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Quantitative determination by UV spectroscopy, structural characterization evaluation by Fourier Transform Infrared Spectroscopy (FTIR) and disintegration analysis of Lisinopril tablets available in the Malaysian outlets

Abstract

Lisinopril is an angiotensin-converting enzyme (ACE) inhibitor that is widely used in the treatment of heart diseases and hypertension.

Objectives: To compare the percentage purity of several brands of Lisinopril tablets available in the Malaysian Outlets by the UV spectrophotometric and the Fourier-Transform Infrared Spectroscopic methods (FTIR) and to evaluate the time taken for each brand of Lisinopril tablets to dissolve during disintegration analysis.

Method: For UV spectrophotometric method, different brands of Lisinopril tablets were diluted with distilled water and undergone a series of dilutions. The absorbance of the diluted sample solutions were measured using a UV spectrometer. The absorbance revealed the concentration of Lisinopril in the sample solution. For FTIR method, the different brands of Lisinopril powders were placed on the diamond crystal plate and pressure was applied. The spectrum of each brand was measured using FTIR spectrometer. The spectrum revealed the functional group of each Lisinopril brand and compared their purity.

Results: For UV spectrophotometric method, only Brand A and C were within the limit specified by B.P. and U.S.P. For FTIR method, structural characterization of all brands of Lisinopril tablets was identified.

Conclusion: It was concluded that Brand A was the best among 3 brands of Lisinopril used in this research.

Keywords: UV spectrophotometer, FTIR, disintegration, Lisinopril

Volume 11 Issue 3 - 2023

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Received: July 26, 2023 | **Published:** August 14, 2023

Introduction

Lisinopril tablets contain Lisinopril dihydrate and it is an angiotensin-converting enzyme (ACE) inhibitor that is widely used in the treatment of heart diseases and hypertension. Lisinopril is related with a low risk of transitory blood aminotransferase increases and has been connected to rare cases of severe and even deadly acute liver damage. Additionally, it is being researched for the prevention and management of side effects brought on by several anticancer medications. It suppresses specific enzymes that tighten blood arteries (narrow). In individuals with congestive heart failure who have not responded to standard therapy with digitalis and diuretics, Lisinopril enhances cardiac output while decreasing pulmonary capillary wedge pressure and mean arterial pressure.[1] Lisinopril is available in tablet form and only accessible with a doctor's prescription. Lisinopril is differs from captopril and enalapril in three different ways as it is hydrophilic, does not break down by liver and it has a long half-life. Besides, there are many different brands and generic products available in Malaysia market. The level of blood pressure, heart rate, blood urea nitrogen (BUN), complete blood count (CBC), serum potassium and creatinine are the important parameters to be monitor after administration of the drug.[1] The chemical structure of Lisinopril is laid down in Figure 1.

Lisinopril tablets are available in oral tablet (2.5, 5, 10, 20, 30, 40mg) and solution dosage form (1mg/mL).[1] It is safe to take with or without meals. The standard dose considerations for an adult range from 2.5mg to 40mg per day, depending on the indication. The beginning dose for adolescents and children older than or equivalent to 6 years is 0.07 to 0.1 mg/kg once day, with a maximum initial dose of 5 mg/day and 1- to 2-week increases. The maximum dose considered is 0.6 mg/kg/day, or 40 mg/day. In general, dose and administration changes with Lisinopril are recommended for patients whose glomerular filtration rate (GFR) is less than or equal to 30 mL/min. (MIMS, 2020). The angiotensin-converting enzyme (ACE) that inhibits angiotensin I from being converted to angiotensin II, a strong vasoconstrictor. A drop in angiotensin II leads to a decrease in aldosterone secretion, which leads to a decrease in sodium reabsorption in the collecting duct and a decrease in potassium excretion, which may result in a slight rise in serum potassium with Lisinopril treatment. Lisinopril increases serum renin activity by reducing the negative feedback of angiotensin II. The favorable effects in hypertensive patients are due to the inhibition of the renin-angiotensin-aldosterone system (RAAS), which results in lower vasopressor and aldosterone activity even in low-renin patients. ACE, on the other hand, destroys bradykinin, and it is through this mechanism that ACE inhibitors may predispose to angioedema.[2] The mechanism of action is shown in Figure 2.

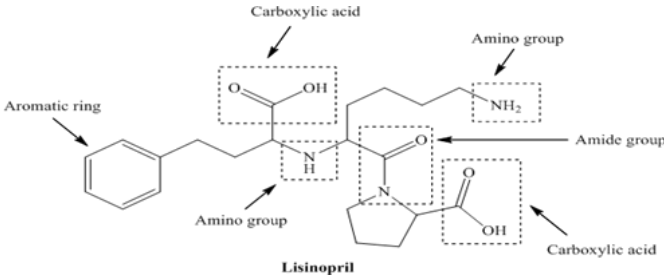


Figure 1 Chemical Structure of Lisinopril.

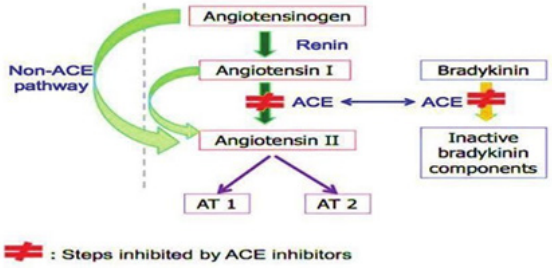


Figure 2 Mechanism of Action of Lisinopril.

Pharmacokinetics

The gastrointestinal tract absorbs Lisinopril slowly and incompletely and food has no effect on Lisinopril absorption. After oral administration, Lisinopril has a low bioavailability of 10-30%. The time to peak concentration might range between 6 and 8 hours. It is eliminated unaltered in the urine and the elimination half-life is about 12 hours. The medicine is not bound to the protein albumin or other types of protein, and its delivery is poor when taken by people with heart failure. The potential chemical impurities of Lisinopril are laid down in Figures 3 (a-e).[3-6]

Impurities of Lisinopril

- Lisinopril (8R,S)-Diketopoperazine (mixture of diastereomers)

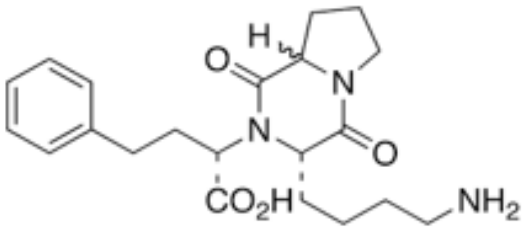


Figure 3a Structure of Lisinopril (8R,S)-Diketopoperazine

- N-Benzyloxycarbonyl (S)-Lisinopril-d5

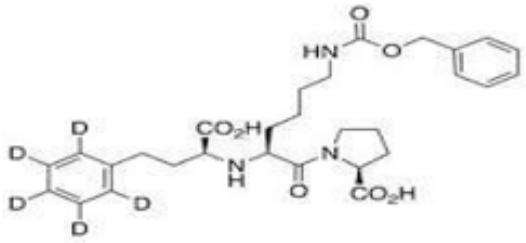


Figure 3b Structure of N-Benzyloxycarbonyl (S)-Lisinopril-d5

- N-Benzyloxycarbonyl (S)-Lisinopril-d5 Ethyl Methyl Diester

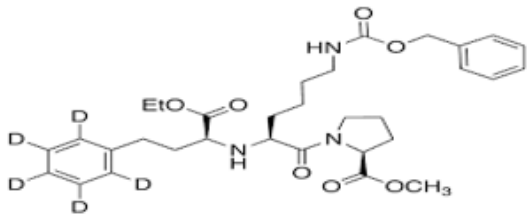


Figure 3c Structure of N-Benzyloxycarbonyl (S)-Lisinopril-d5 Ethyl Methyl Diester

- (E)-Ethyl 4-Oxo-4-phenyl-d5-but-2-enoate

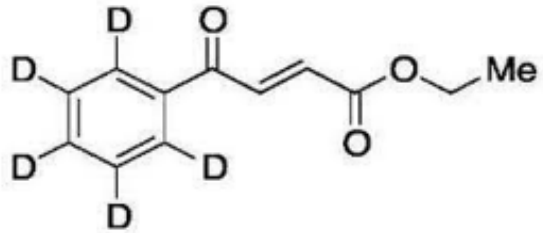


Figure 3d Structure of (E)-Ethyl 4-Oxo-4-phenyl-d5-but-2-enoate

- (S)-Lisinopril-d5 Sodium

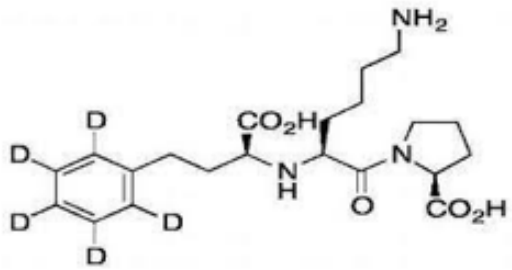


Figure 3e Structure of (S)-Lisinopril-d5 Sodium

Reason and method of assay of Lisinopril tablets

Based on the literature review, there are many well-designed studies for qualitative analysis of Lisinopril in pharmaceutical dosage form in other countries. However, there is a lack of these studies in Malaysia. Thus, this research studies intended to discover and provide basic understandings for the quality of Lisinopril tablets commercially available in local market. UV- spectrophotometry, gas chromatography (GS), quantitative thin-layer chromatography (TLC), high- performance liquid chromatography (HPLC), titrimetry, fluorimetry, colorimetry, as well as FTIR are some of the analytical methods that may be utilised for pharmaceutical analysis.[7,8] These approaches can be employed in pharmaceuticals for the analysis of Lisinopril, either alone or in combinations.[8] On the other hand, due to the FTIR unique mix of sensitivity, flexibility, specificity, and resilience, it is used as a tremendously popular method today. It has become one of the most extensively used analytical instrumental methods in science, capable of dealing with solid, liquid, and gaseous analytes. Therefore, UV-spectrophotometric and FTIR methods will be used in this research project.[9,10]

Hypothesis

a) The concentration determination of each brand of Lisinopril tablets available in Malaysia is to compare with official monograph. According to United State Pharmacopoeia (USP), Lisinopril tablets must not contain less than 90.0 % and not more than 110.0 % of labelled amount of $C_{21}H_{31}N_3O_5$.[10]

Citation: Min TJ, Perveen N, Khan NH. Quantitative determination by UV spectroscopy, structural characterization evaluation by Fourier Transform Infrared Spectroscopy (FTIR) and disintegration analysis of Lisinopril tablets available in the Malaysian outlets. *Pharm Pharmacol Int J.* 2023;11(3):99–108.
DOI: 10.15406/ppij.2023.11.00408

b) According to British Pharmacopoeia (BP),[9] Lisinopril tablets must no contain less than 92.5% and not more than 105.0% the stated amount of $C_{21}H_{31}N_3O_5$.

c) The percentage purity and infrared spectrum of absorption of different brands of Lisinopril tablets is successfully to be determined.

d) The uniformity of the weight of each Lisinopril tablets of different brands will be measured.

Objectives

a. To perform a quantitative analysis of different brands of Lisinopril tablets available in Malaysia by using UV- spectrophotometric and Fourier-Transform Infrared Spectroscopy techniques.

b. To perform a qualitative analysis of simple and cost-effective UV- spectrophotometric methods for Lisinopril tablets available in Malaysian Market.

c. To compare the quality and purity of Lisinopril tablets brands available in Malaysian Market.

d. To evaluate the time taken for the Lisinopril tablets to dissolve in order to assess the quality and performance by using disintegration analysis.

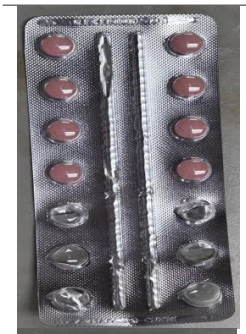
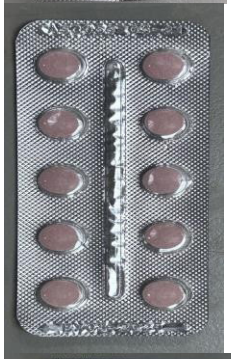
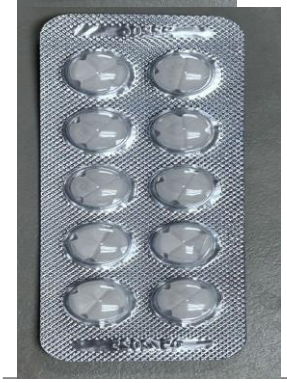
Methodology

Collection of Lisinopril tablets and preparation of Lisinopril powder

Only three different brands of Lisinopril were purchased from Pharmacy outlets in Sungai Petani. These three different brands were labelled as A, B, C in this research. Their description is recorded in Table 1. For each brand, 20 Lisinopril tablets were weighed. The weighed of each tablet was noted. Next, the average weight of each brand were calculated and given in Table 2. Besides, thickness and diameter of Lisinopril Tablet were also measured.

The 20 Lisinopril tablets of each brand were crushed into powder by using mortar and pestle. The powder was then kept inside a re-sealable plastic bag to prevent the powder from moisture as it may cause the drug to denature. The re-sealable plastic bags were labelled clearly with name and date of crushing for easy identification. These powders were then kept in the cool and dry place inside the desiccator. Table 1 shows the different Brands of Lisinopril Tablets and Table 2 shows the descriptions on each brand of Lisinopril tablets.

Table 1 Different brands of Lisinopril tablets

Drugs	Descriptions
 	• Brand A
 	• Brand B
 	• Brand C

Citation: Min TJ, Perveen N, Khan NH. Quantitative determination by UV spectroscopy, structural characterization evaluation by Fourier Transform Infrared Spectroscopy (FTIR) and disintegration analysis of Lisinopril tablets available in the Malaysian outlets. *Pharm Pharmacol Int J.* 2023;11(3):99–108.
DOI: 10.15406/ppij.2023.11.00408

Table 2 Descriptions on each brand of Lisinopril tablets

Brands	Chemical Name	Shape	Colour	Dosage Form	Strips	Weight of Active Ingredient in Each Tablets	Batch No./Lot No.	Expiry
A	Lisinopril dihydrate	Round, biconvex with a "love-shaped and 20" engraving on one side and plain on other side.	Brownish-red in colour	Uncoated Tablet	2 x [1 x14] = 28 tablets/ pack	20 mg	60041315	Sep-25
B	Lisinopril dihydrate	Round, convex tablets	Peach in colour	Uncoated Tablet	3 x [1x 10] = 30 tablets/ pack	Contains 10.89mg Lisinopril dihydrate equivalent to 10mg Lisinopril.	A5C055	Mar-25
C	Lisinopril dihydrate	Round, biconvex tablet, quadrisected on both side (snap-tab) and imprint "20"	White in colour	Uncoated Tablet	3 x [1x 10] = 30 tablets/ pack	Contain 21.78mg Lisinopril dihydrate equivalent to 20 mg Lisinopril	22206	May-25

Determination of Lisinopril tablet using UV spectrophotometric method

Distilled water freshly prepared in the laboratory, Lisinopril Standard Powder (100%) (SIGMA- ALDRICH, USA), UV-Visible Spectrophotometer (SHIMADZU).

Determination of Lisinopril spectrum by using FTIR:

Lisinopril Standard Powder (100%) (SIGMA-ALDRICH, USA), FTIR Spectrometer (Perkin Elmer Spectrum Two™)

Disintegration Test:

Tablet Disintegration Tester (Electrolab ED-2L)

Methodology

Uniformity of Weight of Lisinopril Tablets:

1. 20 Lisinopril tablets of each brand were weighed.
2. Each Lisinopril tablet was weighed individually using a microbalance and recorded in a table.
3. The percentage deviation of its weight from the average weight was determined for each tablet by using formula 1.

$$Deviation(\%) = \frac{Weight\ of\ each\ tablet - Average\ weight}{Average\ weight\ of\ tablets} \times 100\%$$

4. The percentage deviation of individual weight from the average weight should not exceed the limits given by the British Pharmacopoeia (B.P) and USP[9,10] which is shown in Table 3.

Table 3 Limit of deviation of individual weight from the average weight

Average weight of tablet	Deviation (%)	Number of tablets
Less than 80 mg	± 10.0	Minimum 18
	± 20.0	Maximum 2
80 mg to 250 mg	± 7.5	Minimum 18
	± 15.0	Maximum 2
More than 250 mg	± 5.0	Minimum 18
	± 10.0	Maximum 2

Thickness and Diameter Test:

1. 20 Lisinopril Tablets of each brand are selected
2. Each tablet was placed on the lower jaw and the diameter and thickness were measured by using vernier caliper.
3. The value of each tablet diameter and thickness was also recorded.

Assay of Lisinopril tablets by using UV spectrophotometric method

Preparation of standard:

1. 100 mg of standard Lisinopril powder were weighted accurately.
2. The powder was dissolved in water and the volume was made up to 100 ml with distilled water and sonicated. (SOLUTION A, stock solution).
3. 1 ml of solution A was pipetted out into 100 ml of volumetric flask and the volume was made up to 100 ml with distilled water and sonicated. (SOLUTION B).

Sample Preparation:

1. 20 tablets of each brand were weighed using a microbalance.
2. Each brand of Lisinopril tablets was crushed.
3. 100mg of Lisinopril powder was weighed and poured into 100ml of volumetric flask, then made up the volume to 100 ml with distilled water and sonicated and later solution A was filtered. (This is solution A).
4. 1 ml of solution A was pipetted out into 100 ml of volumetric flask and the volume was made up with distilled water and sonicated. This is solution B.
5. Distilled water was employed as blank.

Determination of Absorbance:

1. The spectrophotometer was switched on and allowed to stabilize for 15 minutes
2. Baseline correction was done using blank and the absorbance of the resulting solution B was measured at 215 nm.
3. The percentage purity was calculated by using the given formula 2.

$$Percentage\ purity = \frac{sample\ absorbance}{standard\ absorbance} \times 100$$

4. The weight of powders before and after filtration is shown in Table 4.

Table 4 Weight of residue after filtration

Brand	Weight of Powder taken before filtration	Weight of residue after filtration
A	1140.60 mg	811.20 mg
B	2139.30 mg	1481.40 mg
C	1106.25 mg	785.40 mg

Citation: Min TJ, Perveen N, Khan NH. Quantitative determination by UV spectroscopy, structural characterization evaluation by Fourier Transform Infrared Spectroscopy (FTIR) and disintegration analysis of Lisinopril tablets available in the Malaysian outlets. *Pharm Pharmacol Int J.* 2023;11(3):99–108. DOI: 10.15406/ppij.2023.11.00408

Determination of Lisinopril Spectrum by using FTIR:

1. Powder Lisinopril samples were placed directly on the top of the trough crystal plate and the pressure arm was clamped down.
2. The pressure applied to the crystal plate was adjusted using pressure arm to ensure the consistent contact was achieved between the crystal and the sample.
3. Spectrum of the Lisinopril was started to scan using spectrum software and the spectrum were determined.
4. Spectrum data were analyzed and the results were reported.

Disintegration Test:

1. The tank was filled with water.
2. The baskets were engaged on the basket hook.
3. Two beakers filled with distilled water were placed on the stand.
4. The heater connector was connected to the socket provided at the rear right hand side.
5. The switch put on and maintained at 37°C.
6. 6 tablets of each Lisinopril brand were selected.
7. 1 tablet was placed in each basket's hole and the start button was pressed.
8. The time taken for the tablets to dissolve were determined and noted in a table.

Results and observation

The Average Weight of Different brands of Lisinopril is laid down in Table 5.

Average Weight of different brands of Lisinopril was shown in table 5. This table shows that brand A has the highest weight which was 228.12 mg per tablet while brand B has the lowest weight which was 213.93 mg per tablet. The average weight for brand C was 221.25 mg per tablet.

Table 5 Average weight of different brands of Lisinopril

No.	Brand Weight (mg)	A	B	C
1		228.4	212	218.3
2		226.3	214.8	220.8
3		230.5	217.7	223.3
4		230.3	208.1	221.2
5		231.5	214.3	220.7
6		222.8	212.7	219.8
7		227	213	222.5
8		229.4	212	219.6
9		231.7	217.9	219.8
10		226.9	215	221.6
11		232	213.6	219.7
12		223.1	216.2	222.6
13		227.5	215.4	226.4
14		226.7	212.9	218.2
15		227	209.9	226.4
16		232.6	219.1	220.8
17		228.8	213.8	220.2
18		229.5	215.7	220
19		223.5	211	221.6
20		226.9	213.5	221.5
	Average Weight	228.1	213.9	221.3

Uniformity of weight of Lisinopril tablets

Table 6 had recorded the Uniformity of Weight of Lisinopril Tablets. According to the results recorded in the table, the percentage deviation of all brands of Lisinopril were within the limits given by the British Pharmacopoeia (BP).[9]

Table 6 Uniformity of weight of Lisinopril tablets

No.	Brand	A	B	C
	Average Weight (mg)	228.12	213.93	221.25
	Percentage of Deviation (%)			
1		0.12	-0.9	-1.33
2		-0.8	0.41	-0.2
3		1.04	1.76	0.93
4		0.96	-2.73	-0.02
5		1.48	0.17	-0.25
6		-2.33	-0.57	-0.67
7		-0.49	-0.43	0.56
8		0.56	-0.9	-0.75
9		1.57	1.86	-0.66
10		-0.53	0.5	0.16
11		1.7	-0.15	-0.7
12		-2.2	1.06	0.61
13		-0.27	0.69	2.33
14		-0.62	-0.48	-1.38
15		-0.49	-1.88	2.33
16		1.96	2.42	-0.2
17		0.3	-0.06	-0.47
18		0.6	0.83	-0.56
19		-2.03	-1.37	0.16
20		-0.53	-0.2	0.11

Thickness and diameter of each brand of Lisinopril tablets

Table 7 shows the results of thickness and diameter of each brand.

Table 7 Thickness and diameter of different brands of Lisinopril tablets

No.	Brand	A	B	C	No.	Brand	A	B	C
	Thickness (mm)					Diameter (mm)			
1		3.88	4.06	3.65	1		8.15	7.09	8.6
2		3.88	4.07	3.65	2		8.14	7.07	8.58
3		3.9	4.07	3.65	3		8.14	7.07	8.58
4		3.9	4.06	3.63	4		8.15	7.08	8.58
5		3.87	4.08	3.64	5		8.15	7.08	8.57
6		3.9	4.08	3.63	6		8.15	7.06	8.57
7		3.89	4.06	3.63	7		8.14	7.08	8.57
8		3.9	4.07	3.64	8		8.14	7.07	8.58
9		3.91	4.06	3.65	9		8.15	7.07	8.6
10		3.9	4.06	3.63	10		8.16	7.08	8.58
11		3.9	4.05	3.63	11		8.14	7.07	8.58
12		3.91	4.06	3.64	12		8.15	7.07	8.57
13		3.9	4.05	3.65	13		8.14	7.09	8.58
14		3.9	4.06	3.65	14		8.16	7.07	8.59
15		3.9	4.08	3.66	15		8.16	7.07	8.58
16		3.89	4.05	3.64	16		8.16	7.08	8.58
17		3.91	4.05	3.63	17		8.14	7.08	8.59
18		3.9	4.06	3.66	18		8.15	7.08	8.57
19		3.91	4.05	3.65	19		8.15	7.08	8.6
20		3.88	4.05	3.66	20		8.14	7.08	8.59
	Average Thickness	3.9	4.06	3.64		Average diameter	8.15	7.08	8.58

Citation: Min TJ, Perveen N, Khan NH. Quantitative determination by UV spectroscopy, structural characterization evaluation by Fourier Transform Infrared Spectroscopy (FTIR) and disintegration analysis of Lisinopril tablets available in the Malaysian outlets. *Pharm Pharmacol Int J.* 2023;11(3):99–108.
DOI: 10.15406/ppij.2023.11.00408

UV- absorbance of different brands of Lisinopril

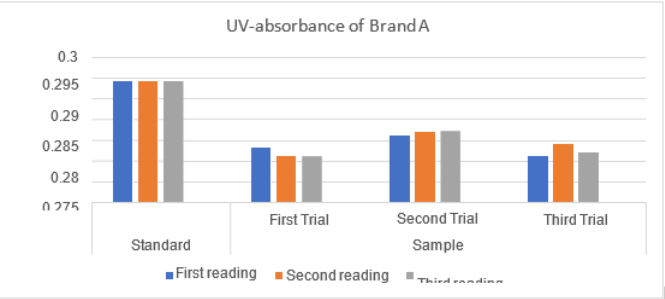
The UV- Absorbance for Different brands of Lisinopril had shown in Table 8.

Table 8 Absorbance of different brands of Lisinopril

Brand	Blank		Standard	Sample		
				First Trial	Second Trial	Third Trial
A	0	First Reading	0.294	0.278	0.281	0.276
		Second Reading	0.294	0.276	0.282	0.279
		Third Reading	0.294	0.276	0.282	0.277
		Average	0.294	0.2767	0.2817	0.2773
B	0	First Reading	0.296	0.26	0.261	0.256
		Second Reading	0.296	0.26	0.256	0.257
		Third Reading	0.295	0.261	0.258	0.255
		Average	0.296	0.2603	0.2583	0.256
C	0	First Reading	0.294	0.279	0.278	0.279
		Second Reading	0.296	0.278	0.276	0.282
		Third Reading	0.294	0.278	0.277	0.282
		Average	0.295	0.2783	0.277	0.281

UV-absorbance of Brand A

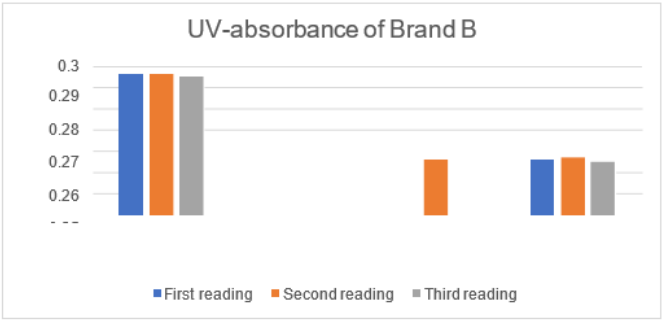
The first, second and third readings of standard Lisinopril all were 0.244. The average absorbance for standard was 0.244. A total of 3 trials were conducted for the assay of Brand A and each trial had 3 readings. In the first trial, the first, second and third readings were 0.278, 0.276 and 0.276 respectively. The average absorbance of Brand A for the first trial was 0.2767. In the second trial, the first, second and third readings were 0.281, 0.282 and 0.282. The average absorbance of Brand A for the second trial was 0.2817. In the third trial, the first, second and third readings were 0.276, 0.279 and 0.277. The average absorbance of Brand A for the third trial was 0.2773 which is shown in Graph 1.



Graph 1 UV-absorbance of Brand A.

UV-absorbance of Brand B

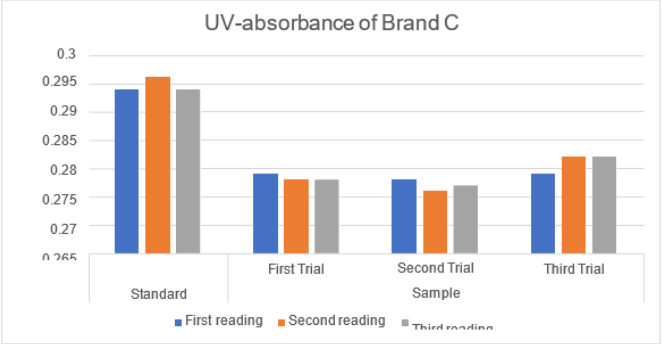
The first, second and third readings of standard Lisinopril were 0.243, 0.245 and 0.245 respectively. The average absorbance for standard was 0.244. A total of 3 trials were conducted for the assay of Brand B and each trial had 3 readings. In the first trial, the first, second and third readings were 0.360, 0.360 and 0.361 respectively. The average absorbance of Brand B for the first trial was 0.3603. In the second trial, the first, second and third readings were 0.361, 0.356 and 0.358. The average absorbance of Brand B for the second trial was 0.3583. In the third trial, the first, second and third readings were 0.356, 0.357 and 0.354. The average absorbance of Brand B for the third trial was 0.3557 which is given in Graph 2.



Graph 2 UV-absorbance of Brand B.

UV-absorbance of Brand C

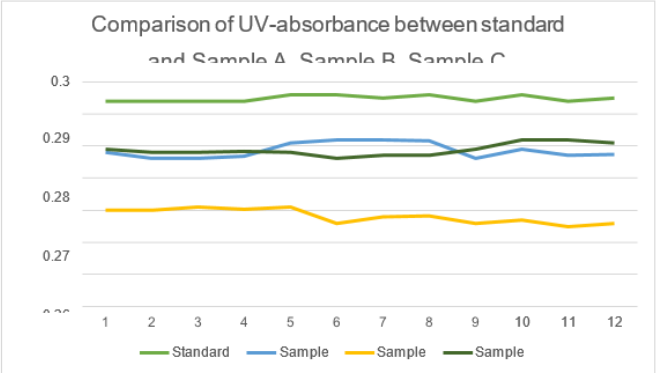
The first, second and third readings of standard Lisinopril were 0.245, 0.244 and 0.245 respectively. The average absorbance for standard was 0.245. A total of 3 trials were conducted for the assay of Brand C and each trial had 3 readings. In the first trial, the first, second and third readings were 0.279, 0.278 and 0.278 respectively. The average absorbance of Brand C for the first trial was 0.2783. In the second trial, the first, second and third readings were 0.278, 0.276 and 0.277. The average absorbance of Brand C for the second trial was 0.2770. In the third trial, the first, second and third readings were 0.279, 0.282 and 0.282. The average absorbance of Brand B for the third trial was 0.2810 and laid down in Graph 3.



Graph 3 UV-absorbance of Brand C.

Comparison of UV-absorbance between standard and sample

The comparison of UV-absorbance between the Standard and Sample A, B, C are shown in graph 4.



Graph 4 Comparison of UV-absorbance between Standard and Sample A, B, C.

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DOI: 10.15406/ppij.2023.11.00408

Percentage purity determination of different brands of Lisinopril by using UV-spectrophotometric method

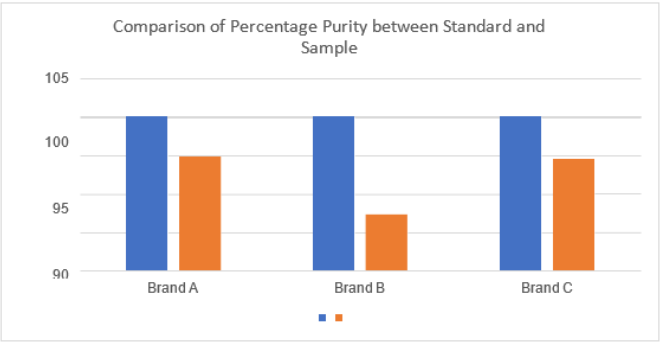
Percentage purity determination of different brands of Lisinopril using UV-spectrophotometric method was tabulated in Table 9. The standard Lisinopril has a purity of 100%. For each sample analysis, three trials were carried out. The percentage purity for Brand A's first, second, and third trials was 94.12%, 95.82%, and 94.32%, respectively. Brand A had an average percentage purity of 94.75%. Moreover, the percentages for Brand B's first, second, and third trials were 87.94%, 87.26%, and 86.49%, respectively. Brand B had an average percentage purity of 87.23%. Furthermore, the percentage purity for the first, second, and third Brand C trials were 94.34%, 93.90%, and 95.25%, respectively. Brand C had an average percentage purity of 94.50%.

Table 9 Percentage purity determination of different brands of Lisinopril by using UV- Spectrophotometric method

Brand	Percentage purity (%)				Standard (%)
	First trial	Second trial	Third trial	Average	
Standard	100	100	100	100	100
A	94.12	95.82	94.32	94.75	100
B	87.94	87.26	86.49	87.23	100
C	94.34	93.9	95.25	94.5	100

Comparison of percentage purity between standard and sample by using UV spectrophotometric method

Comparison of percentage purity between standard and sample using UV-spectrophotometric method was reported in Graph 5. The percentage purity of standard Lisinopril was 100%. Furthermore, the average percentage purity of Brand A, B, and C were 94.75%, 87.23%, and 94.50%, respectively. According to graph 5, Brand A had the highest percentage purity with standard Lisinopril, whereas Brand B had the lowest percentage purity with standard Lisinopril. The percentage purity of Lisinopril in a tablet should be less than 92.5% and not more than 105%, according to the British Pharmacopoeia (BP). As a result, only Brands A and C passed the test. While the United States Pharmacopoeia (USP) recommends that Lisinopril tablets contain no less than 90% and no more than 110% of the advertised quantity of Lisinopril. As a result, Brands A and C passed the test.



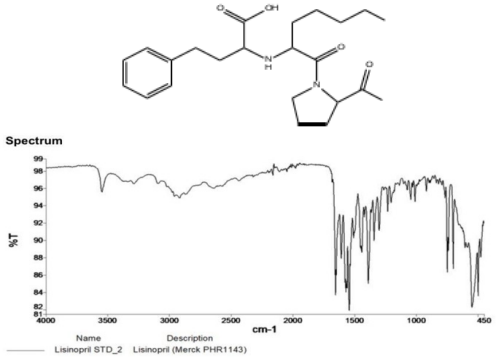
Graph 5 Comparison of Percentage Purity between Standard and Sample using UV-Spectrophotometric Method.

The chemical structures are given along with the corresponding graphs for the identification of the peaks.

Identification of Lisinopril Spectrum by using FTIR

FTIR of Standard Lisinopril

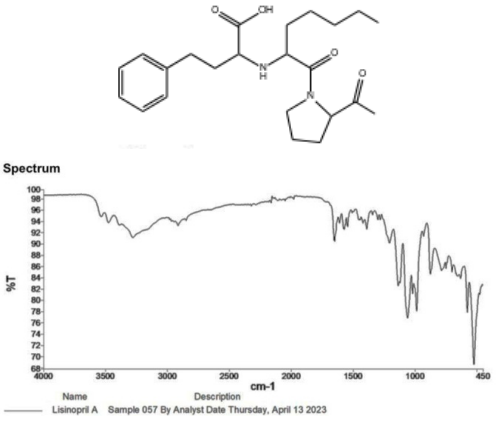
The IR Spectrum of standard Lisinopril was shown in Graph 6. The stretching vibrations of an O-H band of water have been attributed to the FTIR spectrum of standard lisinopril at a peak approximately 3547 cm^{-1}. Primary amine asymmetric and symmetric N-H bands with hydrogen bonding at peaks ranging from 3500 cm^{-1} to 3300 cm^{-1}. Asymmetric C-H stretching vibrations were identified in the peak at 2917 cm^{-1}. Besides, the peak at 1654 cm-1 is caused by the carbonyl stretching of the tertiary amide group or the scissoring NH2 vibration, whereas the peak at 1608 cm^{-1} is caused by the aromatic ring. Moreover, an overtone band was detected in the peak region of 2000 cm^{-1} to 1667 cm^{-1}, indicating that the Lisinopril structure contains a benzene ring. Furthermore, the peak at 1570 cm^{-1} and 1543 cm^{-1} were observed with asymmetric carboxylate.



Graph 6 Standard Lisinopril's IR Spectrum.

FTIR of Brand A Lisinopril

The IR Spectrum of Brand A Lisinopril was shown in Graph 7. FTIR spectrum of the Lisinopril was identified at a peak around 3280 cm^{-1} containing the O-H band due to the firmly bound carboxylic group. This Brand A Lisinopril was spectroscopically examined, the peak around 3500 cm^{-1} to 3300 cm^{-1} indicating the asymmetric and symmetric N-H bands of primary amine having hydrogen bonding. The peak around at 2920 to 2850 cm^{-1} was observed having asymmetric C-H stretching vibrations. Carbonyl vibrations for the amide groups can be observed at roughly 1648 cm^{-1} and 1570 cm^{-1}. Moreover, overtone band was observed at the peak range from 2000 cm^{-1} to 1667 cm^{-1} which indicates the Lisinopril structure consists of benzene ring.



Graph 7 Brand A Lisinopril's IR Spectrum.

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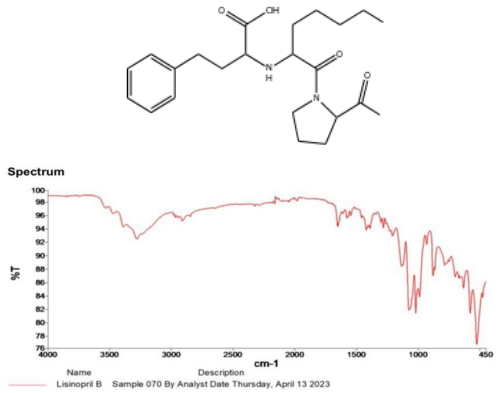
FTIR of Brand B Lisinopril

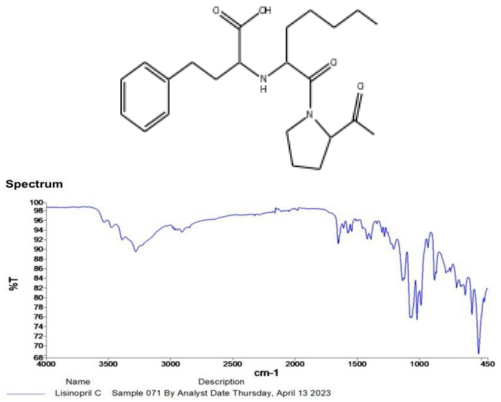
The IR Spectrum of Brand B Lisinopril was shown in Graph 8. FTIR spectrum of the Lisinopril was identified at a peak around 3280 cm^{-1} containing the O-H band due to the firmly bound carboxylic group. This Brand B Lisinopril was spectroscopically examined, the peak around 3500 cm^{-1} to 3300 cm^{-1} indicating the asymmetric and symmetric N-H bands of primary amine having hydrogen bonding. The peak around at 2920 to 2850 cm^{-1} was observed having asymmetric C-H stretching vibrations. Carbonyl vibrations for the amide groups can be observed at roughly 1647 cm^{-1}. Furthermore, an overtone band was detected in the peak region of 2000 cm^{-1} to 1667 cm^{-1}, indicating that the Lisinopril structure contains a benzene ring.



Graph 8 Brand B Lisinopril's IR Spectrum.

FTIR of Brand C Lisinopril

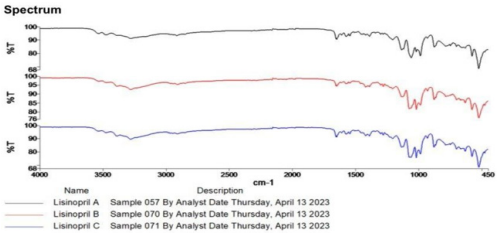
The IR Spectrum of Brand C Lisinopril was shown in Graph 9. FTIR spectrum of the lisinopril was identified at a peak around 3282 cm^{-1} containing the O-H band due to the firmly bound carboxylic group. This Brand C Lisinopril was spectroscopically examined, the peak around 3500 cm^{-1} to 3300 cm^{-1} indicating the asymmetric and symmetric N-H bands of primary amine having hydrogen bonding. The peak around at 2920 to 2850 cm^{-1} was observed having asymmetric C-H stretching vibrations. Carbonyl vibrations for the amide groups can be observed at roughly 1645 $cm^{-1}$and 1570 cm^{-1}. Moreover, an overtone was detected in the peak region of 2000 cm^{-1} to 1667 cm^{-1}, indicating that the Lisinopril structure consist a benzene functional group.



Graph 9 Brand C Lisinopril's IR Spectrum.

Comparison between all brands of Lisinopril

Comparison of IR spectrum between all brands of Lisinopril are shown in Graph 10. According to the figure 5.5, the spectrum range of all Lisinopril brands were very similar to each other.



Graph 10 All Brands of Lisinopril IR Spectrum.

Disintegration test on different brands of Lisinopril

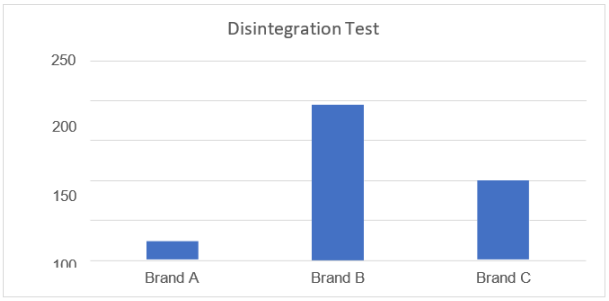
According to Table 10, time taken for Brand A Lisinopril to dissolve was 23s. Time taken for Brand B Lisinopril to dissolve was 194s and for Brand C Lisinopril was 100s. Time taken for Brand A Lisinopril to dissolve was the fastest while Brand B was the slowest.

Table 10 Time taken for Lisinopril tablets to dissolve

Brand	Time taken for each tablets to dissolve (seconds)
A	23 s
B	194 s
C	100 s

Comparison of each brand of Lisinopril on disintegration test

According to Graph 11, it showed the comparison of all brands of Lisinopril on disintegration test.



Graph 11 Comparison of each brand of Lisinopril on disintegration test.

Discussion

The aim of this study was to assess the percentage purity of several brands of Lisinopril tablets which are commercially accessible in the local market using UV-spectrophotometric and structural characterization through FTIR methods. The UV-spectrophotometric approach was recommended by both the United Stated Pharmacopoeia and the British Pharmacopoeia for Lisinopril in bulk or tablet forms. Therefore, this UV-spectrophotometric method will be utilized in this research to evaluate the percentage purity and determine which brand of Lisinopril is more pure. Besides, FTIR method is used to determine the spectrum of different brands of Lisinopril. First and foremost, before performing the Lisinopril test, every single tablet was weighted and crushed into powder. The weight homogeneity of different brands of Lisinopril tablets was determined by weighting each tablet. After being crushed, the powder was sealed in a re-sealable plastic bag to safeguard it from coming into contact with the surrounding moisture. These powders were then labelled and stored in a cold, dry spot inside the desiccator.

Brand A had the highest weight while Brand B had the lowest weight. Thus, this indicated that Brand A may contain the most

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excipients while Brand B may consist of the least excipient such as diluent, binder, lubricant, disintegrating agents, colours and others. Based on the average weight of Lisinopril tablets, each brand's Lisinopril tablets were under B.P.'s category of "80 mg to 250 mg". According to British Pharmacopoeia, the percentage deviation of individual weight differences from the average weight should not exceed ±7.5% for a minimum of 18 tablets and ±15% for a maximum of two tablets. The weight uniformity test was passed by all brands of Lisinopril pills. It also guarantees that all tablets are within the limits of their average weight and provides statistics on intra and inter batch consistency.[11] The quality control tests for thickness were carried out to ease product packaging either in blisters or plastic container and to control customer acceptability of the product since they were crucial and had an influence on disintegration and dissolution behaviour. Percentage purity determination of different brands of Lisinopril was performed by using UV-Spectrophotometric method. UV-spectrometer was used to measure the amount of ultraviolet radiation absorbed by Lisinopril in sample solution. Freshly prepared distilled water was used in the assay of Lisinopril as it is soluble in water. Besides, sonication was done for 15 minutes to dissolve the Lisinopril powder uniformly. Filtration was involved in this method in order to remove the residue which consists of the undissolved excipients used in a tablet formulation from the Lisinopril solution. Furthermore, the absorbance of standard and sample were measured. The absorbance of the standard must be higher than the sample in order to produce the percentage purity which was within the limit given by B.P. and U.S.P.[12,13] Comparison of percentage purity between standard and samples using UV-spectrophotometric method was recorded According to British Pharmacopoeia, the percentage purity of Lisinopril should be in the range of 92.5% and 105%.[9] Thus, only Brand A and Brand C passed the test while Brand B failed the test. Besides, according to U.S.P., the percentage purity of Lisinopril should be in the range of 90% to 110% of the labelled amount of Lisinopril.[14] Therefore, only Brand A and C passed the test while Brand B failed the test. This indicated that brand A was comparatively better than other brands which used in this research. In conclusion, only brand A and C was within the limit specified by both B.P and U.S.P. Brand A was the best while brand B was the worst among others brands of Lisinopril tablets during the research by using UV-spectrophotometric method.

Moreover, this research also included the determination of spectrum of all brands of Lisinopril by using FTIR method. FTIR is a powerful analytical tool for discovering functional groups and analyzing covalent bonding data. Covalent bonds in a molecule selectively absorb infrared ray of certain wavelengths, causing the vibrational energy of the bond to vary. The type of vibration caused by infrared ray either stretching or bending is determined by the atom. This is due to that various bonds and functional groups absorb different frequencies thus the transmittance pattern for each molecule is unique. The FTIR technique was used to determine and identify infrared spectrum of all brands Lisinopril tablets. To disinfect the surface of the crystal, ethanol was utilized to eliminate the contamination and ensure that the surface of the diamond crystal was not scratched during cleaning. The pressure arm was used to provide pressure to the crystal plate in order to create constant contact between the crystal and the sample. Before scanning the Lisinopril powder, a background scan should be performed. After placing the Lisinopril sample, the spectrum was scanned 16 times in order for the spectrum to be more to the predicted peak instead of only one scan. Since noise is an unpredictable phenomenon, combining numerous scans results in a decrease owing to noise cancellation. As a result, combining many scans will result in a higher signal-to- noise ratio.[15] IR spectrum of standard Lisinopril powder and the comparison between all other brands of Lisinopril tablets were recorded respectively. In this research, only the peak of 4000 cm^{-1} to 1500 cm^{-1} was identified from the Lisinopril. The stretching vibrations of an O-H band of water have been attributed to the FTIR spectrum from the standard Lisinopril and sample Lisinopril. Primary amine asymmetric and symmetric N-H bands with hydrogen bonding at peaks ranging from 3500 cm^{-1} to 3300 cm^{-1} were also observed in the spectrum. Asymmetric C-H stretching vibrations were revealed at the peak of 2920 cm^{-1} to 2850 cm^{-1}. Besides, the peak at 1654 cm-1 is caused by the carbonyl stretching of the tertiary amide group or the scissoring NH2 vibration, whereas a medium to strong absorptions at the peak of 1650 cm^{-1} to 1450 cm^{-1} is caused by the aromatic ring. Moreover, an overtone band was detected in the peak between the regions of 2000 cm^{-1} to 1667 cm^{-1}, indicating that the Lisinopril structure contains a benzene ring. All the major peaks were observed in this research using FTIR method.

The disintegration test was carried out to study the time taken for a Lisinopril tablet to dissolve using a basket type apparatus and the temperature was maintained at 37±2°C. According to the B.P. and U.S.P., all the tablets must be disintegrated within 15 minutes for uncoated tablets. Time taken for brand A to dissolve was 23s, brand B was 194s and brand C was 100s. All brands of Lisinopril tablets were dissolved within the limit given thus indicating that they had passed the test. Time taken for Brand A Lisinopril to dissolve was the fastest while Brand B was the slowest. Besides, the disintegration test determines how rapidly the tablet dissolves into smaller particles, offering a greater area of contact together with the availability of the medicine when administered to a patient. On the other hand, it may be used to analyze the possible impact of formulation and manufacturing factors on the biopharmaceutical characteristics of the tablet, as well as a quality control tool to evaluate consistency.[16-23]

Conclusion

In a nutshell, Brand A was the best among these three brands of Lisinopril used in the research, although both Brand A and Brand C were having almost same percentage purity. It had almost the same amount of Lisinopril active ingredient with standard Lisinopril. Brand B was the worst among other brands of Lisinopril tablets used in the research. It should be considered as substandard product. Although the Brand B contained Lisinopril but the content of Lisinopril was under the percentage requirement set by B.P. and U.S.P. In this research, it is conclude that both UV-spectrophotometric method and FTIR method can be used to evaluate the percentage purity and the structural characterization spectrum of different brands of Lisinopril tablets. Last but not least, qualitative analysis should always be performed to ensure the safety, quality, quantity and efficacy of pharmaceutical product that will help in the treatment of disease with confidence and satisfaction.

Funding details

The authors are much grateful to the Faculty of Pharmacy, AIMST University, Malaysia for funding and providing all facilities to carry out this research project.

Acknowledgments

Thanks to science officers, Ms. Amalina and Ms Jaya of MDL 4.

Conflicts of interest

Authors declare that there is no conflict of interests.

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