ABSTRACT
Objectives: Carbamazepine (CBZ) is an anticonvulsant drug used in the treatment of epilepsy and neuropathic pain. The aim of present study was to develop and evaluate lozenges of Carbamazepine for improvement of bioavailability and patient compliance especially for those patients who have difficulty in swallowing
Methods: The lozenges were prepared using sucrose as base; HPMC K4M, methyl cellulose were used as polymers by heating and congealing method on laboratory scale. All the formulations prepared were subjected to various physicochemical parameters like hardness, friability, weight variation, drug content and in vitro dissolution studies. Stability studies of selected formulations of batch CL4 were also carried out at 40/75% relative humidity for 6 months.
Results: All the formulations showed good physical appearance. The Thickness of the formulations was in the range of 14.23±0.12 to 14.50±0.06cm, weight variation was found to be in the range of 2.34± 0.12 to 4.51± 0.08%. The percent drug release was found in the range of 55.49 to 93.27%. Selective formulation was found to be stable at different temperature conditions.
Conclusion: Study concludes that incorporating polymers like HPMC K4M and methylcellulose can be used to formulate effective medicated Carbamazepine lozenges especially for patients who cannot swallow solid oral dosage forms
Keywords: Carbamazepine (CBZ), in vitro dissolution, HPMC K4M, Lozenges, stability studies, swallowing.

INTRODUCTION
The word "Lozenge" is derived from French word "Losenge" which indicates a diamond shaped geometry with four equal sides3. Lozenges are the flavored medicated solid, unit dosage forms intended to be sucked and held in the mouth or pharynx containing one or more medicaments usually in the sweetened base3. They dissolve slowly in the mouth and so release the drug dissolved in the saliva. The drugs having a large dose can be easily administrated formulating as lozenges. The oral route of drug administration is most preferred route because of many advantages associated with it like ease of ingestion, pain avoidance, versatility and most important patient compliance3. However geriatric and pediatric patients suffer from dysphagia (difficulty in swallowing), thus oral route for drug administration is not suitable in these cases. There are other conditions in which oral route is not preferred like unavailability of water, sudden episodes of allergic attack, mentally retarded patients4. Most of the lozenge preparations are available as over the counter medications. The dosage form can be adopted for local as well as systemic therapy and a wide range of drugs like analgesics, anesthetics, antimicrobials, antiseptics, antitussives, aromatics, astringents, corticosteroids, decongestants, demulcents and other can be delivered in the form of lozenges5. Lozenges are associated with many advantages like avoidance of first pass hepatic metabolism, no need of water intake, reduction in gastric irritation, improved bioavailability with reduced dosing frequency to minimum side effects6.

Carbamazepine (CBZ) is an anticonvulsant is a medication used primarily in the treatment of epilepsy and neuropathic pain7. It is used in schizophrenia along with other medications and as a second line agent in bipolar disorder. Carbamazepine is relatively slowly but well absorbed after oral administration8. Its plasma half-life is about 30 hours when it is given as single dose, but it is a strong inducer of hepatic enzymes and the plasma half-life shortens to about 15 hours when it is given repeatedly. It is highly lipophilic with an aqueous solubility of 0.078 mg/L. After oral administration it has poor bioavailability of 42-58%. It is a bitter drug with an unpleasant aftertaste9. In present study lozenges of Carbamazepine were prepared in
order to improve bioavailability and increase patient compliance.

MATERIALS AND METHODS
Carbamazepine was obtained from Reals Pharmaceuticals Limited, Lagos, Nigeria. Eudragit E 100, methyl cellulose, Polyethylene glycol 8000 and HPMC K4M were obtained from AC drugs ltd (Enugu, Nigeria). Sucrose and dextrose were provided by McNichols Plc, Ogun State, Nigeria. Citric acid was obtained from Mezk Global Limited (Lagos)

Preparation of Carbamazepine lozenges
Carbamazepine lozenges were prepared in laboratory scale by heating and congealing technique, the composition as given in table 1. Required quantity of all ingredients were transferred into a copper bowl, and then heated in a heating mantle at 150°C for 15 minutes. Then the temperature of the mixture was brought into 90°C, then Carbamazepine, polymers, flavoring agent and coloring agent were added with stirring by using glass rod, and the solution was transferred into a lubricated mould. It was allowed to cool for solidification then lozenges were collected and packed in an aluminum foil.

| Table 1: Composition of Carbamazepine lozenges

| Ingredients (mg) | Batch Code |
|------------------|------------|
|                  | CL1 | CL2 | CL3 | CL4 |
| Carbamazepine    | 10  | 10  | 10  | 10  |
| Eudragit E 100   | 10  | 15  | 20  | 25  |
| HPMC K4M         | 25  | 20  | 15  | 10  |
| Sucrose          | 800 | 740 | 730 | 700 |
| Dextrose         | -   | -   | 30  | 60  |
| Polyethylene glycol 8000 | 200 | 250 | 300 | 350 |
| Methylcellulose  | 25  | 20  | 15  | 10  |
| Citric acid      | 30  | 30  | 30  | 30  |
| Aspartame        | 100 | 100 | 100 | 100 |
| Talc             | 0.0126 | 0.0126 | 0.0126 | 0.0126 |
| Coloring agent   | 0.5 | 0.5 | 0.5 | 0.5 |
| Menthol          | 25  | 25  | 25  | 25  |

Evaluation of formulations
1. Measurement of thickness
The thickness of Carbamazepine lozenges were determined using Vernier callipers. Three lozenges from each batch were used and average values were calculated.

2. Weight variation
The formulated Carbamazepine lozenges were tested for weight uniformity. Twenty formulations were collectively and individually weighed. From the collective weight, average weight was calculated. Each lozenge weight was then compared with average weight to ascertain whether it is within permissible limits or not.

3. Hardness
The lozenge crushing strength, which is the force required to break the lozenge by compression in the diametric direction. The hardness of the Carbamazepine lozenges was determined by using Monsanto Hardness tester, where the force required to break the lozenges was noted. It is expressed in kg/cm².

Ten formulations of each batch were used for the estimation of hardness.

4. Friability
The Roche friability test apparatus was used to determine the friability of the lozenges. Six pre weighed Carbamazepine lozenges were placed in the apparatus, for 4 min at 25 rpm. Then the lozenges were reweighed. The percentage friability was calculated by using the formula.

\[
\% \text{ Friability} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100
\]

5. Drug content
Three Carbamazepine lozenges from each batch were selected and weighed individually and crushed in a mortar. Drug was extracted with 100 ml of distilled water. The drug content was determined spectrophotometrically at 285 nm with blank lozenge extract as the reference. The formulated lozenges were evaluated for the following parameters.

6. In vitro dissolution studies
In vitro dissolution studies of Carbamazepine lozenges were carried out in 900 ml phosphate buffer pH6.8 using USP dissolution testing apparatus with a rotating stirrer speed at 100 rpm, and temperature of dissolution medium maintained at 37±0.5°C. The rpm of the paddle was fixed at 100. Aliquots of 5ml were withdrawn at regular intervals; filtered and same amount of fresh dissolution medium was replaced at the same temperature. The filtered solutions were analyzed by using (Shimadzu, Japan) UV-spectrophotometer at 285 nm.

7. Disintegration test
The disintegration time of Carbamazepine lozenges were determined by USP Disintegration apparatus and disintegration time was noted in buffer of pH 6.4 at 37°C.

8. Stability test
For accelerated stability study, selected formulation was kept in airtight dark container according to ICH guidelines at 40/75% relative humidity for 6 months.

RESULTS AND DISCUSSION
Four different formulations of Carbamazepine lozenges were prepared successfully in laboratory scale by heating and congealing technique. Different ingredients i.e. Eudragit E 100, HPMC K4M, sucrose, dextrose, polyethylene glycol 8000, methylcellulose, citric acid, aspartame, talc, coloring agent, menthol were incorporated in different ratio. In the Carbamazepine lozenges formulations menthol was used as flavoring agent, it provides a desirable soothing effect.

Figure 1: Physical appearance of prepared Carbamazepine lozenges
Table 1: Evaluation parameters for Carbamazepine lozenges formulations

| Batch code | Thickness (cm) | Hardness (Kg/cm²) | % Weight variation | % Friability | % Drug content | Disintegration time (min) |
|------------|----------------|-------------------|--------------------|--------------|----------------|--------------------------|
| CL1        | 14.32±0.08     | 15.95±0.13        | 3.25±0.14          | 0.96±0.07    | 96.72±0.09     | 25±0.2                  |
| CL2        | 14.50±0.06     | 16.43±0.18        | 2.42±0.07          | 0.93±0.13    | 95.28±0.12     | 24±0.1                  |
| CL3        | 14.38±0.16     | 16.35±0.08        | 4.51±0.08          | 0.94±0.25    | 97.47±0.43     | 21±0.2                  |
| CL4        | 14.23±0.12     | 16.47±0.08        | 2.34±0.12          | 0.95±0.18    | 99.82±0.52     | 20±0.3                  |

Table 3: Stability study of Carbamazepine lozenges of batch CL4

| Time (Month) | Hardness | Friability | Weight Uniformity | % Drug content | Disintegration time (min) |
|--------------|----------|------------|-------------------|----------------|--------------------------|
| 0            | 16.47±0.08 | 0.95±0.18  | 2.34±0.12         | 99.82±0.52     | 20±0.3                  |
| 2            | 16.42±0.06 | 0.94±0.07  | 2.31±0.23         | 99.81±0.03     | 19.2±0.05              |
| 4            | 16.39±0.11 | 0.94±0.06  | 2.30±0.05         | 99.80±0.02     | 19±0.04                |
| 6            | 16.31±0.23 | 0.93±0.15  | 2.29±0.09         | 99.79±0.01     | 18.95±0.03             |

All the formulations showed good physical appearance. The prepared Carbamazepine hard lozenges evaluated for physicochemical parameters like hardness, friability, content uniformity, weight variation, thickness and drug content, results reported in the Table 3. The Thickness of the formulations was in the range of 14.23±0.12 to 14.50±0.06cm which indicates uniformity for all formulations. Weight variation was found to be in the range of 2.34± 0.12 to 4.51± 0.08%. Hardness of the formulations was in the range of 15.95±0.13 to 16.47±0.08kg/cm². Friability was in between 0.93±0.13 and 0.96±0.07%. The results of hardness and friability indicated that the Carbamazepine lozenges formulations were mechanically stable. Drug content was found to be in the range of 95.28±0.12 to 99.82±0.52%. Disintegration time of all Carbamazepine lozenges formulations lies in between 20±0.3 to 25±0.2min. Thus, it can be concluded that all the formulations passed physicochemical evaluation. In-vitro release study was performed for 30 minutes, results are shown in figure 1. The percent drug release was found in the range of 55.49 to 93.27%. Carbamazepine lozenges formulations of batch CL4 showed a release of 93.27% in 30 minutes, which was relatively faster in comparison to the other formulations prepared from ordered mixture, which may be due to the presence of Polyethylene glycol 8000, which aid in faster disintegration of the prepared lozenges. Since methylcellulose is a hydrophilic polymer, it facilitates quick release of drug. But as the concentration crosses the optimum quantity it retards drug release. During stability study of 6 months of selected Carbamazepine lozenges formulations of batch CL4, it was observed that the concentrations of drug in all the formulations were decreased a bit, within the pharmacopoeia limits. It was found that there was a slight change in taste and color of all the lozenges. Hence in the stability studies carried for six months it was found that there wasn’t any substantial changes in hardness, friability, weight uniformity, % drug content, disintegration time the selected formulations were stable throughout the study.

CONCLUSION

Lozenges enjoy an important position in pharmacy and will continue to remain at the same in future. From present study it is concluded that incorporating polymers like HPMC K4M and methylcellulose can be used to formulate effective medicated Carbamazepine lozenges especially for patients who cannot swallow solid oral dosage forms like tablet and capsules. This will offer better patient compliance and innovative dosage form. Lozenges are intended to slowly dissolve in the mouth over a relatively long period of time usually about 2-15 min or more as needed. By incorporation of synthetic polymers yields good results and release the drugs for a prolonged period of 30 min. Based on different parameters Carbamazepine lozenges formulations of batch CL4 can be considered as the optimized formulation.

AUTHOR’S CONTRIBUTION

The manuscript was carried out, written, and approved in collaboration with all authors.
CONFLICT OF INTERESTS
There are no conflicts of interest.

REFERENCES
1. Nagoba SN, Rao KP, Sameer S, Gujarathi DS, Nagoba BS. Studies in candy bases Ketaconazole pediatric lozenges. Int J Res Ayurveda and Pharm 2011; 2(1), 239-243. https://doi.org/10.13040/IJPSR.0975-8232.3(1).138-40
2. Gibbs KP, Portlock JC. Clinical Pharmacy and therapeutics. 2nd Edn. Published Walker Edwards, Scotland 1999; 347-367.
3. Pattanayak D, Das S. Formulation Development and Optimization of Medicated Lozenges for pediatric use. Int J Pharm Sci Res 2012; 3(1):138-140. https://doi.org/10.13040/IJPSR.0975-8232.3(1).138-40
4. Allen L.V. Troches and Lozenges. Secundum Artem. Current and practical compounding information for the Pharmacist 2001; 4(2): 23-25.
5. Kini R, Rathnandam M, Kamath D. Investigating the suitability of Isomalt and liquid glucose as sugar substitute in the formulation of Salbutamol sulfate hard candy lozenges. J Chem Pharm Res 2011; 3(4): 69-75.
6. Ceron-Litvoc D, Soares BG, Geddes J, Litvoc J, de Lima MS. Comparison of carbamazepine and lithium in treatment of bipolar disorder: a systematic review of randomized controlled trial”. Hum Psychopharmacol 2009; 24 (1): 19–28.
7. Gandelman, MS. Review of carbamazepine-induced hyponatremia. Progress in neuro-psychopharmacology and biological psychiatry. 1994; 18 (2): 211–33. https://doi.org/10.1016/0261-3177(94)90055-8
8. Tateno A, Sawada K, Takahashi I, Huijwara Y. Carbamazepine-induced transient auditory pitch-perception deficit. Pediatr Neurol 2006; 35: 131–4. https://doi.org/10.1016/j.pediatrneurol.2006.01.011
9. Zaid AN, Qaddomi A. Development and stability evaluation of enteric coated diclofenac sodium tablets using suretec. Pak J Pharm Sci 2012; 25, 59-64.
10. Esimone CO, Okoye FBC, Odimegwu DC, Nworu CS, Ologho PO, Ejahga PW. In vitro antimicrobial evaluation of lozenges containing extract of garlic and ginger. Int J Health Res 2010; 3(2): 105-110. https://doi.org/10.4314/jchr.v3i2.70274
11. Nagoba SN, Purushotham RK, Zakaullah S. Formulation of clotrimazole as lozenge tablet for improved delivery to oral thrush. J Pharm Biomed Sci 2011; 12(17): 1-4.
12. Peters D. Medicated Lozenges. In: Lieberman HA, Lachman L, Schwartz JB, editors. Pharmaceutical Dosage Forms: Tablets. 2nd ed. New York: Marcel Dekker Inc.; 2005; 419-577. https://doi.org/10.7897/2230-8407.07432
13. Mario DLM, Vanna S, Alessandra TP. Development of new topical formulations of Diphenhydramine hydrochloride: In vitro diffusion and In vivo preliminary studies. Int J Pharm Tech Res 2010; 2(1): 863-869.
14. Phaechamud T, Tuntarawongs S. Clotrimazole soft lozenges fabricated with melting and mold technique. Res J Pharm Bio Chem Sci 2011; 2(1): 869.
15. Kini R, Rathnandam M, Kamath D. Investigating the suitability of Isomalt and liquid glucose as sugar substitute in the formation of Salbutamol sulphate hard candy lozenges. J Chem Pharm Res 2011; 3(4): 69-75.
16. Herbert A, Lieberman, Lachman L. Pharmaceutical dosage forms. tablet series. Medicated Lozenges. 2nd ed. Marcel Dekker Inc. New York and Basel, 1991, 339-467. https://doi.org/10.7897/2230-8407.07432
17. Crotts G, Sheth A, Twist J. Development of an enteric coating formulation and process for tablets primarily composed of a highly watersoluble, organic acid. Eur J Pharm Biopharm 2001; 71-76. https://doi.org/10.1016/S0939-6411(00)00129-6
18. Mendes RW, Bhargarva H. Lozenges. In: Swarbrick J, editor. Encyclopedia of Pharmaceutical Technology. 3rd ed. North California, USA: Informa Healthcare Inc 2006; 2231-2235. https://doi.org/10.5923/j.ajoms.20150502.07