*Research Article*

Available Online at: www.ijpir.com

**International Journal of Pharmacy and Industrial Research**

ISSN Print 2231 – 3648
Online 2231 – 3656

# Formulation and evaluation of albendazole tablet by using sublimating agent

**Raj Ganeshalingam.P*, R.Suresh, Dr.S.Chandra, S.Kavibharathi, S.Sangeetha**

**JKKMMRF'S Annai sampoorani ammal college of pharmacy, Kumarapalayam, Namkkal, Tamilnadu, India.**

## ABSTRACT

Sublimation technique is one of the promising approaches for the formulation of drug compounds with poor aqueous solubility. The characterization of the prepared tablet was carried such as FTIR, XRD and AFM studies. XRD graph revealed the absence of peak due to sublimation of camphor. The AFM microgram described the uneven surface due to pores formed by sublimation. SEM indicated the circular shapes contrast on the tablet surface formed due to sublimation of camphor.
Porosity was the most critical element in the uptake of water, but porosity beyond certain extent is regulated by an effective surface area of the tablet. The concentration of camphor had a little effect because of the limited surface area present in the tablet. Avicel enhanced the liquid transport into a tablet matrix, accelerating both diffusion and capillary action because avicel exhibited the fast aqueous penetration even at low porosity due to the breaking of hydrogen bonds and widening of pores. This phenomenon enhanced the solubility by increasing the surface area and water penetration leading to an increased dissolution. Thus it may be concluded that the developed novel method for preparing fast dissolving tablets for albendazole increases the porosity and enhances the bioavailability.

**Keywords:** Albendazole, Sublimating agent, Avicel, Camphor, manitol

## INTRODUCTION

Oral drug delivery is the most preferred and convenient route of drug administration due to high patient compliance, cost effectiveness, good stability, flexibility in the design of dosage form and ease of production [1]. Albendazole is a white to yellowish powder. It is freely soluble in anhydrous formic acid and very slightly soluble in ether and in methylene chloride. Albendazole is practically insoluble in alcohol and in water. Albendazole is used to treat neurocysticercosis, an infection of the nervous system caused by pork tapeworms. This medicine is also used to treat cystic hydatid disease of the liver, lung, and peritoneum, an infection caused by dog tapeworms.
Albendazole is used to treat infections caused by worms. It works by keeping the worm from absorbing sugar (glucose), so that the worm loses energy and dies
Albendazole, also known as albendazolum is a medication used for the treatment of a variety of parasitic worm infestations. It is useful for giardiasis, trichuriasis, filariasis, neurocysticercosis, hydatid disease, pinworm disease, and ascariasis, among other diseases. It is taken orally.
Common side effects include nausea, abdominal pains, and headaches.[2] Potentially serious side effects include bone marrow suppression which usually improves on stopping the medication.[3] Liver inflammation has been reported and those with prior liver problems are at greater risk.[3] It is pregnancy category C in the United States and category D in Australia, meaning it may cause harm if taken by pregnant women. Albendazole is a broad-spectrum antihelminthic agent of the benzimidazole type.

### Rationale of drug selection

Albendazole is benzimidazole derivative, anti-parasitic drug against protozoan infection such as cystic hydatid, enterobiasis, Strongyloidiasis, Trichuriasis, neuro-

**Author for Correspondence:**
**Raj Ganeshalingam.P**
**JKKMMRF'S Annai sampoorani ammal college of pharmacy, Kumarapalayam, Namkkal, Tamilnadu, India.**

cysticerosis, Filariasis, Giardiasis and ascariasis [9]. Albendazole is poorly absorbed from gastrointestinal tract due to its low aqueous solubility which comes under the category of BCS class-II. The pharmacokinetic studies reveal that bioavailability is meager which varies from 5% and tends to change with the gastric contents [10-11]. Albendazole has the half life of 8-9 hours and exhibits hepatic metabolism. In this context, there is a need to increase the systemic availability of drug for an increased plasma residence time for better therapeutic effect. This study will be an attempt to optimize the therapeutic effect of Albendazole by formulation as a sublimated tablet.

## METHODOLOGY

### Preparation of Sublimated tablets

By using design expert software, the optimized concentration of subliming material was determined and the combined effect of formulation variable was analyzed. Accurately weighed quantity of Albendazole, sublimating agent (i.e. Camphor) and Avicel 102 were passed through number 60 mesh and physically mixed using mortar for 15 minutes. To this, sodium starch glycolate (super disintegrant) is added to impart swelling leading to rapid breakdown and fast drug dissolution. Mannitol is added to impart the good aqueous solubility and also enhances the property of breakdown of particles in tablet. The obtained blend was lubricated with talc and magnesium stearate for 5 minutes. The final mixture was directly compressed into tablets with 8mm round flat punches using rotary tableting machine [45]. The tablets were then subjected to sublimation by placing in a hot air oven at 60$^{o}$ C for 2 hours to generate a porous matrix, due to removal of volatile component [46]. The final weight of the tablet is adjusted to 750 mg and the composition of the tablets were given in table (1)

**Table 1: Formulation of Albendazole tablet by sublimation technique**

| FORMULATION | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 |
|---|---|---|---|---|---|---|---|---|---|
| DRUG | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| CAMPHOR | 150 | 187.5 | 225 | 150 | 187.5 | 225 | 150 | 187.5 | 225 |
| MCC | 176.25 | 176.25 | 176.25 | 213.75 | 213.75 | 213.75 | 251.25 | 251.25 | 251.25 |
| MANNITOL | 156.25 | 118.75 | 81.25 | 118.75 | 81.25 | 43.75 | 81.25 | 43.75 | 6.25 |
| SSG | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| MG.ST | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| TALC | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 | 22.5 |
| **TOTAL** | **750** | **750** | **750** | **750** | **750** | **750** | **750** | **750** | **750** |

## RESULTS AND DISCUSSION

### Drug-excipient compatibility study

### Fourier Transform Infrared Spectroscopy (FT-IR)

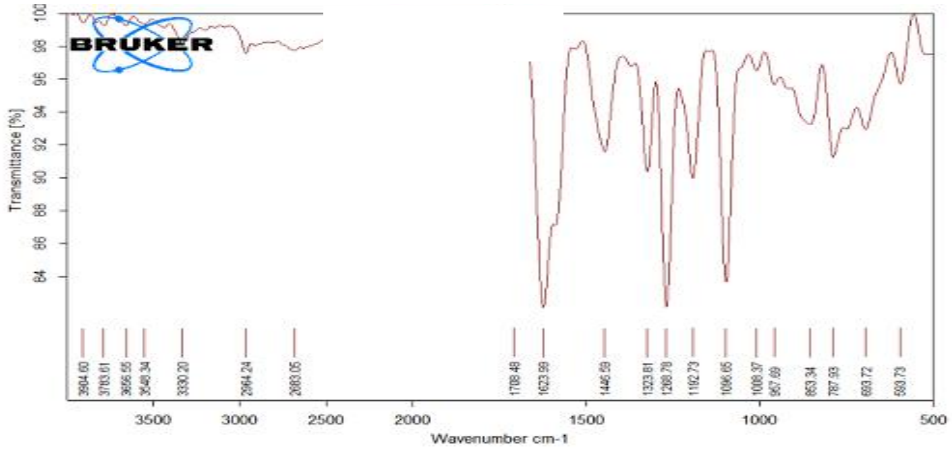



**Fig 1: Drug (API)**

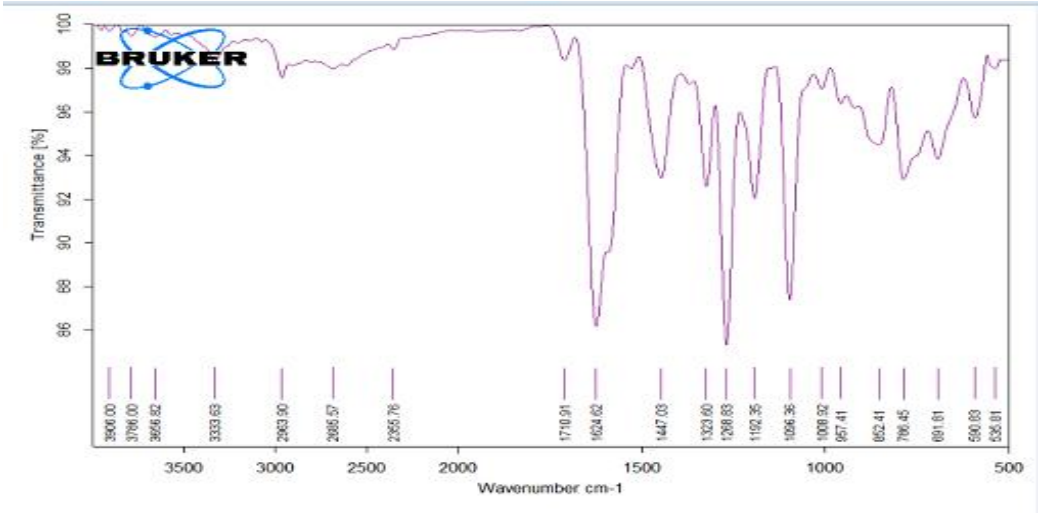



**Fig 2: Drug + Sodium Starch Glycolate**

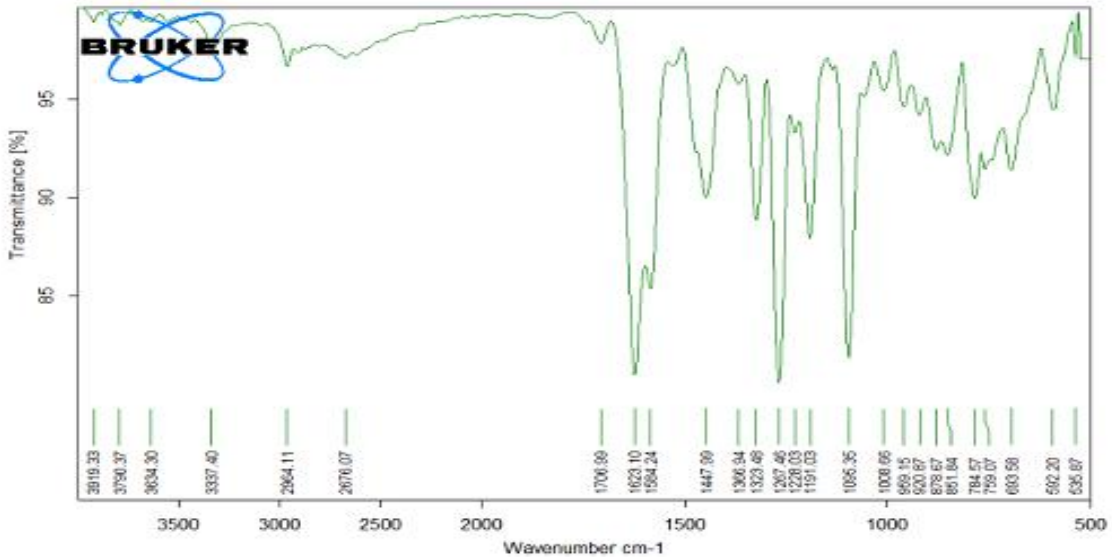
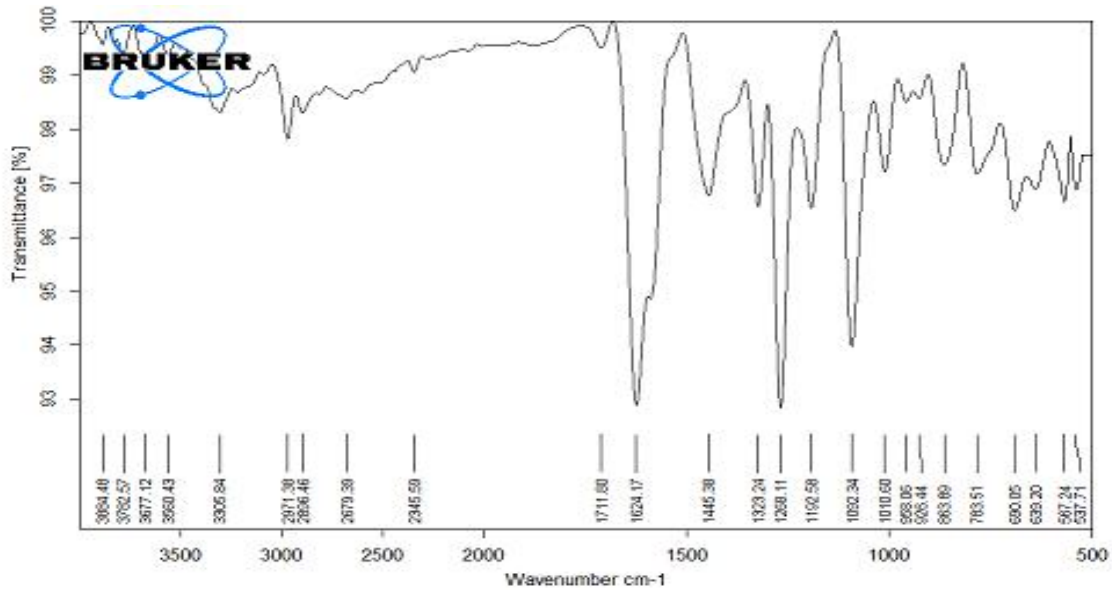



**Fig 3: Drug + Camphor**



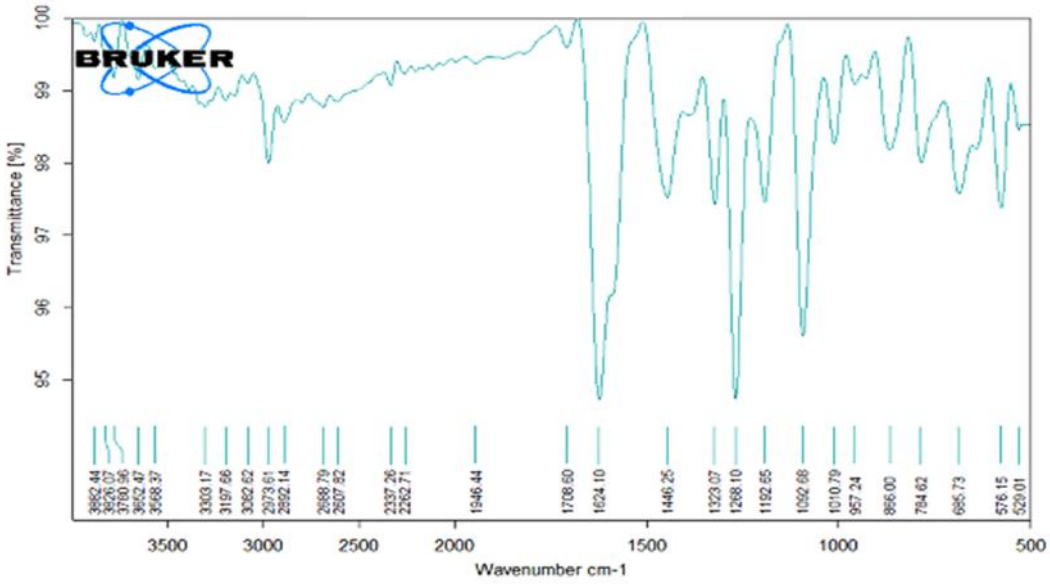



**Fig 5: Drug + Avicel**

Active Pharmaceutical Ingredient (API) was subjected to FT-IR study to evaluate the compatibility with other Excipients. FT-IR spectra of Albendazole exhibited characteristic benzimidazole vibrations. The stretching vibration observed at 1096 cm-1 represented the C-S bond, a typical propyl-thio feature of Benzimidazole.

Compatibility studies were performed by comparing the FT-IR spectra of API and its physical mixture with Excipients. The examination clearly indicated the retention of ABZ core functional group, thereby indicating the Compatibility with the selected ingredients.

**Table 2:**

| Formulation | Weight Variation | | Hardness (kg/cm2) | Friability (%) | Drug Content (%) | DT (sec) |
|---|---|---|---|---|---|---|
| | Before sublimation | After sublimation | | | | |
| F1 | 749±1.2 | 617±1.2 | 3.7±0.2 | 0.51±0.09 | 98.8±0.8 | 56±5 |
| F2 | 748±1.6 | 587±0.4 | 3.8±0.5 | 0.56±0.11 | 99.5±0.4 | 59±3 |
| F3 | 750±2.2 | 545±1.6 | 3.7±0.3 | 0.63±0.07 | 98.6±1.0 | 61±7 |
| F4 | 747±1.8 | 619±1.8 | 3.9±0.7 | 0.46±0.17 | 99.2±0.6 | 55±4 |
| F5 | 751±0.8 | 585±0.6 | 3.7±0.4 | 0.68±0.13 | 99.8±0.6 | 57±2 |
| F6 | 748±0.4 | 541±2.2 | 3.8±0.2 | 0.74±0.07 | 98.7±0.8 | 63±5 |
| F7 | 749±0.6 | 613±0.6 | 3.7±0.5 | 0.54±0.15 | 99.4±1.2 | 65±3 |
| F8 | 750±0.8 | 581±0.8 | 3.9±0.2 | 0.59±0.12 | 99.3±0.7 | 62±7 |
| F9 | 748±1.2 | 551±0.8 | 3.8±0.3 | 0.62±0.17 | 98.2±1.3 | 60±4 |

Values are expressed as Mean ± S.D

## Weight variation test

The decrease in mean weight of tablets after sublimation corresponds to weight of camphor added as shown in table (8.5). This study revealed that almost 90% of camphor had sublimated from the tablets. In all the formulation weight variations was within ±3.74% which was found to be within the IP limits.

## Friability

Friability of all formulations was found to be 0.46-0.74% (±0.07%). The Formulation F3, F6, F9 containing 225 mg of camphor shows more % friability when compared to other formulation. The friability data clearly indicates that as the concentration of camphor increases, % friability of formulation is also increased due to increased porosity. As per IP, All the formulation passed the % friability test.

## Hardness

Hardness of all formulations was found to be 3.7-3.9 kg/cm$^2$. The hardness and friability studies revealed that the tablets possessed good mechanical resistance.

**Uniformity of Drug Content**

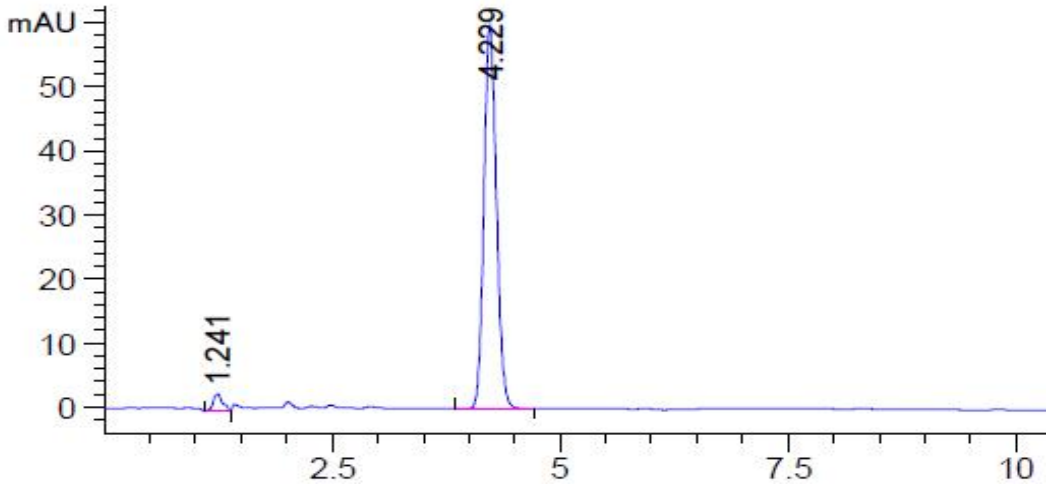



**Fig 6: Uniformity of drug content**

Uniformity of drug content was found to be more than 90% in all formulations. Hence, it was found to be within the IP limits.

## In-vitro disintegration test

The most important parameter that needs to be optimized in the development of Fast dissolving tablets is the disintegration time of tablets. In present study all tablets disintegrated in less than 70 seconds. All formulation was prepared using 150 to 225 mg concentration of camphor. In addition, sodium starch glycolate swells and Avicel enhances the breakage of hydrogen bond leads to widening of the pores [51-52]. The results showed that as concentration of camphor increases, the porosity of the tablet also increases which reveals the fastest disintegration, but due to higher porosity the tablet becomes more fragile.

## Measurement of Porosity

**Table 3: Evaluation of % Porosity**

| S.no. | FORMULATION | %POROSITY (% ±S.D) |
|---|---|---|
| 1. | F1 | 22.1±0.5 |
| 2. | F2 | 27.9±0.3 |
| 3. | F3 | 41.5±0.8 |
| 4. | F4 | 25.2±0.2 |
| 5. | F5 | 34.7±0.9 |
| 6. | F6 | 41.1±0.5 |
| 7. | F7 | 25.4±0.4 |
| 8. | F8 | 29.4±0.7 |
| 9. | F9 | 38.1±0.6 |

Values are expressed as Mean ± S.D

Tablets exhibit % porosity in the range of 22.1±0.5-41.5±0.8 for camphor concentration in the range of 150-225 mg. Hence many porous structures are responsible for faster water uptake and also facilitate wicking action of sodium starch glycolate. Therefore, Porosity is directly proportional to concentration of camphor and the effect of avicel on porosity has a negligible effect.

## In-vitro dissolution study

**Table 4: Cumulative percent drug release of Albendazole**

| Time | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | Control |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **15** | 22.7 | 21.1 | 26.8 | 22.7 | 30.6 | 32.3 | 31.9 | 27.4 | 32.1 | 5 |
| **30** | 38.9 | 31.9 | 34.1 | 38.9 | 39.7 | 38.5 | 41.6 | 42.20 | 42.4 | 9 |
| **45** | 44.4 | 44.3 | 44.4 | 44.4 | 48.7 | 45.4 | 47.9 | 47.5 | 45.5 | 11 |
| **60** | 48.6 | 46.8 | 45 | 48.6 | 49.9 | 48.6 | 50.2 | 49.6 | 47.7 | 15 |
| **90** | 52.9 | 49.3 | 52.9 | 54.7 | 51.9 | 54.8 | 53.1 | 52.6 | 53.6 | 19 |

Values are expressed in %CDR

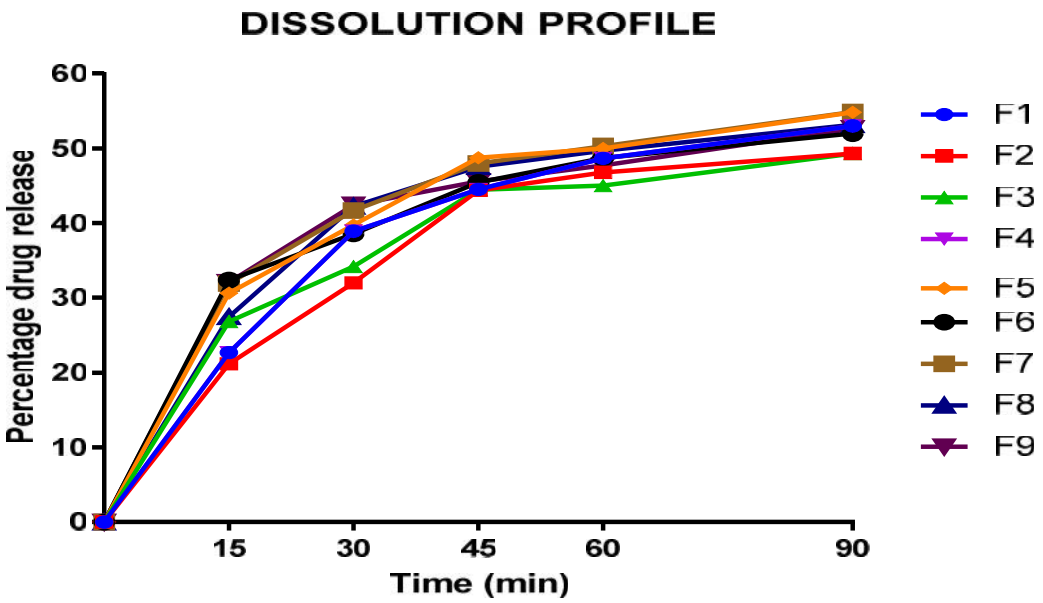



**Fig 7: Percentage drug release of Albendazole**

**X-ray Powder Diffraction (XRD) Analysis**

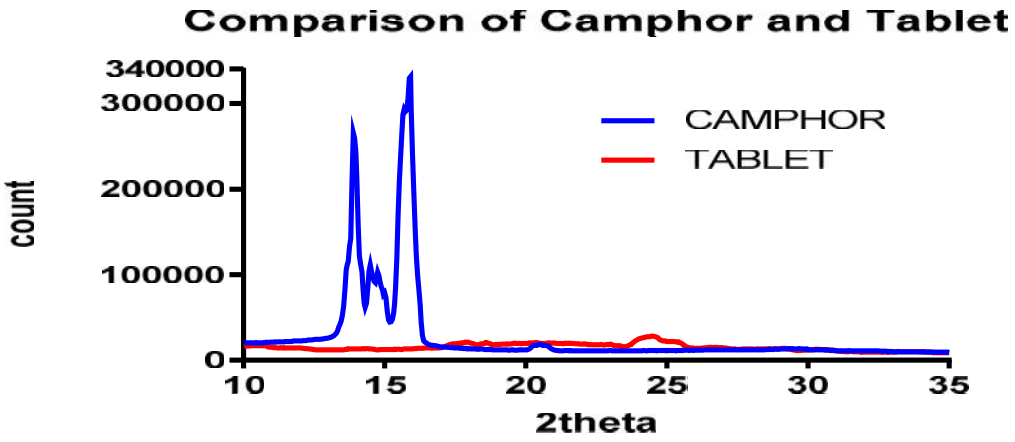



**Fig 8A: XRD of Camphor and Tablet**

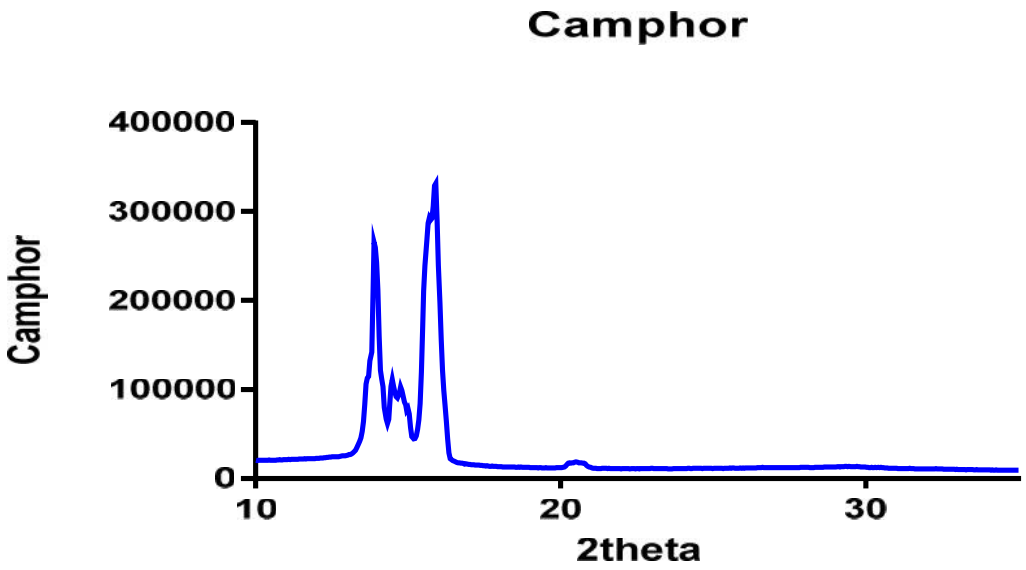



**Fig 8B: XRD of Camphor**

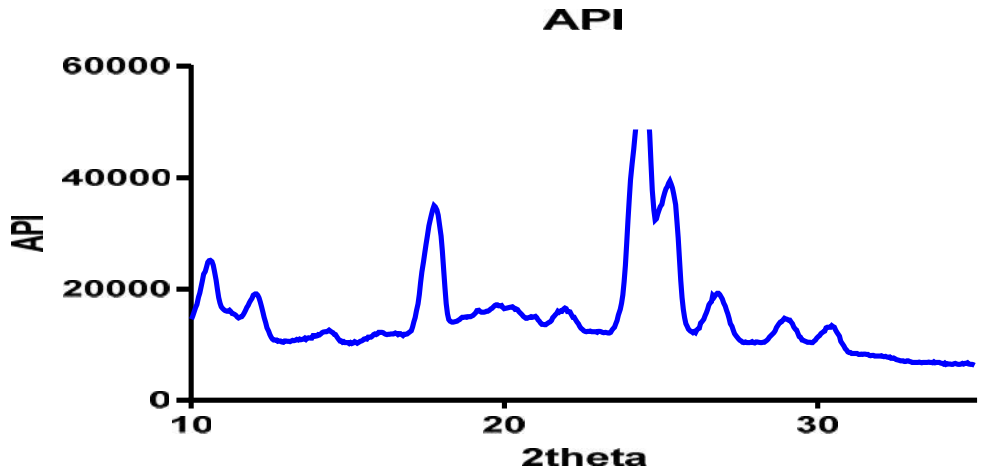



**Fig 8C: XRD of API**

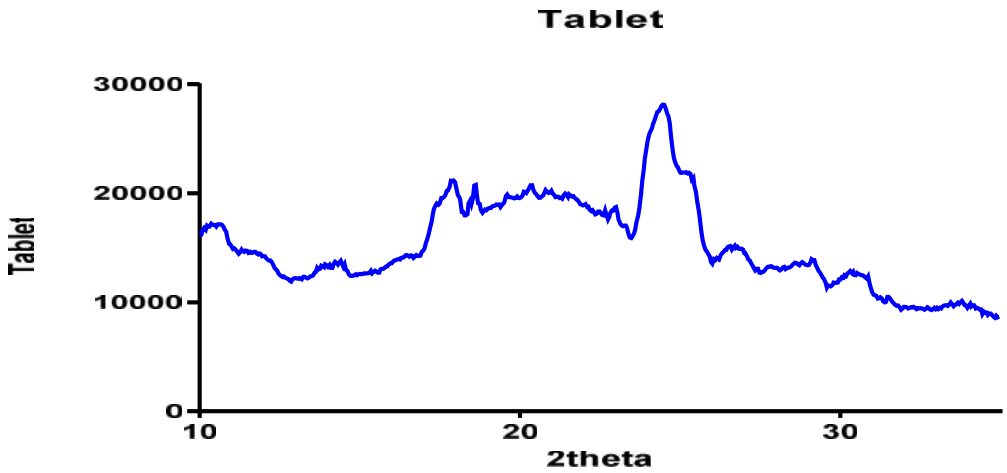



**Fig 8D: XRD of Tablet**

X-ray Powder Diffraction was conducted to establish the change in the crystalline nature of API and to establish the porosity of tablets. Powder XRD studies were conducted at a 2θ range of 10-35° with a sampling width of 0.01° in continuous scanning mode [53]. Camphor exhibited a highly intense sharp peak at 2θ= 13.9 and 15.5 illustrate the highly ordered crystal lattice structure. This is a unique characteristic nature of terpenoid derivative. Meanwhile, API exhibited a peak at 2θ=24.5° and 17.9°. The peaks were intense and clearly illustrated its crystalline nature. Consequently, this crystalline nature explains the low soluble and dissolution of albendazole. After sublimation, XRD analysis was conducted on a tablet to evaluate the degree of crystallinity. The graph revealed the absence of peak corresponding to terpenoids which indicates the complete sublimation of camphor.

## Scanning Electron Microscopic

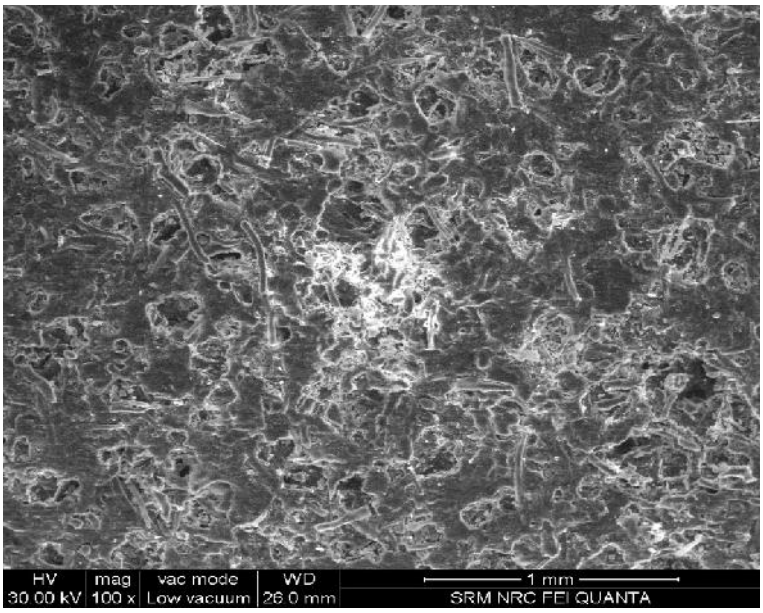



**Fig 9A: Surface Topology of Tablet**

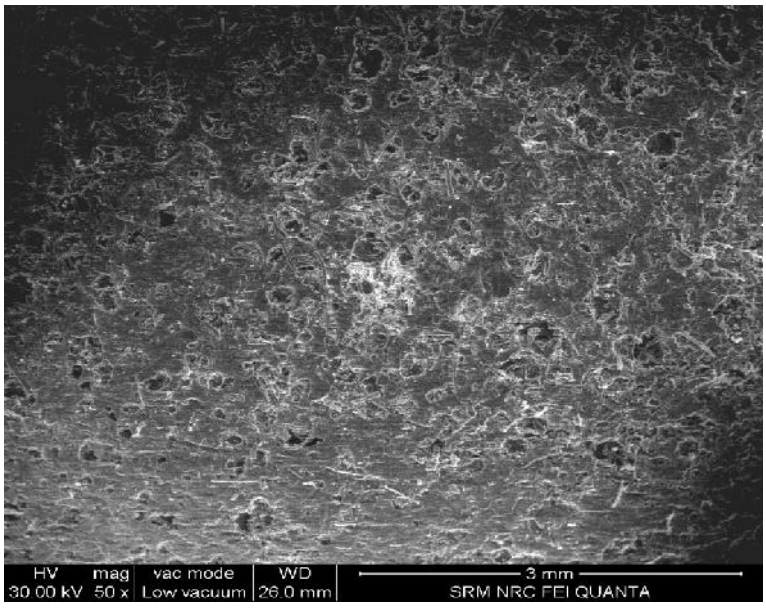



**Fig 9B: Surface Topology of Tablet**

SEM helps to analyze the surface morphology of the tablet at the microscopic level through a high-resolution image. Electrons were tunneled onto the tablet surface at high voltage to achieve better penetration in depth and to analyze the anomalous identification on the tablet surface. It was observed that tablet surface exhibited variations in secondary electron intensity appearing in a circular shape. This can be attributed to the electron channeling contrast, which indicates the uneven surface of the tablet. Furthermore, numerous circular shapes contrast observed can be attributed to the porous nature of the tablet surface formed due to camphor sublimation. Edge effect was observed around circular contrast also leverages the porosity of the tablet. In addition, the elongated rod-shaped crystals of microcrystalline cellulose were also seen in the field of examination.

## Effect of Variables

Dissolution is an important parameter for a dosage form to determine the extent of bioavailability. The effect of variables on dissolution at 30 minutes was fitted in a linear regression model, and the results were represented in table [6]. It showed that dissolution at 30 minutes was increased significantly with increase in the concentration of microcrystalline cellulose, but camphor did not play a significant role in improving the dissolution. This can be witnessed in the Pareto chart and from P value- was observed in the model. As a subliming material, camphor increased the percentage porosity of the tablet in the embedded spaces. But, it was observed that camphor didn't increase the percentage release significantly. This effect can be related at high concentration of camphor cannot impart maximum surface porosity beyond a certain extent, as dissolution is regulated by an effective surface area of the tablet.

Avicel, Because of its porous nature, aids in direct compression and also influences the disintegration and dissolution of a tablet. Increasing Avicel concentration significantly promoted the dissolution behavior of the tablet (P-value- 0.0105). This dissolution enhancing property absorbed in the study can be due to two reasons. In dissolution media, Avicel behaves by imbibing the water and widens the existing pores, and this phenomenon subsequently boosts the water imbibing nature of tablet in a higher effective surface area formed due to porosity by sublimation [52]. Albendazole tablet being prepared by direct compression technique with Avicel as a major ingredient was the primary reason for increased dissolution. The earlier investigation reported the conversion of crystalline avicel to a fracture and plastically deformed during compression [55]. The study reported structural change could have reduced the crystalline nature of Avicel. The combined effect of these two phenomenons could have amplified the solubility by increasing the surface area and water penetration leading to an increased dissolution.

**Table 5: Model characteristics**

| Statistical term | Value |
|---|---|
| Model p value | 0.0105 |
| Camphor p value | *0.3832* |
| Avicel p value | *0.0023* |
| Interaction p Value | *0.1771* |
| Regression coefficient ($R^2$) | 0.8271 |
| Coefficient of variance (%CV) | 4.66% |
| Lack of Fit | *0.1523* |

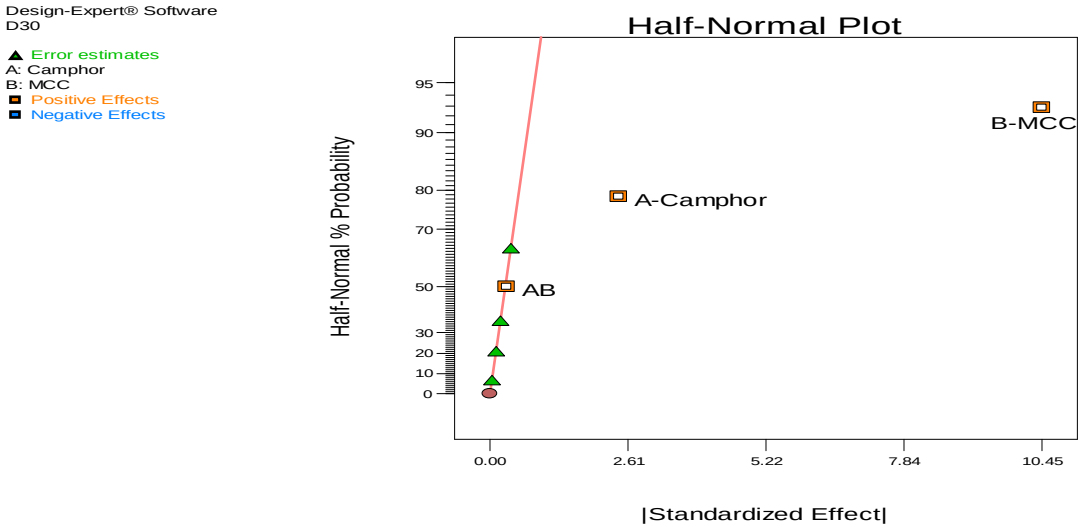



**Fig 10.1: Effects of Ecipients**

The results demonstrated that the effect of MCC plays a vital role in dissolution at 30 min when compared to camphor. It also reveals that interaction of camphor and MCC also influences the variables. This can also be witnessed in Pareto chart and also from low p-value, p <0.0001 observed in the model. The higher t-value observed in the Pareto chart endorse the selection of dominant effects altering the dissolution parameter.

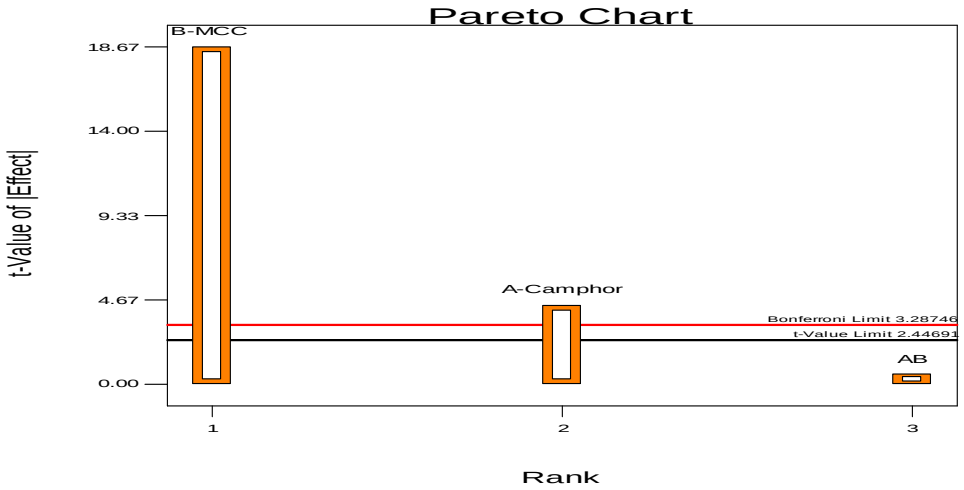



**Fig 10.2: Pareto chart**

Applying multiple regression analysis, the experimental data was analyzed and fitted to various models (linear, interactive, and quadratic) [56]. The results proclaim that linear order model exhibited higher regression (R2), low P value, and better descriptive statistics. Hence, linear model was adopted to fit the experimental data to establish an empirical model to facilitate the interrelation between formulation variables and response.

**Table 6: Analysis of variance table**

| Source | Sum of Squares | df | Mean Square | F Value | p-value Prob> F | |
|---|---|---|---|---|---|---|
| Model | 142.03 | 3 | 47.34 | 139.44 | < 0.0001 | significant |
| *A-Camphor* | *6.46* | *1* | *6.46* | *19.02* | *0.0048* | |
| *B-AVICEL* | *118.33* | *1* | *118.33* | *348.51* | *< 0.0001* | |
| *AB* | *0.11* | *1* | *0.11* | *0.32* | *0.5917* | |

**Table 7: Statistical data model**

| | | |
|---|---|---|
| Standard Deviation | 0.58 | R-Squared |
| Mean | 38.31 | Adj R-Squared |
| C.V. % | 1.52 | Pred R-Squared |
| PRESS | 7.17 | Adeq Precision |
| -2 Log Likelihood | 12.47 | BIC |

**Table 8: Final Equation in terms of Actual Factors**

| | |
|---|---|
| D30 | +10.58067 |
| Camphor | +3.76444E-003 |
| Avicel | +0.10444 |
| Camphor * Avicel | +1.17333E-004 |

Intending to visualize the relationship between dissolution and formulation variables, model graphs, namely, contour plots, and 3D response surface, were generated, to assess the individual and interactive effects on the response. It was evident that the increasing the concentration of variables will influence the percentage porosity and dissolution of the formulation. The planar 3D surface diagram (Fig 6) and linear curves observed that its contour region also assures the same. Moreover, the3D plot also indicated an absence of curvature effect in the explored design space.

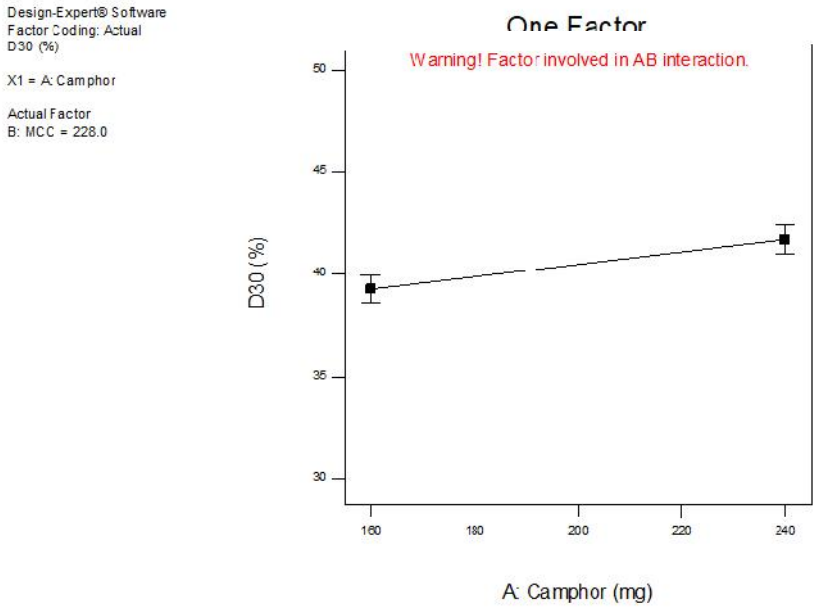



**Fig 10.3: Factor coding of Camphor**

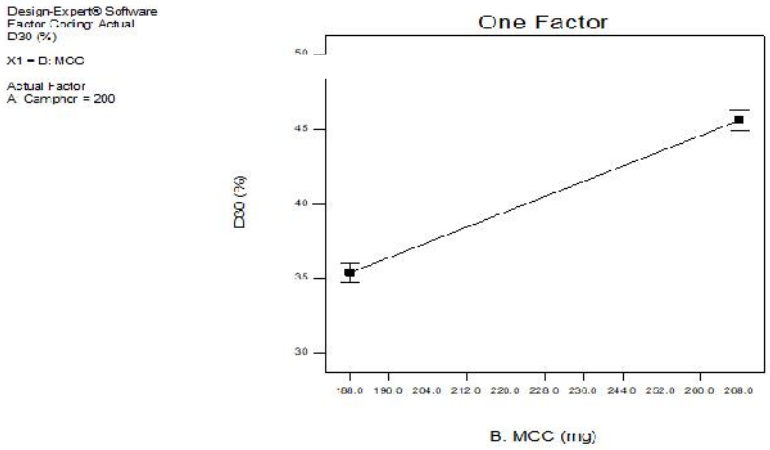



**Fig 10.4: Factor coding of MCC**

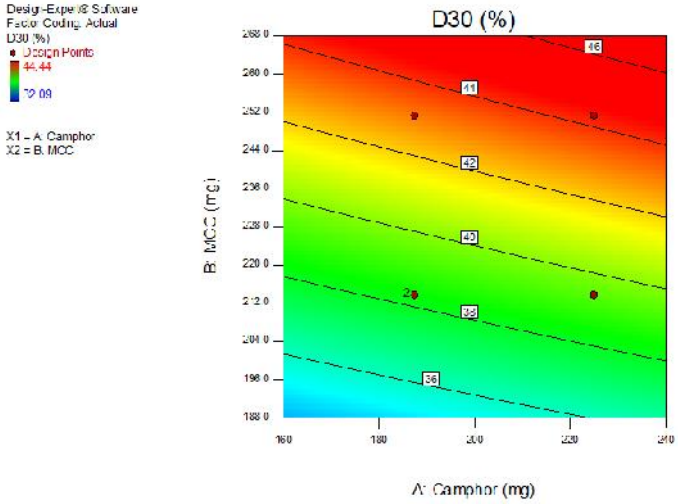



**Fig 10.5: Model Diagnostics**

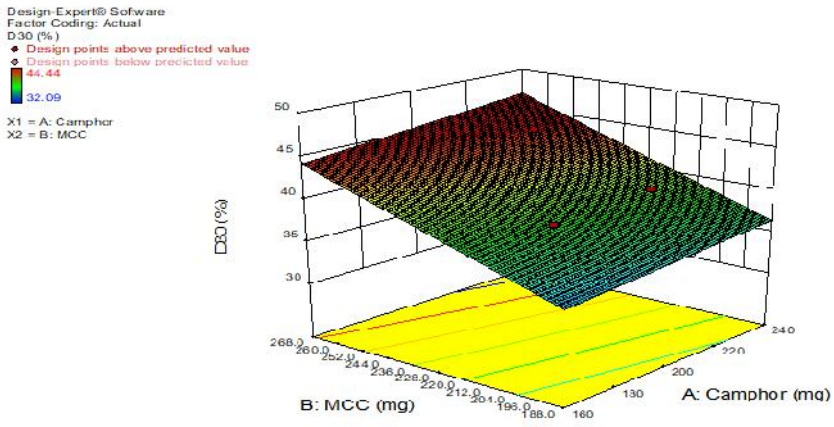



**Fig 10.6: Dimensional plot of response (%CDR)**

ANOVA analysis depicted that developed linear model was highly significant, as was evident from very low probability value .The goodness of the fit was checked by regression coefficient (R2). Here, the value of regression coefficient (R2 =0.8271) indicated that only 0.58% of the total variations was not explained by the adopted regression model. Furthermore, a good deal of reliability and high degree of precision of conducted experiments was indicated by low value of coefficient of variation (CV=1.52) which indicates the best fitness of developed model.

### Stability Studies

The stability studies for the formulation (F6) of sublimation of albendazole - tablet was conducted over 3 months of time with the following parameters and the observations are tabelated below. This is done in order to access the stability of the drug along the period of time.

**Table 9: Results of Stability studies**

| Parameters | Initial value | Value after 30 days |
|---|---|---|
| **Description** | White to off white colored, oblong shaped tablets | White to off white colored, oblong shaped tablets |
| **Hardness (kP)** | 3.8±0.2 | 3.8±0.2 |
| **Average Weight (mg)** | 551±2.2 | 551±2.2 |
| **D.T. (sec)** | 63±5.0 | 63±5.0 |
| **Friability (%)** | 0.74±0.07 | 0.74±0.07 |
| **Dissolution:** Fluconazole | 54.8 | 54.8 |

## SUMMARY AND CONCLUSION

Sublimation technique is one of the promising approaches for the formulation of drug compounds with poor aqueous solubility. The characterization of the prepared tablet was carried such as FTIR, XRD and AFM studies. XRD graph revealed the absence of peak due to sublimation of camphor.

The AFM microgram described the uneven surface due to pores formed by sublimation. SEM indicated the circular shapes contrast on the tablet surface formed due to sublimation of camphor.

Porosity was the most critical element in the uptake of water, but porosity beyond certain extent is regulated by an effective surface area of the tablet. The concentration of camphor had a little effect because of the limited surface area present in the tablet.

Avicel enhanced the liquid transport into a tablet matrix, accelerating both diffusion and capillary action because avicel exhibited the fast aqueous penetration even at low porosity due to the breaking of hydrogen bonds and widening of pores.

This phenomenon enhanced the solubility by increasing the surface area and water penetration leading to an increased dissolution. Thus it may be concluded that the developed novel method for preparing fast dissolving tablets for albendazole increases the porosity and enhances the bioavailability.

## REFERENCES


1. Ahmed IS, Aboul-Einien MH, Mohamed OH, Farid SF. Relative bioavailability of griseofulvin lyophilized dry emulsion tablet vs. immediate release tablet: A single-dose, randomized, open-label, six-period, crossover study in healthy adult volunteers in the fasted and fed states. Eur J Pharm Sci. 2008;35(3):219-25. doi: 10.1016/j.ejps.2008.07.002, PMID 18675344.
2. Ahmed IS, Nafadi MM, Fatahalla FA. Formulation of a fast-dissolving ketoprofen tablet using freeze-drying in blisters technique. Drug Dev Ind Pharm. 2006;32(4):437-42. doi: 10.1080/03639040500528913, PMID 16638681.
3. Ahmed IS, Shamma RN, Shoukri RA. Development and optimization of lyophilized orally disintegrating tablets using factorial design. Pharm Dev Technol. 2013;18(4):935-43. doi: 10.3109/10837450.2011.619543, PMID 22107175.
4. Alhusban F, ElShaer AM, Kansara JH, Smith AM, Grover LM, Perrie Y, Mohammed AR. Investigation of formulation and process of lyophilised orally disintegrating tablet (ODT) using novel amino acid combination. Pharmaceutics. 2010;2(1):1-17. doi: 10.3390/pharmaceutics2010001, PMID 27721339.
5. Alhusban F, Perrie Y, Mohammed AR. Preparation, optimisation and characterisation of lyophilised rapid disintegrating tablets based on gelatin and saccharide. Curr Drug Deliv. 2010;7(1):65-75. doi: 10.2174/156720110790396427, PMID 19863486.
6. AlHusban F, Perrie Y, Mohammed AR. Preparation, optimisation and characterisation of lyophilised rapid disintegrating tablets based on gelatin and saccharide. Curr Drug Deliv. 2010;7(1):65-75. doi: 10.2174/156720110790396427, PMID 19863486.
7. Allamneni Y, Murthy TE, Rao MV, Rao YU. Formulation design and development of lyophilzation cycles for novel formulation of proteasome inhibitor: bortezomib. WJPPS. 2017:1832-41. doi: 10.20959/wjpps20176-9420.
8. Ashish P, Harsoliya MS, Pathan JK, Shruti S. A review-formulation of mouth dissolving tablet. Int J Pharm Clin Sci. 2011;1(1):1-8.
9. Basu B, Bagadiya A, Makwana S, Vipul V, Batt D, Dharamsi A. Formulation and evaluation of fast dissolving tablets of cinnarizine using superdisintegrant blends and subliming material. J Adv Pharm Technol Res. 2011;2(4):266-73. doi: 10.4103/2231-4040.90885, PMID 22247895.
10. Chandrasekhar R, Hassan Z, AlHusban F, Smith AM, Mohammed AR. The role of formulation excipients in the development of lyophilised fast-disintegrating tablets. Eur J Pharm Biopharm. 2009;72(1):119-29. doi: 10.1016/j.ejpb.2008.11.011, PMID 19073253.

11. Corveleyn S, Remon JP. Formulation and production of rapidly disintegrating tablets by lyophilisation using hydrochlorothiazide as a model drug. Int J Pharm. 1997;152(2):215-25. doi: 10.1016/S0378-5173(97)00092-6.
12. Corveleyn S, Remon JP. Formulation of a lyophilized dry emulsion tablet for the delivery of poorly soluble drugs. Int J Pharm. 1998;166(1):65-74. doi: 10.1016/S0378-5173(98)00024-6.
13. Dave V, Yadav RB, Ahuja R, Yadav S. Formulation design and optimization of novel fast dissolving tablet of chlorpheniramine maleate by using lyophilization techniques. Bull Fac Pharm Cairo Univ. 2017;55(1):31-9. doi: 10.1016/j.bfopcu.2016.12.001.
14. Divya L, Ravichandiran V, Lavakumar V, Sowmya C, Venkateshan N, Niranjan Babu M. Preparation and evaluation of Fluoxeitine hydrochloride oral dispersible tablets. Int J Pharm Pharm Sci. 2014;6:216-22.
15. Douroumis D. Orally disintegrating dosage forms and taste-masking technologies; 2010. Expert Opin Drug Deliv. 2011;8(5):665-75. doi: 10.1517/17425247.2011.566553, PMID 21438776.
16. Fitzpatrick S, Saklatvala R. Understanding the physical stability of freeze dried dosage forms from the glass transition temperature of the amorphous components. J Pharm Sci. 2003;92(12):2495-501. doi: 10.1002/jps.10474, PMID 14603495.
17. Fu Y, Yang S, Jeong SH, Kimura S, Park K. Orally fast disintegrating tablets: developments, technologies, taste-masking and clinical studies. Crit Rev Ther Drug Carrier Syst. 2004;21(6):433-76. doi: 10.1615/critrevtherdrugcarriersyst.v21.i6.10, PMID 15658933.
18. Gugulothu D, Desai P, Pandharipande P, Patravale V. Freeze drying: exploring potential in development of orodispersible tablets of sumatriptan succinate. Drug Dev Ind Pharm. 2015;41(3):398-405. doi: 10.3109/03639045.2013.871551, PMID 24384027.
19. Gupta AK, Kumar AS, Mishra DN, Singh SK. Formulation of rapid mouth dissolving tablets of cetirizine DI HCL using sublimation method. Int J Pharm Pharm Sci. 2011;3(3):285-7.
20. Hawe A, Friess W. Impact of freezing procedure and annealing on the physico-chemical properties and the formation of mannitol hydrate in mannitol–sucrose–NaCl formulations. Eur J Pharm Biopharm. 2006;64(3):316-25. doi: 10.1016/j.ejpb.2006.06.002, PMID 16875806.
21. Hawe A, Friess W. Physico-chemical lyophilization behavior of mannitol, human serum albumin formulations. Eur J Pharm Sci. 2006;28(3):224-32. doi: 10.1016/j.ejps.2006.02.003, PMID 16580820.
22. Jeevanandham S, Dhachinamoorthi D, Sekhar KC, Muthukumaran M, Sriram N, Joysaruby J. Formulation and evaluation of naproxen sodium orodispersible tablets–A sublimation technique. Asian Journal of Pharmaceutics (AJP): free full text articles from. Asian J Pharm. 2014;4(1).
23. Jones RJ, Rajabi-Siahboomi A, Levina M, Perrie Y, Mohammed AR. The influence of formulation and manufacturing process parameters on the characteristics of lyophilized orally disintegrating tablets. Pharmaceutics. 2011;3(3):440-57. doi: 10.3390/pharmaceutics3030440, PMID 24310589.
24. Karsono JT, Fatma D. Formulation of ibuprofen orally disintegrating tablets (ODTs) by lyophilization method using gelatin and mannitol. Int J PharmTech Res. 2014;6:996-1002.
25. Martinez-Marcos L, Lamprou DA, McBurney RT, Halbert GW. A novel hot-melt extrusion formulation of albendazole for increasing dissolution properties. Int J Pharm. 2016;499(1-2):175-85. doi: 10.1016/j.ijpharm.2016.01.006, PMID 26768722.
26. Meena AK, Sharma K, Kandaswamy MU, Rajagopal S, Mullangi R. Formulation development of an albendazole self-emulsifying drug delivery system (SEDDS) with enhanced systemic exposure. Acta Pharm. 2012;62(4):563-80. doi: 10.2478/v10007-012-0031-0, PMID 24000442.
27. Pahwa R, Piplani M, Sharma PC, Kaushik D, Nanda S. Orally disintegrating tablets-Friendly to pediatrics and geriatrics. Arch Appl Sci Res. 2010;2(2):35-48.
28. Patil MH, Rane MS. Formulation and evaluation of Nifidepine mouth dissolving tablet by direct compression method. Imperial J Interdiscip Res. 2016;2(11).
29. Rao YM, Kumar MP, Apte S. Formulation of nanosuspensions of albendazole for oral administration. Curr Nanosci. 2008;4(1):53-8. doi: 10.2174/157341308783591807.
30. Sznitowska MA, Płaczek M, Klunder MA. The physical characteristics of lyophilized tablets containing a model drug in different chemical forms and concentrations. Acta Pol Pharm. 2005;62(1):25-9. PMID 16022490.
31. Torrado S, López ML, Torrado G, Bolás F, Torrado S, Cadórniga R. A novel formulation of albendazole solution: oral bioavailability and efficacy evaluation. Int J Pharm. 1997;156(2):181-7. doi: 10.1016/S0378-5173(97)00204-4.
32. Torrado S, Torrado S, Cadorniga R, Torrado JJ. Formulation parameters of albendazole solution. Int J Pharm. 1996;140(1):45-50. doi: 10.1016/0378-5173(96)04545-0.
33. Vemula SK, Reddy SG. Formulation and pharmacokinetics of flurbiprofen sublimated fast dissolving tablets. Open pharmaceutical. Sci J. 2015;2(1).
34. Vemula SK, Vangala M. Formulation development and characterization of meclizine hydrochloride sublimated fast dissolving tablets. Int Sch Res Notices. 2014;2014:281376. doi: 10.1155/2014/281376, PMID 27355021.