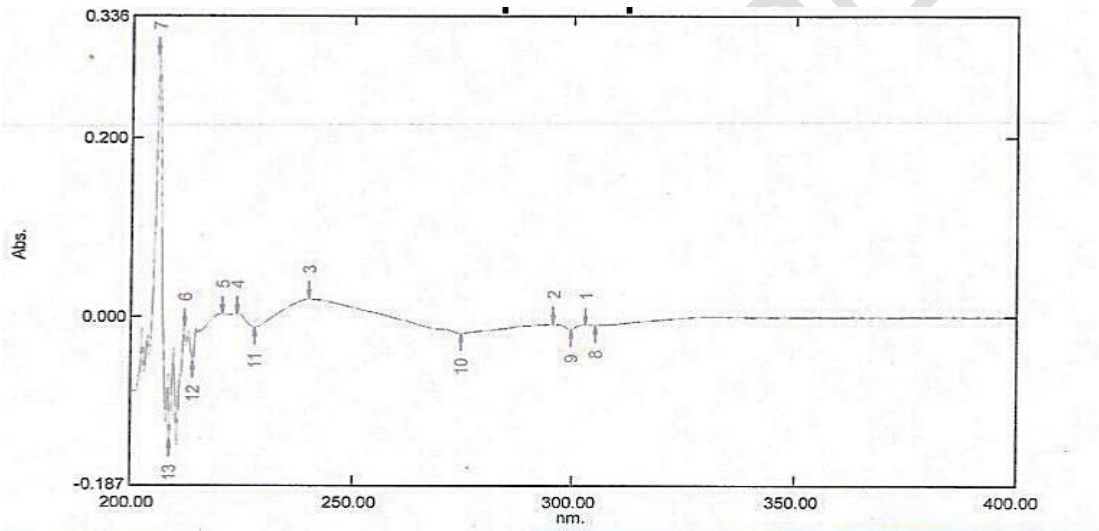

Fig.19: First order derivative linearity spectra sample No Pain the UV spectrum of (16.5 µg/ml, 10.0 µg/ml and 1.5 µg/ml) of PAR, IBU and CAF, respectively

Table 6: Statistical validation for the commercial form (No Pain)® capsules

Conc. Taken µg/mL	Conc. Found* µg/mL	Error%*	R.S.D%*	Recovery%*
PAR 325 mg	320.4	1.41	0.87	98.58
IBU 200 mg	196.3	1.85	0.93	98.15
CAF 30 mg	29.6	1.33	0.97	98.66

*: mean of seven determinations, RSD: relative standard deviation

4. CONCLUSION

Simple, accurate and precise methods have been pronounced for simultaneous determination of Ibuprofen, Caffeine, and Paracetamol in pure and in the capsules dosage form. The methods were approved by examining the linearity, accuracy, precision, limit of detection and quantification. Further, Results showed that the application of these methods is efficient for routine analysis, quality control of a mixture and marketing preparations comprising these three drugs.

COMPETING INTERESTS

The authors affirm there's no conflict.

AUTHORS' CONTRIBUTIONS

This work was achieved in collaboration between all authors. All authors read and approved the final manuscript.

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