



Assessment of paracetamol and caffeine containing non-opioid analgesics tablets commercially available in Bangladesh

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ABSTRACT

Context: Paracetamol is widely used as an over-the-counter (OTC) drug, often combined with caffeine to enhance its activity. In Bangladesh, there are multiple brands of paracetamol and caffeine formulations, but their quality is not consistently assured. **Objective:** This study aims to evaluate the quality and quantitative assessment of sixteen different brands of paracetamol and caffeine tablets in Bangladesh. **Methods:** Specifically, it focuses on assessing parameters such as weight variation, moisture content, ash content, pH, and the actual doses present in the tablets. The formulations of the tablets were identified using FT-IR spectrophotometry. Quantitative analysis of the actives (paracetamol and caffeine) was carried out using a double-beam UV-visible spectrophotometer. **Results:** The findings indicate that the tablets generally met quality standards. Moisture content (0.41-3.32%), ash content (0.01-1.62%), and pH (6.20 to 7.20), all are within acceptable limits. Weight variation, at 0.01-1.68%, was also below the permitted threshold of 5%. FT-IR spectroscopy confirmed the presence of both paracetamol and caffeine in all samples. The UV-visible spectrophotometric analysis revealed that the actual doses of paracetamol (335.37-536.56 mg) and caffeine (46.43-60.56 mg) per dosage were slightly lower than the labeled manufactured doses. **Conclusion:** The tablets generally met quality standards regarding moisture, ash, pH, and weight variation, the discrepancy between labeled and actual doses of paracetamol and caffeine highlights the need for improved quality control measures in the manufacturing process.

Keywords: Caffeine, Non-Opioid Analgesics, Paracetamol, Ultraviolet-Visible spectrophotometric, FT-IR

INTRODUCTION

Medications are predominantly formulated to diagnose, control, and treat illnesses in people of all ages (Wittich et al., 2012). Ensuring the quality of medicines is essential for accessibility, as it ensures that pharmaceutical products are suitable for their intended purpose, comply with marketing authorization requirements, and do not pose any risks to consumers (Kahsay and Egziabher, 2010). In developing nations such as Bangladesh, it is essential to have affordable and high-quality people's medicines to reduce the notable diseases such as fever, migraine, headache, sore throat, toothache, back pain, neuralgia, pain and aches of colds and flu, etc. The combination of paracetamol and caffeine (Figure 1) in single dosages (paracetamol 500 mg plus caffeine 65 mg in a tablet) formulation is an effective non-opioid analgesic for the treatment of diseases (<https://medex.com.bd/brands/10584/fast-plus-500-mg-tablet>).

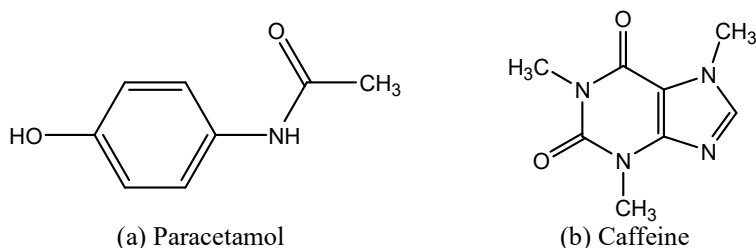


Figure 1. Structural formula of (a) Paracetamol and (b) Caffeine

Paracetamol, commonly utilized as an over-the-counter (OTC) analgesic and antipyretic, is chemically classified as 4-hydroxyacetanilide, also known as acetaminophen, N-acetyl-p-aminophenol (Wu et al., 2012). The suggested analgesic mechanism of paracetamol involves the inhibition of central cyclooxygenases (COX-1, COX-2, and COX-3), with prostaglandins playing a role in this process (Teklu et al., 2014; Abebe et al., 2020). Paracetamol exhibits mild anti-inflammatory effects as well (Ayoub, 2021). Caffeine, an alkaloid similar to theophylline, interacts with paracetamol to increase its solubility and ability to pass through cell membranes (Okore, and Osuji, 2001). In addition, caffeine has been found to increase both the pain threshold and pain tolerance (Keogh and Witt, 2001; Overstreet et al., 2018). Moreover, caffeine has the inherent ability to enhance cerebral vessel tone, which provides an additional benefit in the management of migraines and headaches (Addicott et al., 2009). In certain countries, the presence of inadequate regulatory authorities and substandard quality control practices has facilitated the circulation of low-quality drugs (Newton et al., 2010). Common issues in the pharmaceutical industry include the prevalence of counterfeit medicines, degradation of active ingredients due to unfavorable storage conditions, and insufficient quality assurance measures during manufacturing (Risha et al., 2003; Hebron et al., 2005; Glass, 2014). Paracetamol is a non-prescription drug widely used for common ailments and is available OTC. Numerous studies have indicated its consumption without appropriate prescriptions, particularly in rural areas (Okumura et al., 2002; Shankar et al., 2002). This research delves into assessing key quality control parameters in analgesic drugs combining paracetamol and caffeine, including pH, moisture content, ash content, and weight variation. It endeavors to advance analytical techniques by devising cost-effective UV-Visible spectrophotometric methods tailored for identifying and quantifying paracetamol and caffeine within pharmaceutical formulations. Furthermore, the study employs FT-IR

spectrometry to dissect and understand the composition and characteristics of paracetamol and caffeine present in the examined pharmaceutical samples. Through these meticulous objectives, the research aims for a holistic evaluation of the medications, encompassing their quality, efficacy, safety, and availability. Ultimately, this contributes valuable insights for healthcare practitioners, regulatory bodies, and consumers in Bangladesh, empowering them to make well-informed decisions about their usage.

MATERIALS AND METHODS

Materials and instruments: The research was involved with the use of laboratory materials like glassware, solvents, and chemicals, alongside analytical and electronic instruments. Laboratory components included a micropipette, measuring cylinder, mortar and pestle, test tubes, pipette, spatula, and various others. Prior to use, all glass apparatus is meticulously cleaned with detergent, rinsed with distilled water and acetone, and dried at 60-70°C in oven. Organic solvents like methanol (Merck KGaA, Darmstadt, Germany) and dimethyl sulfoxide (RCI Labscan Limited, USA) were employed. Analytical processes utilized instruments such as an electronic balance (ATY124, Shimadzu, Kyoto, Japan), oven (GSM 11/8 Hope valley, S336RB, UK), carbolite furnace (30-3000 °C, Hope valley, S336RB, UK), forced convection oven (JSOF-250, Korea), UV-Visible spectrophotometer (UV-1800, Shimadzu, Kyoto, Japan), Fourier-Transform Infrared Spectrophotometer (FT-IR; Model: IRPrestige-21, Shimadzu, Kyoto, Japan), pH meter (Model no: HI 2211, HANNA instruments, 270 George Washington Hwy, United States), and vortex mixer (Stuart SA8, Westwood Avenue Long Branch, NJ 07740, United States).

Sample collection: A dosage of paracetamol and caffeine of 500 mg and 65 mg tablets of sixteen brands were collected from different local pharmacies and super shops in Dhaka city, exhibiting varying levels of popularity. A sample size of 5 tablets of each brand was chosen for the analysis. The collection process involved comprehensive verification of sample information such as the manufacturing companies, batch number, and manufacturing and expiry dates. The individual samples of each brand were coded (P₁ to P₁₆) for the respective paracetamol and caffeine formulations (Table 1).

Weight Variation: Five tablets from each type of brand (n=16) were weighed individually using an analytical balance. The average weight of the tablets was calculated. The percentage of weight variation was calculated by using the following formula (USP, 2010; Ahmed et al., 2020):

$$\text{Percentage of weight variation} = \frac{|\text{individual weight} - \text{average weight}|}{\text{average weight}} \times 100\%$$

$$\text{Standard deviation, } \sigma = \sqrt{\frac{\sum(x - \mu)^2}{n - 1}}$$

$$\text{Relative standard deviation, } (\%) = \frac{\sigma}{\mu} \times 100$$

pH: A pH meter was used to determine the pH of the collected samples (Cheng and Zhu, 2005). The samples were weighed accurately and dissolved in 100 mL of distilled water. After inserting the pH probe in the sample and holding it for a few minutes to get a stable reading, the value of each sample was taken. After each test, the probe was cleaned with deionized water to avoid cross contamination among various samples.

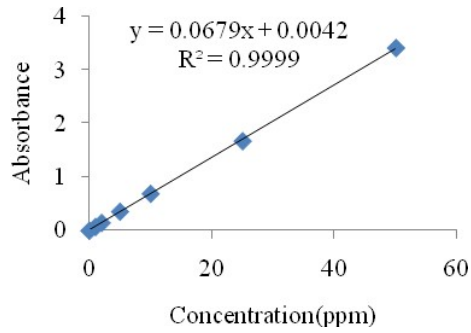
Moisture and ash content: Moisture content was assessed following the AOAC (2000) standard method, involving the meticulous preparation of porcelain crucibles. After cleaning and drying, the crucibles were cooled in desiccator, and their initial weights were measured. Samples were then powdered, placed in the crucibles, and weighed. Subsequently, the crucibles with samples underwent a drying process at 105 °C for 3 hours, followed by cooling in desiccators. The final weights of the crucibles with samples were determined, allowing for the computation of moisture content percentages. Similarly, ash content analysis was conducted using the AOAC (2000) method, involving further heating at 700°C for 4 hours after the initial 105 °C drying phase, followed by calculations based on the crucibles' final weights (Patel et al., 2023).

$$\text{Moisture content (\%)} = \frac{\text{weight before heating} - \text{weight after heating}}{\text{weight before heating}} \times 100$$

$$\text{Ash content (\%)} = \frac{\text{weight of ash}}{\text{weight of the sample}} \times 100$$

UV-Visible spectral analysis: The UV spectra of the standard paracetamol and caffeine were taken as a reference to assess the collected samples. To prepare standard stock solutions, 0.025 g of paracetamol was dissolved in distilled water in a 50 mL volumetric flask. The solution was labeled, indicating the name of the standard, solvent, and concentration. To prepare standard stock solutions of caffeine, 0.01 g was dissolved in distilled water in a 100 mL volumetric flask. The solution was labeled, indicating the name of the standard, solvent, and concentration. The working standard solutions were prepared by serial dilution. The standard working solutions of paracetamol were prepared in concentrations of 250, 125, 50, 25, 10, 5, 2, 1 and 0.5 mgL⁻¹, respectively. The standard working solutions of caffeine were prepared in concentrations of 40, 20, 10, 8, 6, 4, 2, and 1 mgL⁻¹, respectively. A double-beam UV-Visible spectrophotometer measured the absorbance of these solutions to draw calibration curves (Figure 2) constructed by plotting the absorbance versus concentration of the working standard paracetamol and caffeine solutions at a wavelength of 243 nm and 273 nm, respectively (Figure 3).

Sample Preparation: At first, the finely powdered sample was dissolved in 100 mL of distilled water using a vortex machine for a homogeneous mixture. After that, the solution was filtered and diluted two hundred times using distilled water as solvent. All of the sample solutions were made similarly. Absorbance of these solutions were measured by a double-beam UV-Visible spectrophotometer having a 1 cm cell made of quartz. The instrument was run initially with distilled water as blank at a wavelength of 200-400 nm. At this fixed wavelength, the absorbance of each sample solution was taken in a UV-Visible spectrophotometer. Some of the spectrums of the samples are shown in Figure 4.



(a)

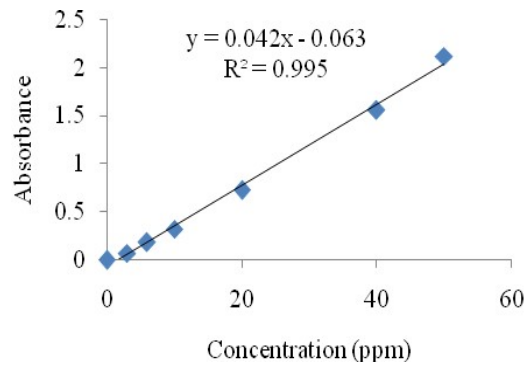


Figure 2. Calibration curve of (above) standard paracetamol and (below) standard caffeine

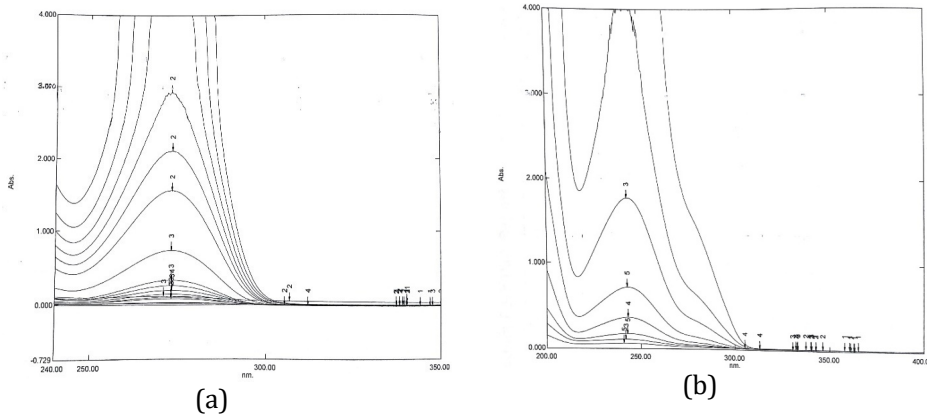


Figure 3. UV-visible overlain spectrum of (a) standard paracetamol and (b) standard caffeine

FT-IR spectral analysis: The FT-IR spectrum of the standard paracetamol and caffeine was used to confirm their presence and assess the quality of the samples (Mallah et al., 2015). The finely ground sample was mixed with powdered KBr and pressed under high pressure. Under pressure, the potassium bromide melted, and the sample was sealed in a matrix. The resulting KBr pellet is

inserted into the FT-IR instrument. The FT-IR spectra were recorded over the range of 400- 4000 cm^{-1} . To improve the signal-to-noise (S/N) ratio, the background spectrum was subtracted from the sample spectrum and compared with the reference spectrum in the database.

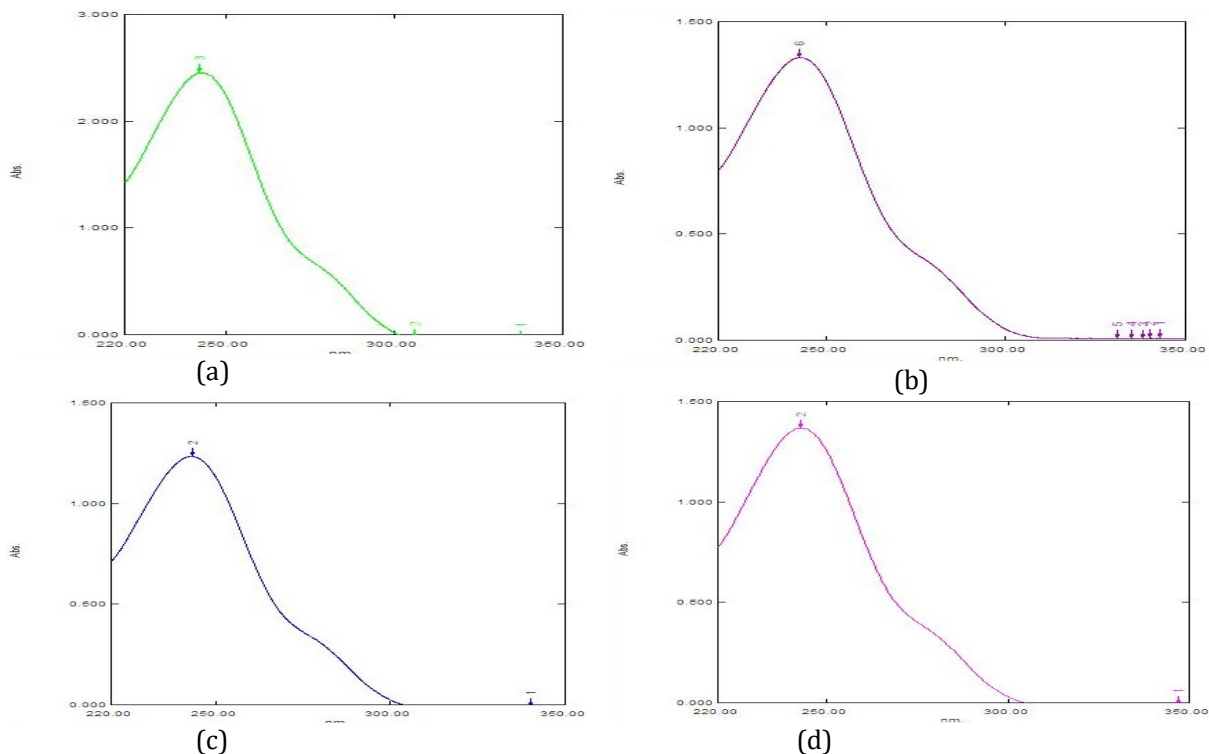


Figure 4. UV spectrum of sample solutions (a)=P₁, (b)=P₄, (c)=P₅, (d)=P₈

RESULTS AND DISCUSSION

The assessment includes Table 1, presenting quality assessing parameters for various pharmaceutical formulations (n=16) which are commonly prescribe in Bangladesh. The table outlined average weight (646.10-785.30 mg), RSD (0.20-1.32%), weight variation (0.01-1.68%), moisture content (0.41-3.32%), ash content (0.01-1.62%), and pH (6.20-7.20) for each sample (P₁ to P₁₆). Additionally, a note clarifies that n=5 tablets were used for weight variation calculation. Table 2 defines allowed relative standard deviation based on average weight, categorizing relative standard deviation (RSD) limits for different weight ranges. As seen the RSD (%) in weight of the manufactured tablets was above 0.20% and below 1.32%. The average weights were also in the range of 646.10 mg to 785.30 mg. According to British pharmacopeia, a deviation in weight of 5% or less is acceptable for tablets with an average weight of 250 mg or more (Commission BP, 2021; Sabere et al., 2021). Generally, as the average weight becomes higher the deviation percentage decreases. All the samples have passed the weight variation uniformity test specified in the British Pharmacopoeia (not exceeding 5% deviation) (Commission BP, 2021). This comprehensive tabulated data serves as a crucial foundation for evaluating and comparing the quality of pharmaceutical formulations, offering insights into key parameters and adherence to standards.

Table 1. Quality assessing parameters of different pharmaceutical formulations

Sample ID	Average weight \pm SD (mg)	RSD (%)	Weight variation (%) (n=1 to 5)	Moisture content (%)	Ash content (%)	pH
P ₁	648.04 \pm 4.27	0.66	0.27, 0.72, 1.00, 0.31, 0.24	3.32	0.20	7.20
P ₂	785.30 \pm 10.34	1.32	0.19, 1.41, 1.68, 0.76, 1.22	2.40	0.88	6.90
P ₃	653.14 \pm 3.37	0.52	0.04, 0.45, 0.87, 0.17, 0.28	1.48	1.62	6.40
P ₄	699.96 \pm 4.44	0.63	0.17, 0.17, 0.29, 0.84, 0.88	2.07	0.76	6.20
P ₅	701.28 \pm 6.83	0.97	1.28, 1.21, 0.45, 0.15, 0.67	2.45	0.64	6.80
P ₆	679.84 \pm 7.09	1.04	0.71, 1.36, 0.20, 0.61, 1.26	1.99	1.36	6.60
P ₇	681.16 \pm 3.02	0.44	0.60, 0.23, 0.59, 0.11, 0.12	2.16	1.43	6.80
P ₈	771.22 \pm 2.54	0.33	0.25, 0.15, 0.43, 0.37, 0.15	2.12	0.75	6.20
P ₉	665.70 \pm 3.63	0.54	0.46, 0.64, 0.62, 0.04, 0.42	0.61	0.03	7.10
P ₁₀	717.80 \pm 3.80	0.53	0.58, 0.67, 0.40, 0.07, 0.40	0.41	0.02	6.90
P ₁₁	668.70 \pm 5.70	0.85	1.23, 0.88, 0.66, 0.43, 0.09	0.64	0.03	7.00
P ₁₂	782.70 \pm 2.09	0.27	0.38, 0.33, 0.11, 0.06, 0.10	0.60	0.01	6.90
P ₁₃	646.10 \pm 2.55	0.39	0.20, 0.53, 0.32, 0.03, 0.45	0.76	0.04	7.00
P ₁₄	657.10 \pm 1.29	0.20	0.08, 0.29, 0.15, 0.17, 0.12	0.57	0.03	6.80
P ₁₅	715.90 \pm 1.62	0.23	0.01, 0.33, 0.10, 0.14, 0.25	0.48	0.04	7.20
P ₁₆	690.60 \pm 1.54	0.22	0.03, 0.36, 0.04, 0.20, 0.16	0.77	0.02	6.80

Note: n= 5; Five tablets of each brand were taken for weight variation calculation

Table 2. Allowed Relative Standard Deviation (Sengupta, 1988)

Average Weight (mg)	Relative Standard Deviation (%)
Less than 80	10
Greater than 80 and less than 250	7.5
Greater than 250	5

The pH of standard paracetamol in a saturated aqueous solution was 6.5, and standard caffeine was 6.9 (O'Neil, 2013). Of the 16 tested tablets samples, all have a pH close to the literature value, they are almost neutral, and most were slightly acidic. Pharmaceutical tablets were mainly subjected to quality control via moisture content analysis, which is an essential factor in material quality. The physical consistency and binding properties of the tablet formulations are influenced by moisture content in it (Thapa, et al., 2017; Crouter and Briens, 2014). A decrease in tablet strength was observed at higher moisture contents

than 3.5% w/w because of hydrostatic resistance to excess moisture in void spaces, which causes force transmission that reduces particle-particle contact areas, surface energy, and adhesive forces (Nokhodchi et al., 1995). The presence of excess (> 5.0 %) much moisture can lead to bacteria or fungi (Manani et al., 2017). This can cause a product to rot after a week or two on the shelf, which could be dangerous for medicine transported to remote places. Too little moisture could cause a tablet to crumble before it is packaged (Koumbogle et al., 2023). The collected samples have moisture content within 0.41-3.32 %, which is appropriate for pharmaceutical tablets. Ash content in a sample signifies the number of inorganic materials present in the sample. The collected samples have a very low percentage of ash content, indicating the presence of some inorganic materials. The FT-IR absorbance bands of standard paracetamol and caffeine are tabulated in Table 3.

Table 3. Assessment of FT-IR Absorbance bands of standard paracetamol and caffeine

FT-IR Absorbance bands of standard paracetamol				
Absorbance (cm ⁻¹)	Bond types	Mode of vibrations	Literature values (cm ⁻¹)	Peak types
3317	N-H (amide)	Stretching	3300	Strong, Sharp
3171	O-H (phenol)	Stretching	3400-3200	Strong, Broad
2797	C-H (alkane)	Stretching	3000	Strong
1643	C=O (amide)	Stretching	1690-1630	Strong, Sharp
1561,1437	C=C (aromatic)	Stretching	1600, 1475	Strong
1017	C-O	Stretching	1100-1000	Medium
815	=C-H (aromatic)	Out-of-plane	900-690	Medium
FT-IR Absorbance bands of standard caffeine				
3437	N-H (amide)	Stretching	3500-3100	Strong, Sharp
3111,2951	=C-H (aromatic)	Stretching	3100-3000	Strong
2351, 1696	C=O (amide)	Stretching	1698-1630	Strong, sharp
1658	-C=N	Stretching	1690-1640	Strong, sharp
745	=C-H (aromatic)	Out-of-plane bending	900-690	Medium

The prominent IR bands of paracetamol were as follows: Secondary N-H amide gave only one stretching peak near 3317 cm⁻¹, which was close to the literature value of 3300 cm⁻¹. This peak was strong and sharp. A strong O-H (phenol) stretching peak was observed near 3171 cm⁻¹, which was close to the literature value of 3400-3200 cm⁻¹. This peak was broad due to the formation of a strong H-bond. A strong and sharp C=O (amide) stretching peak was observed near 1643 cm⁻¹, which was close to the literature value of 1690-1630 cm⁻¹. Aromatic C=C gave two strong stretching peaks. One peak was observed near 1561 cm⁻¹, and another peak was observed near 1437 cm⁻¹ which were close to the literature values of 1600 cm⁻¹ and 1475 cm⁻¹. Medium =C-H (aromatic) out-of-plane bending peak was observed near 815 cm⁻¹, close to the literature value 900-690 cm⁻¹.

The prominent IR bands of caffeine were as follows: N-H amide gave only one stretching peak near 3437 cm⁻¹, which was close to the literature value of

3500-3100 cm^{-1} . This peak was strong and sharp. Aromatic =C-H gave two strong stretching peaks. One peak was observed near 3111 cm^{-1} , and another peak was observed near 2951 cm^{-1} which were close to the literature values of 3100-3000 cm^{-1} . C=O (amide) stretching peak was observed near 1696 cm^{-1} , which was close to the literature value of 1680-1630 cm^{-1} . It also gave a peak at a higher frequency which is 2351 cm^{-1} . -C=N stretching peak was observed near 1658 cm^{-1} , which was close to the literature value of 1690-1640 cm^{-1} . Medium =C-H (aromatic) out-of-plane bending peak was observed near 745 cm^{-1} , which was close to the literature value 900-690 cm^{-1} . The excipients do not create interference in these regions stated above. Mainly the absorbance bands of the functional of the principal component are prominent. All the collected samples can be qualitatively analyzed, possibly concerning standard paracetamol and caffeine.

A qualitative analysis was performed on the absorbance bands of the collected samples. The absorbance bands of P_1 and P_6 are tabulated in Table 4 and Table 5, respectively. The data depicted that absorption peaks appear at 3324 cm^{-1} , 2929 cm^{-1} , 1653 cm^{-1} , and 1021 cm^{-1} . It also showed peaks at 3488 cm^{-1} , 2362 cm^{-1} , 1653 cm^{-1} and 723 cm^{-1} . These are the characteristic peaks for paracetamol and caffeine formulations in P_1 . The absorbance bands of P_6 were tabulated in Table 5.

Table 4. Assessment of Absorbance bands of P_1

Absorbance bands (cm^{-1})	Groups	Vibration Mode	Peak Strength
3324	N-H (amide)	Stretching	Strong, Sharp
2929	O-H (phenol)	Stretching	Strong, Broad
2795	C-H (alkane)	Stretching	Strong
1653	C=O (amide)	Stretching	Strong, Sharp
1561,1440	C=C (aromatic)	Stretching	Strong
1021	C-O	Stretching	Medium
802	=C-H (aromatic)	Out-of-plane bending	Medium
3488	N-H (amide)	Stretching	Strong
2362	C=O (amide)	Stretching	Strong, Sharp
1615	-C=N	Stretching	Strong, Sharp
723	=C-H (aromatic)	Out-of-plane bending	Medium

Table 5. Assessment of Absorbance bands of P_6

Absorbance bands (cm^{-1})	Groups	Vibration Mode	Peak Strength
3164	N-H (amide)	Stretching	Strong, Sharp
2795	C-H (alkane)	Stretching	Strong, Broad
1654	C=O (amide)	Stretching	Strong
1561,1438	C=C (aromatic)	Stretching	Strong, Sharp
1018	C-O	Stretching	Strong
803	=C-H (aromatic)	Out-of-plane bending	Medium
3324	N-H (amide)	Stretching	Strong
2358	C=O (amide)	Stretching	Strong, Sharp
1505	-C=N	Stretching	Strong, Sharp
725	=C-H (aromatic)	Out-of-plane bending	Medium

The spectra data depicted that absorption peaks appear at 3164 cm^{-1} , 2795 cm^{-1} , 1654 cm^{-1} , 1018 cm^{-1} , which are characteristic peaks for paracetamol. It also showed peaks at 3324 cm^{-1} , 2358 cm^{-1} , 1505 cm^{-1} , indicating the presence of caffeine in the sample. Similarly, IR absorbance bands of other samples were analyzed. All the samples have strong N-H stretching peaks close to the literature value indicating the presence of secondary amide groups. C=O stretching peaks observed at lower and higher frequencies conclude that amide is present. Collected samples have aromatic C=C stretching and out-of-plane bending vibrations within them that concludes the presence of the benzene ring. Strong and sharp peaks of C=N stretching were observed for each sample. Strong and broad peaks were observed in all samples for the O-H group. The IR spectra of samples provide information about the chemical composition of the product. Comparing the observed absorbance bands with standard paracetamol and caffeine, it can be concluded that all the samples are a combination of paracetamol and caffeine. The λ_{max} of standard paracetamol and caffeine in water were 243 nm and 273 nm, respectively.

All the samples were quantitatively analyzed by UV-Visible spectrophotometer and the amount of paracetamol and caffeine in each sample was determined (Table 6). Three replicates ($n=3$) were done for each brand. The analysis of the active substances in the targeted analgesic tablets is presented in Table 6, detailing the amounts of paracetamol and caffeine in each sample. The average values, standard deviations (SD), and relative standard deviations (RSD %) are provided for a comprehensive understanding of the variability within the samples. Paracetamol content in the samples ranged from 342.85 mg (P_{13}) to 536.56 mg (P_{11}), with an average RSD of 0.60%. Notably, sample P_{11} exhibited a higher Paracetamol content, surpassing 100% of the expected value. This could be attributed to formulation variations or analytical discrepancies, warranting further investigation. Caffeine levels varied between 46.43 mg (P_1) and 59.64 mg (P_{14}), displaying an average RSD of 1.68%. Samples P_{13} and P_{14} deviated notably from the mean, possibly indicating formulation challenges or measurement inconsistencies. The elevated RSD in P_{14} suggests potential manufacturing issues affecting caffeine uniformity.

The active substance percentages were calculated based on the total amount of active components. Paracetamol's active content ranged from 67.10% (P_{16}) to 107.31% (P_{11}), while Caffeine content ranged from 71.43% (P_1) to 93.17% (P_9). Sample P_{11} again stood out with a remarkably high paracetamol percentage, emphasizing the need for quality control measures. These findings suggest formulation variations among the targeted analgesic tablets, impacting the uniformity of active substances. The data raises concerns about the consistency and accuracy of the manufacturing process, potentially influencing the tablets' therapeutic efficacy. To address these discrepancies, stringent quality control measures should be implemented during production, focusing on precise formulation and dosage uniformity. The deviation observed in the amount of paracetamol and caffeine might be due to the Ultraviolet-visible spectrophotometric technique (Figure 2). This method was used for the assessment of paracetamol and caffeine. The study's limitations could be potential variations in tablet formulations among different manufacturers. There might be challenges in accurately identifying impurities or contaminants using FT-IR and UV-Visible spectrophotometer alone, potentially overlooking other factors impacting product quality. Moreover, individual differences in tablet

Table 6. Active substance in single dosage of the targeted analgesic tablets

Sample ID	Paracetamol			Caffeine		
	Amount \pm SD (mg)	RSD (%)	Active (%) in single dosage	Amount \pm SD (mg)	RSD (%)	Active (%) in single dosage
P ₁	370.68 \pm 1.39	0.38	74.14	46.43 \pm 0.48	1.03	71.43
P ₂	406.03 \pm 1.67	0.41	81.21	53.1 \pm 0.82	1.55	81.69
P ₃	399.94 \pm 0.78	0.19	79.99	55.63 \pm 0.73	1.31	85.58
P ₄	402.98 \pm 1.23	0.30	80.60	53.73 \pm 0.73	1.35	82.66
P ₅	373.82 \pm 1.48	0.40	74.76	48.97 \pm 0.73	1.49	75.34
P ₆	389.14 \pm 1.62	0.42	77.83	51.98 \pm 0.73	1.40	79.97
P ₇	391.30 \pm 1.67	0.43	78.26	50.71 \pm 1.26	2.48	78.02
P ₈	400.53 \pm 1.06	0.27	80.11	48.49 \pm 1.20	2.47	74.60
P ₉	434.44 \pm 4.51	0.60	86.89	60.56 \pm 2.78	1.60	93.17
P ₁₀	356.42 \pm 4.85	0.90	71.28	50.71 \pm 2.68	1.30	78.02
P ₁₁	536.56 \pm 1.80	0.60	107.31	46.88 \pm 2.56	1.95	72.12
P ₁₂	383.26 \pm 4.30	0.40	76.65	53.18 \pm 2.43	2.50	81.82
P ₁₃	342.85 \pm 3.01	0.80	68.57	55.91 \pm 2.37	0.80	86.02
P ₁₄	361.59 \pm 0.30	0.80	72.32	59.64 \pm 1.67	2.80	91.75
P ₁₅	456.35 \pm 0.36	0.60	91.27	50.14 \pm 3.83	2.76	77.14
P ₁₆	335.37 \pm 0.60	0.41	67.10	53.37 \pm 2.28	1.50	82.11

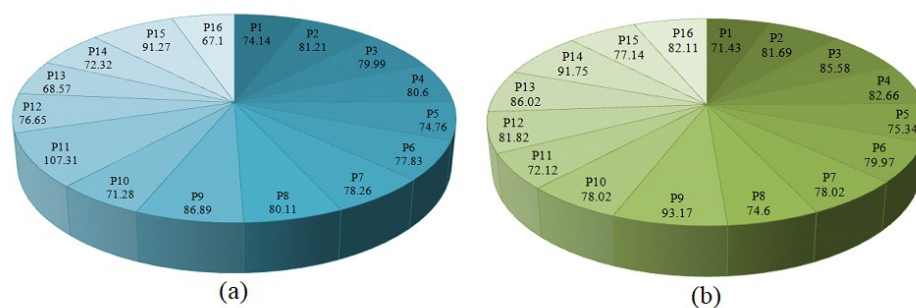


Figure 2. Percentage of (a) paracetamol and (b) caffeine in single dosage non-opioid analgesics tablets

formulations could influence the study's outcomes, warranting further investigation. Additionally, the study might not assess long-term stability or degradation of the analyzed tablets, which could affect their efficacy and safety over time. Although the techniques imparted in this study might have some inaccuracy and less sensitivity, this technique was more cost-effective than other established techniques (HPLC, LC-MS/MS, etc.) for assessing paracetamol and caffeine.

CONCLUSION

An evaluation of the quality and quantity of paracetamol and caffeine in different pharmaceutical tablets was performed in the present study based on the availability of these two ingredients in the pharma market of Bangladesh. Quality parameters determine how well a formulation will perform therapeutically. FT-IR spectra of all samples depicted characteristic absorbance bands for paracetamol and caffeine, which ascertains their presence. The quantitative analysis was done using ultraviolet-visible spectrophotometry, and the amount of most formulations found within the labeled manufactured doses. As it is the simplest, most cost-effective method, it can be used for quality assurance and quality control of materials and finished products in pharmaceuticals laboratories.

DECLARATION OF CONFLICT OF INTEREST

No conflict of interest.

DECLARATION OF HONOR

We declare on our honor that our results are not fake and made up.

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