



RESEARCH ARTICLE

QUALITY CONTROL ASSESSMENT OF DIFFERENT BRANDS OF CIPROFLOXACIN 500 MG TABLETS IN YEMEN

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Abstract

Objective: Antimicrobial resistance is a growing concern worldwide. The indiscriminate use of antibiotics for a period of time has led to the emergence of antibiotic resistance in pathogenic bacteria. The present study was designed to evaluate the antibacterial efficacy of fluoroquinolone drugs, ciprofloxacin, enrofloxacin, moxifloxacin, sparfloxacin, norfloxacin, pefloxacin and ofloxacin against avian *Salmonella gallinarum* bacterial biofilms.

Methods: The study parameters, minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC) and biofilm elimination concentration (BEC) were determined on days 1, 3, 7, 10, 14 and 20 post inoculation for the planktonic (free) and biofilm cells of *S. gallinarum* by macro broth dilution method. The MIC and MBC values determined on days 1, 3, 7, 10, 14 and 20 for each of the fluoroquinolone drugs against the planktonic and biofilm forms of avian *S. gallinarum* were found to be non-significant.

Results: BEC values determined against the biofilm forms of *S. gallinarum* during the study period were found to be non-significant among the tested fluoroquinolones.

Conclusion: The results of the present study demonstrated that fluoroquinolone drugs were effective *in vitro* against both the planktonic and biofilm forms of avian *S. gallinarum*.

Keywords: Antibiotic resistance, biofilm, biofilm elimination concentration (BEC), fluoroquinolones, minimum bactericidal concentration (MBC), minimum inhibitory concentration (MIC), *S. gallinarum*.

INTRODUCTION

Ciprofloxacin is a synthetic fluoroquinolone derivative with broad spectrum antibacterial activity¹. It is widely used in the treatment of urinary tract infections, lower respiratory tract infections, bacterial diarrhoea, skin and soft tissue infections, bone and joint infections, gonorrhoea, and in surgical prophylaxis². In most of the cases, it would appear that for treatment of above said infections, physicians prescribe ciprofloxacin as a first choice of drug. Ciprofloxacin (CIP) is fluoroquinolone with fluorine at position 6 of naphthyridine ring. The chemical structure of ciprofloxacin is shown in Figure 1³. Quality control is all measures designed to ensure the output of uniform batches of drugs that conform to established specifications of identity, strength, purity, and other characteristics⁴. According to pharmaceutical manufacturers association of U.S. "quality is the sum of all the factors which contribute directly or indirectly to the safety, effectiveness and acceptability of the product"⁵. Also, quality control is the part of Good

Manufacture Practice (GMP) that is concerned with sampling, specifications, testing, documentation and release procedures which ensure that the necessary and relevant tests are actually carried out and that the materials are not released for use, not products released for sale or supply, until their quality has been judged to be satisfactory⁶.

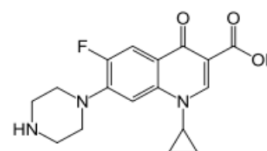


Figure 1: Ciprofloxacin.

A comprehensive evaluation, however, involves the determination of uniformity of weight, chemical content, friability, hardness, and disintegration tests along with dissolution rate. Drugs that are chemically and biopharmaceutically equivalent must be identical in strength, quality, and

purity. The content uniformity, disintegration, and dissolution rates must be comparable⁷. The United States Pharmacopoeia describes an HPLC method for CIPRO and CIPRO HCl assay in bulk, CIPRO injection, ophthalmic ointment, ophthalmic solution and tablets⁸. Despite most methods presented in official compendia are physicochemical assays, these methods do not represent the potency of antimicrobials neither can predict the loss of activity. The aim of the present study is to evaluate the quality of different brands of Ciprofloxacin tablets.

MATERIALS AND METHODS

Comparative *in-vitro* quality control parameters between six commercially available tablet different brands of ciprofloxacin were purchased from the retail pharmacies in Sana'a, Yemen. All brands were studied through the evaluation of weight variation, drug content, hardness, friability, disintegration time and dissolution profile. All the tablet brands of ciprofloxacin were labeled to contain 500 mg of ciprofloxacin per tablet and coded as A, B, C, D, and E (Table 1). The study was done by performing various test procedures associated to assess the quality of tablets. USP and British pharmacopoeia were used as standard for the evaluation study.

Table 1: Brands of Ciprofloxacin.

Code Brand	Country of origin	Strength in mg	Batch number
A	Yemen	500	12669
B	Yemen	500	13219
C	Yemen	500	1991
D	India	500	1301
E	India	500	FD3175

Methodology

Various analytical methods and tests are important for the development and manufacture of pharmaceutical formulations. The evaluation was done according to USP and BP standards.

Weight Variation

Twenty (20) tablets from each of the brands were weighed individually using an analytical weighing balance. The average weight for each brand as well as percentage deviations were calculated.

Drug content

The estimation of drug content for ciprofloxacin tablets was performed by crushing three tablets and quantity equivalent to 45 mg was taken and determined using 0.1M HCl using UV spectrophotometer at about 276 nm,

Hardness Test

A tablet was placed vertically on the Monsanto Hardness tester. The load was then applied along the radial axis of the tablet. The weight or load required for breaking the tablet was noted down. Similarly it was done for 10 tablets.

Friability

It was performed using Roche Friabilator, 10 tablets were weighed and placed in apparatus. The apparatus was rotated at a speed of 25 rpm. The apparatus was

made to rotate for 4 min. The tablets were reweighed (W_2) and compared with their initial weights and percentage friability was obtained. Percentage friability was calculated as:

$$\text{Percentage friability} = \frac{W_1 - W_2}{W_1} \times 100$$

Disintegration Test

Six tablets from each brand were employed for this test in a freshly prepared medium, 0.1N HCl at 37°C using the BP disintegration apparatus. The disintegration time was taken to be the time no particle remained on the basket of the system.

Dissolution Test

The dissolution test was carried out using USP apparatus II (paddle method) 5 in 6 replicates for each brand. The dissolution medium was 900 ml 0.1N HCL which was maintained at 37±0.5°C. In all the experiments 5 ml of dissolution sample was withdrawn at 0, 10, 20, and 30 min and replaced with equal volume of dissolution medium to maintain sink condition. The sampling times were selected in due consideration for the short disintegration times. Samples were filtered and assayed by ultraviolet spectrophotometry at 276 nm. The concentration of each sample was determined from a predetermined calibration curve for ciprofloxacin hydrochloride.

Data processing and analysis

After the completion of all test procedures data for all the individual tablets were recorded and separated on a different sheets according to the manufacturer. Finally, data were analyzed by using the above mentioned mathematical formula and MS-Excel®, 2007.

RESULTS AND DISCUSSION

General aspect

The present study was conducted to assess the quality of 500 mg ciprofloxacin tablets marketed in Sana'a Yemen. To achieve this purpose, four different pharmaceutical companies (brands) A, B, C, D, and E were used (Table 1). They were obtained from different retail pharmacies in Sana'a and then were subjected to a number of tests.

Table 2: Average weight, % deviation from average weight, content uniformity, and % deviation from content uniformity of different brands of ciprofloxacin tablets.

Brands	Average weight (mg), % RSD	Content uniformity (%), % RSD
A	679.3 ±2.63	98.10±2.2990
B	758.3 ±1.07	101.3 ±0.897544
C	809.6 ±1.57	101.34±3.264
D	812.5 ±1.70	100.30±3.607
E	842.7 ±3.6	101.40±0.3778

A quality control study is very important to evaluate tablet properties. Different quality control parameters (e.g., weight variation, drug content uniformity, hardness, friability, disintegration time and dissolution tests) were performed to determine the differences

among various conventional ciprofloxacin tablets that are available in the Yemeni drug market.

Average Weight and Weight Variation:

Although the uniformity of weight does serve as a pointer to good manufacturing practice (GMP) as well as amount of the active pharmaceutical ingredients, especially for reproducibility of the product which is very essential for mass production of any product. The average weight and weight variation of the different brands of ciprofloxacin tablets tested are shown in Tables 3 and Figure 3. It was found that the average weight of different five brands tablets of ciprofloxacin

tablets ranged from 679.3 mg \pm 2.63% (A brand) to 842.7 mg \pm 3.58% (E brand), while the deviation from average weight for all product is not more than 3.58%. Therefore, all the five brands tested in this study complied with the compendia specification for uniformity of weight which states that for tablets weighing more than 324 mg, weight of not more than 2 tablets should not differ from the average weight by more than 5%⁹. Thus, all brands passed the weight uniformity test set by USP. Also, the results indicate the use of different excipients with different weights.

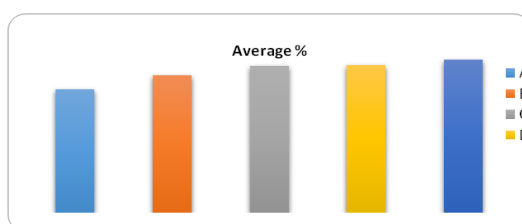


Figure 2: Comparison of different brands weight variation of different brands of ciprofloxacin tablets.

Table 3: Hardness (kg/cm²), % deviation from hardness, friability percent (%), disintegration time (min), dissolution (30 min), % deviation from dissolution of different brands of ciprofloxacin tablets.

Brands	Hardness (kg/cm ²) % RSD	Friability (%)	Disintegration time (min)	Dissolution (30 min), % RSD
A	20.03 \pm 14.397	0.36	1.41	99.33 \pm 2.03711
B	27.41 \pm 7.98681	0.37	3.16	100.15 \pm 1.4314
C	25.585 \pm 8.3994	0.12	3.51	98.15 \pm 1.796
D	23.35 \pm 8.16783	0.013	1.41	96.4 \pm 1.16786
E	31.535 \pm 7.37343	0.06	4.15	98.00 \pm 1.2712

Content Uniformity (Assay)

Every unit of tablet should contain the amount of drug substance equivalent to its label amount. For the evaluation of content, assay should be performed. The weight variation test is simplified and alternative to content uniformity test to assure therapeutic utility¹⁰ and is an indicator of variations in the drug content¹¹. The average chemical content (assay) values of the different brands of ciprofloxacin tablets tested shown in Table 2 and Figure 3. The results of the assay of chemical content of ciprofloxacin tablets showed that the active content of all the brands were between 98.10 \pm 2.2990% (A brand) and 101.40 \pm 0.3778% (E brand) of the labeled amount specified for ciprofloxacin tablets. A and B brands were chemically equivalent because they had chemical content not less than 90% and not more than 100% (w/w)¹². According to the United State Pharmacopoeia¹³, ciprofloxacin tablets should contain not less than 90% and not more than 110% of ciprofloxacin tablets.

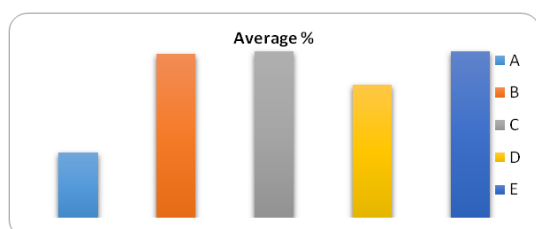


Figure 3: Comparison of assay content (%) of different brands of ciprofloxacin tablets.

The results indicated that although different manufacturer formulates the different brands are under the BP/USP specification¹⁴. Furthermore, all the brands of the tablets passed the test for the content of ciprofloxacin tablets. All these brands fall within the British Pharmacopoeia Specification of 95–105%¹⁵.

Hardness Test

The crushing strength of the tablets is an essential criterion in the determination of the ability of the tablets to resist chipping, abrasion or breakage under conditions of storage, transportation and handling before storage¹⁶. Hardness, which is now more appropriately called crushing strength of the tablet is determined to make adjustments to the pressure in the tablet press¹⁷. It can also influence other parameters such as friability and disintegration¹⁸. The average values of hardness of the different brands of ciprofloxacin tablets tested shown in Table 3 and Figure 4.

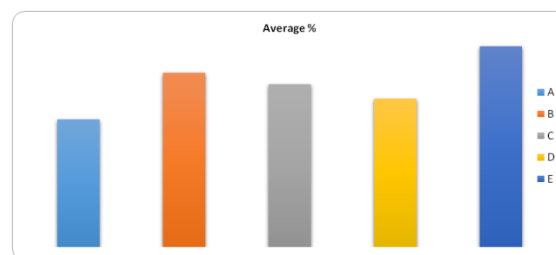


Figure 4: Comparison of hardness of different brands of ciprofloxacin tablets.

Average hardness was found in the range of 20.03 kg/cm² (A brand) to 31.535 kg/cm² (E brand). The results indicated that all brands of ciprofloxacin tablets were not in the limit range of between 4 to 10 kg/cm² stated^{17,19}. Where all brands were greater than 20 kg/cm². The hardness of the tablets showed that all brands gave the highest crushing strength. Hardness is referred to as non-compendial test. The hardness or crushing strength assesses the ability of tablets to withstand handling without fracturing or chipping. It can also influence other parameters such as friability and disintegration. Normally, a force of about 4 kg is the minimum requirement for satisfactory tablets²⁰. Therefore, the tablets of all products were satisfactory for hardness.

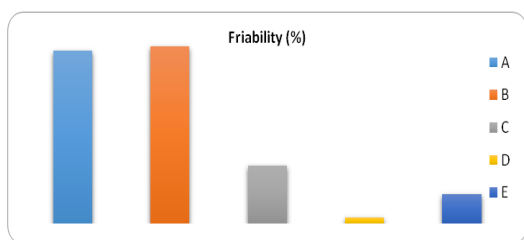


Figure 5: Comparison of friability percent (%) for different brands of ciprofloxacin tablets.

Friability Test

Tablet hardness is not the absolute indicator of the tablet strength since some formulations when compressed to very hard tablet tend to cap or laminate on attrition losing their crown part. Therefore, another measure of the tablet strength, its friability is often measured. The loss due to abrasion is a measure of the tablet friability. The average values of friability of the different brands of ciprofloxacin tablets tested shown in Table 3 and Figure 5. The average values of friability ranging from 0.01% (D brand) to 0.37% (B brand). The friability was less than 0.5%, indicating that it is within the compendia limits, which showed that the tablets possess good mechanical strength. Also, this showed that all the brands could withstand abrasion without loss of tablet integrity, and the causes of high friability were taken in consideration during manufacturing the tablet. Namely tablets compressed with larger force tend to have slightly lower friability compared with the ones compressed with smaller force²¹. The pharmacopoeia states that the friability value of tablets should be less than 1% and as such all the brands of ciprofloxacin had passed this friability specification²⁰.

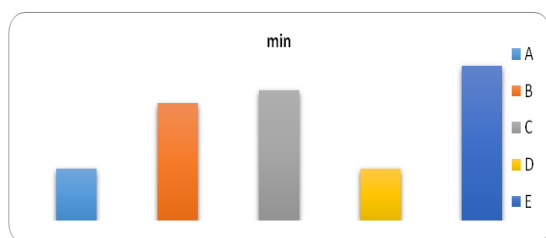


Figure 6: Comparison of disintegration time (min) of different brands of ciprofloxacin tablets.

Disintegration Time

Tablet disintegration time is one of the very important physicochemical properties in solid dosage forms. The disintegration test measures the time required for tablets to disintegrate into particles. This is a necessary condition for dissolution and could be the rate-determining step in the process of drug absorption. The average values of disintegration of the different brands of ciprofloxacin tablets tested shown in Table 3 and in Figure 6. The results of disintegration time (min) of ciprofloxacin tablets were ranging from 1.41 min (A and D brands) to 4.15 min (E brand). All brands of the ciprofloxacin tablets passed the pharmacopoeia²² standard which stipulates a disintegration time of not more than 15 minutes for uncoated tablets, while USP specification for disintegration is 30 min both for uncoated and film coated tablets. All the brands were complied with the both BP and USP specifications. All the brands were complied with the both BP and USP specifications. The rapid disintegration time exhibited by all the brands might be due to type and amount of disintegrant used in the formulation. All the disintegration times had fallen within the acceptable range.

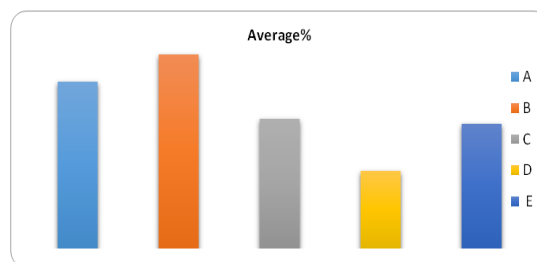


Figure 7: Comparison of dissolution test of different brands ciprofloxacin tablets.

Dissolution Test

The process of dissolution plays a vital role in liberation a drug from its dosage form and making it available for subsequent gastrointestinal absorption. So, dissolution analysis of pharmaceutical solid dosage forms is a very important test of product quality and it can be used as a sensitive method for differentiating between formulations of same therapeutic agent²³⁻²⁴. Drugs with poor dissolution profile will not be available in the body system to elicit therapeutic effect²⁵. Also, the dissolution study was carried out to determine the resistance of the materials the acidic environment of the stomach and their suitability as enteric coating materials. The drug release study is a measure of the amount of the drug released into the dissolution medium with time. This study gives an idea of amount of drug available for absorption after oral administration. Drugs with poor dissolution profile will not be available in the body system to elicit therapeutic effect²⁵. The average values of dissolution of the different brands of ciprofloxacin tablets tested shown in Table 3 and graphically in Figure 7. The obtained dissolution content at 30 minutes was found to be ranged from 96.48±1.168% to 100.15±1.4314%. All brands of ciprofloxacin tablets showed more than 90% drug release after 30 minutes. At 30 mins, all the

brands released more than the pharmacopoeia (USP 30, NF 25) requirement of 70% active pharmaceutical ingredient²⁰. All the brands of the ciprofloxacin hydrochloride tablets complied with the official specification for content uniformity having between 92-104% as stipulated by the USP. This might be as a result of strict adherence to good manufacturing practice in the process of manufacturing these tablets.

CONCLUSIONS

From the present study, it was clearly demonstrated that all five brands of the ciprofloxacin hydrochloride tablet comply with BP and USP specifications for *in vitro* quality control tests of uniformity of weight, uniformity of content, friability, disintegration time, and dissolution except hardens test for five brands. The USP and BP specification of maximum hardens value of 10 kg/cm², where the lower value of hardens is 20.03 kg/cm² and the value is 31.535 kg/cm². But Hardness is referred to as non-compendial test. Finally, bioequivalence studies are essential and important. Also such studies may be more important in developing countries where counterfeit and sub-standard drugs have become a major challenge to health care services.

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AUTHOR'S CONTRIBUTION

Ali A: writing original draft, conceptualization. **Alsaifi A:** methodology, investigation. The final manuscript was read and approved by all authors.

DATA AVAILABILITY

Data will be made available on request.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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