Evaluation of Liposomal Formulations of Quercetin on Promonocytic Human Myeloid Leukemia Cell Line

Shreya Banerjee1,2, Debasis Dutta2, Shila Elizabeth Besra1*
1 Central Instrumentation Facility and Cancer Biology & Inflammatory Disorder Division, CSIR- Indian Institute of Chemical Biology, 4 Raja S.C. Mullick Road, Kolkata-700032, West Bengal, India.
2 Pharmaceuticals Division, Department of Pharmacy, School of Health Sciences, NSHM Knowledge Campus, Kolkata-Group of Institutions, 124 (60), B. L. Saha Road, Tara Park, Behala, Kolkata -700053, West Bengal, India.

*Corresponding author’s E-mail: shilabesra@iicb.res.in

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ABSTRACT

Novel Drug Delivery System is a recent and advanced field of study which can be used to modify the pharmacokinetic and pharmacodynamics properties of a drug. Quercetin is a flavonoid of natural origin known to have anti-cancer and antioxidant properties. It belongs to BCS Class IV and hence challenges are faced to combat the solubility issues of the drug. Therefore, this study aims to preparing a liposomal formulation of Quercetin to improve its solubility profile and thereby intensify its pharmacological activity. Initial characterizations of the prepared Quercetin liposomal formulations (QTLF) were evaluated on promonocytic human myeloid leukemia (U937), cell by MTT assay. QTLF produced notable cytotoxic effect on U937. The Quercetin liposomal formulations showed greater efficacy than the free drug in U937. Thus, it can be considered safe for administration into the human body which proved that the solubility enhancement of drug produced a more potent form of the drug.

Keywords: Novel Drug Delivery, Quercetin, Liposome, Leukemia, Cytotoxicity.

INTRODUCTION

Conventional drug delivery systems have limited efficiency in this medical world of large number of diseases and complications that affect the human body on a regular basis. Hence, the needs for faster and sustainable therapies arise. Novel drug delivery system is an advanced delivery system which appears suitable for fulfilling such requirements. Novel drug delivery system (NDDS) consists of carriers which maintain the drug concentration in therapeutic range for longer period of time and improve the bioavailability. Novel drug delivery follows the method of drug release modification by using modified polymers and also different carriers which release the drug at the site of action. Carriers include nanoparticles, liposomes, phytosomes etc.

Liposomes are a group of novel vesicular systems which can incorporate a variety of drugs of both hydrophobic and hydrophilic natures. They are biocompatible as they resemble the structure of a biological membrane. It primarily consists of phospholipids, which are molecules that have a head group and a tail group. The head is attracted to water, and the tail, which is made of a long hydrocarbon chain, is repelled by water. Researchers all over the world have been working on natural products, keeping in mind the harmful effects of synthetic drugs and have succeeded in establishing their affectivity on various diseases. Flavonoids are a group of natural products which are present in quite a number of fruits and vegetables and can be useful in treating various pathological conditions. Quercetin is one such flavonoid possessing cytotoxic activity. Its pharmacological actions are limited by hydrophobicity, instability in physiological media, poor gastrointestinal dissolution rate and absorption and extensive xenobiotic metabolism at intestines and liver. Hence, its formulation in a suitable delivery system may improve its oral bioavailability, ensuring protection from degradation and preventing premature release.

Cancer is the biggest cause of mortality in the world and happens when the tumor suppressing genes are obstructed by various environmental or lifestyle factors. The types of cancer are sarcoma which includes growth of malignant tumours in connective tissues, lymphoma which causes proliferations in lymphocytes, leukaemia which leads to uncontrolled and exaggerated growth of blood cells and sarcoma which results in uncontrolled division of cells in the skin or tissue which cover the internal organs. Leukemia being one of the most dangerous types of cancers is associated with serious impact on human body.

So, this study focuses on the development and evaluation of a liposomal formulation (QTLF) of a drug of natural origin named Quercetin and thereby analyzing its activity on human myeloid leukemia cell line U937.
MATERIALS AND METHODS

Chemicals

Quercetin (Loba Chemie, India), Ethanol absolute (Balaji Drugs Pvt. Limited, India), Chloroform (Balaji Drugs Pvt. Limited, India), Soya Lecithin (Himedia, India), Hydrogen Chloride (Rankem, Avantor, India), Potassium chloride, Potassium di-hydrogen phosphate, Sodium hydroxide (Merck Specialties Pvt. Ltd., Mumbai), Distilled water, RPMI1640 medium with L-glutamine (GIBCO), Foetal calf serum (FCS), Penicillin-Streptomycin, Gentamycin, MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazoliumbromide], Dimethyl sulfoxide (DMSO).

Cell Culture

Human leukemic cell line U937 cell line was obtained from National Centre for Cell Science, Pune for in-vitro studies. These cells were sub-cultured as per the requirement of the experiment at an initial concentration of $1 \times 10^6$ cells/ml. U937 cells were maintained in sterile RPMI 1640 medium supplemented with 10% heat activated FCS and cultures was maintained at 37°C in a humified atmosphere containing 5% CO₂ in air.

Preparation of Standard Curve of Quercetin in Ethanol at 370nm

50 mg Quercetin was measured and taken into a 50 ml volumetric flask. 50ml ethanol was added into the flask to solubilise the Quercetin (QTF) properly and concentration becomes 100μg/ml. 5ml of solution was taken and dissolved in 50ml ethanol to make 100μg/ml. From this stock solution different concentrations of QTF solution i.e., 2μg/ml, 4μg/ml, 6μg/ml, 8μg/ml and 10μg/ml were prepared using ethanol. The Quercetin solutions were scanned in UV Visible Spectrophotometer (UV 1800, Shimadzu, Japan) at 200-400nm. Then absorbance was measured by UV Spectrophotometry at 370nm wavelength using ethanol as blank.

Preparation of Standard Curve of Quercetin in Phosphate buffer pH 7.4 at 370nm

25 mg quercetin was measured and taken in a 100ml volumetric flask. Around 1ml of ethanol was added into the flask to solubilise the Quercetin properly and the volume was made up to 100ml with phosphate buffer solution pH 7.4 to make a concentration of 250μg/ml. From this stock solution different concentrations of QTF solution 5μg/ml, 10μg/ml, 15μg/ml, 20μg/ml and 25μg/ml were prepared using phosphate buffer pH 7.4. The quercetin solution was scanned in UV Visible spectrophotometer (UV 1800, Shimadzu, Japan) at 200-400nm. Then absorbance was measured by UV Spectrophotometry at 370nm wavelength using phosphate buffer as blank.

Preparation of Liposomal Formulations of Quercetin

Blank liposomes were prepared using lipid and the organic solvents only and the consistency of the formulation was checked. After that lipid mixture of phospholipid and Quercetin was dissolved in two organic solvents which were present in a fixed ratio and shaken continuously for some time under a temperature of 50-55°C. The film formed was then hydrated by an aqueous buffer solution and the dispersion was then sonicated. The liposome dispersion was transferred into a tube and then placed in a bath sonicator. Controlling the temperature of the lipid dispersion is usually easier in this method. The dispersion was then kept in a sterile container and stored for evaluation.

**Table 1: Formulations of Liposome Preparation**

<table>
<thead>
<tr>
<th>INGREDIENT</th>
<th>QTLF1</th>
<th>QTLF2</th>
<th>QTLF3</th>
<th>QTLF4</th>
<th>QTLF5</th>
<th>QTLF6</th>
<th>QTLF7</th>
<th>QTLF8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quercetin/mg</td>
<td>80</td>
<td>75</td>
<td>150</td>
<td>270</td>
<td>200</td>
<td>234</td>
<td>270</td>
<td>200</td>
</tr>
<tr>
<td>Soya Lecithin/mg</td>
<td>20</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Ethanol/ ml</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Chloroform/ ml</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Drug Identification Study by FTIR

Fourier Transform Infrared Spectroscopy (FTIR) of pure drug using FTIR spectrophotometer. The sample is prepared with potassium bromide and data are collected at a spectral range of 450-4000 cm⁻¹.

Entrapment Efficiency (%EE)

The mixture was centrifuged for 70 minutes at 14000 rpm, the supernatant containing free Quercetin was obtained, and the absorbance was measured using HPLC. The entrapment efficiency of liposomes was determined by the following formula: EE (%) = [(C₀ - Cᵢ)/C₀] × 100 where EE is the concentration of entrapped sample (mg/mL), C₀ is the initial concentration of sample used in formulating the liposomes (mg/mL), Cᵢ is the concentration of sample in the supernatant (mg/mL), and EE (%) is the percentage of the sample’s entrapment.

Cytotoxicity Study by MTT Assay

For cytotoxicity analysis, $1 \times 10^5$ concentrations of human leukemic cell U937 in log phase were used as stock suspension. 100 μl of these cell suspensions were seeded in each well of 96 well tissue culture plates. They were treated separately with freshly prepared 1mg/ml stock solution of free Quercetin as well as the Liposomal formulations of Quercetin (QTLF1-QTLF8), with doses of 25μg, 50μg, 100μg and 200μg for 24, 48, 72 hours at 37°C in a humified atmosphere containing 5% CO₂ in air. Untreated cells served as control. At the end of treatment,
20µl of MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazoliumbromide] was added to each well and incubated for another 4 hours at 37-degree C in a CO2 incubator. The MTT assay is a colorimetric assay for measuring the activity of enzymes that reduce MTT to formazan dyes, giving a purple colour. A solubilisation solution DMSO (Dimethyl sulphoxide) 100µl is added to dissolve the insoluble purple formazan product into a coloured solution. The absorbance was taken at 490 nm by micro plate manager (Reader Type: Model 680 XR Bio-Rad laboratories Inc.). From the absorbance values obtained at 490 nm the % inhibition was determined using the following formula:

\[
\% \text{Cell Inhibition} = 100 \times \frac{(O.D \text{ of Control} - O.D \text{ of Treated})}{O.D \text{ of Control}}
\]

### RESULTS

#### Preparation of Standard Curve of Quercetin in Ethanol at 370nm

The Quercetin solutions (2µg/ml, 4µg/ml, 6µg/ml, 8µg/ml and 10µg/ml dissolved in ethanol) were scanned in UV Visible spectrophotometer (UV 1800, Shimadzu, Japan) at 200-400nm. Then absorbance was measured by UV Spectrophotometry at 370nm wavelength using ethanol as blank. A graph was plotted keeping the concentrations in the X-axis and the absorbance found in the Y-axis.

#### Table 2: Standard Curve of QTF in Ethanol

<table>
<thead>
<tr>
<th>Concentration (µg/ml)</th>
<th>Absorbance</th>
<th>Average ± S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
</tr>
<tr>
<td>2</td>
<td>0.156</td>
<td>0.162</td>
</tr>
<tr>
<td>4</td>
<td>0.331</td>
<td>0.353</td>
</tr>
<tr>
<td>6</td>
<td>0.439</td>
<td>0.452</td>
</tr>
<tr>
<td>8</td>
<td>0.697</td>
<td>0.699</td>
</tr>
<tr>
<td>10</td>
<td>0.775</td>
<td>0.781</td>
</tr>
</tbody>
</table>

#### Preparation of Standard Curve of Quercetin in Phosphate buffer pH 7.4 at 370nm

The Quercetin solutions (2µg/ml, 4µg/ml, 6µg/ml, 8µg/ml and 10µg/ml dissolved in phosphate buffer pH 7.4) were scanned in UV Visible spectrophotometer (UV 1800, Shimadzu, Japan) at 200-400nm. Then absorbance was measured by UV Spectrophotometry at 370nm wavelength using phosphate buffer as blank. A graph was plotted keeping the concentrations in the X-axis and the absorbance found in the Y-axis.

#### Table 3: Standard Curve of QTF in Phosphate Buffer pH 7.4

<table>
<thead>
<tr>
<th>Concentration (µg/ml)</th>
<th>Absorbance</th>
<th>Average ± S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
</tr>
<tr>
<td>5</td>
<td>0.237</td>
<td>0.238</td>
</tr>
<tr>
<td>10</td>
<td>0.403</td>
<td>0.405</td>
</tr>
<tr>
<td>15</td>
<td>0.583</td>
<td>0.589</td>
</tr>
<tr>
<td>20</td>
<td>0.771</td>
<td>0.778</td>
</tr>
<tr>
<td>25</td>
<td>0.996</td>
<td>0.994</td>
</tr>
</tbody>
</table>

The graph gives us an R² value of 0.9875.

### Statistical Analysis

This was done by Student’s t-test P < 0.05 was considered as significant. The percentage cell inhibition was calculated by the following formula:

\[
\% \text{Cell Inhibition} = \frac{100 \times (O.D \text{ of Control} - O.D \text{ of Treated})}{O.D \text{ of Control}}
\]

where O.D= Optical Density
Figure 2: Standard Curve of Quercetin at pH 7.4. The concentration is plotted in the X-axis and the Absorbance is plotted in the Y-axis. The graph gives us an R² value of 0.9978.

Identification of Quercetin by FTIR

Fourier Transform Infrared Spectroscopy (FTIR) of pure drug was taken using FTIR spectrophotometer. The sample was prepared with potassium bromide and data were collected at a spectral range of 500-4000 cm⁻¹.

Figure 3: Structure of Quercetin

The peaks obtained were at 3407.70 cm⁻¹, 3317.57 cm⁻¹, 1666.07 cm⁻¹, 1609.04 cm⁻¹, 1561.71 cm⁻¹, 1520.73 cm⁻¹, 1456.34 cm⁻¹, 1380.78 cm⁻¹, 1317.85 cm⁻¹, 1260.70 cm⁻¹, 1203.93 cm⁻¹, 1166.85 cm⁻¹, 1131.64 cm⁻¹, 1010.77 cm⁻¹, 939.90 cm⁻¹, 821.38 cm⁻¹, 792.08 cm⁻¹, 722.14 cm⁻¹, 678.32 cm⁻¹ and 601.35 cm⁻¹. The peak at 1380.78 cm⁻¹ shows O-H bending and that at 3407.70 cm⁻¹ show O-H stretching of phenolic groups. The peak at 1520.73 cm⁻¹ points out the presence of aromatic C=C stretching and that at 939.90 cm⁻¹ is responsible for aromatic C=C bending. The peaks at 1456.34 cm⁻¹ is responsible for in-plane aromatic C-H bending and at 722.14 cm⁻¹ leads to presence of out of plane bending of aromatic C-H bond.

C=O stretching is detected by the presence of sharp peak at 1666.07 cm⁻¹.

Entrapment Efficiency: The entrapment efficiency of liposomes was determined by the following formula:

\[ EE(\%) = \left( \frac{C_i - C_f}{C_i} \right) \times 100, \]

where EE is the concentration of entrapped sample (mg/mL), \( C_i \) is the initial concentration of sample used in formulating the liposomes (mg/mL), \( C_f \) is the concentration of sample in the supernatant (mg/mL), and EE (\%) is the percentage of the sample’s entrapment. The entrapment efficiencies were found to decrease with the increase in the amounts of lipid.
### Table 4: Entrapment Efficiency of Quercetin Liposomal Formulation

<table>
<thead>
<tr>
<th>Code</th>
<th>Drug (mg)</th>
<th>Lipid (mg)</th>
<th>Initial Conc. in mg/ml (C_i)</th>
<th>Final Conc. in mg/ml (C_f)</th>
<th>EE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QTLF1</td>
<td>20</td>
<td>80</td>
<td>1.00</td>
<td>0.1214</td>
<td>87.86</td>
</tr>
<tr>
<td>QTLF3</td>
<td>20</td>
<td>150</td>
<td>1.00</td>
<td>0.1653</td>
<td>83.47</td>
</tr>
<tr>
<td>QTLF5</td>
<td>20</td>
<td>200</td>
<td>1.00</td>
<td>0.1705</td>
<td>82.95</td>
</tr>
<tr>
<td>QTLF6</td>
<td>20</td>
<td>234</td>
<td>1.00</td>
<td>0.1912</td>
<td>80.88</td>
</tr>
<tr>
<td>QTLF4</td>
<td>20</td>
<td>270</td>
<td>1.00</td>
<td>0.2997</td>
<td>70.03</td>
</tr>
<tr>
<td>QTLF2</td>
<td>25</td>
<td>75</td>
<td>1.25</td>
<td>0.3049</td>
<td>75.60</td>
</tr>
<tr>
<td>QTLF7</td>
<td>40</td>
<td>270</td>
<td>1.00</td>
<td>0.2093</td>
<td>79.07</td>
</tr>
<tr>
<td>QTLF8</td>
<td>30</td>
<td>200</td>
<td>1.00</td>
<td>0.1681</td>
<td>83.19</td>
</tr>
</tbody>
</table>

### Determination of IC₅₀ values of Quercetin Liposomal Formulations

IC₅₀ value is the concentration of a drug which inhibits 50% of the cancer cell growth. This value was determined for the drug QTF as well as the formulations QTLF1-QTLF8. The results for the same are represented in a tabular form as follows:

### Table 5: IC₅₀ Values of the Liposomal Formulations

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Formulation</th>
<th>24hrs IC₅₀ value (µg/ml)</th>
<th>48hrs IC₅₀ Value (µg/ml)</th>
<th>72hrs IC₅₀ Value (µg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>QTF</td>
<td>240</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>QTLF1</td>
<td>106.70</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>QTLF2</td>
<td>169.32</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>QTLF3</td>
<td>-</td>
<td>35.36</td>
<td>-</td>
</tr>
<tr>
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<td>10.41</td>
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<td>63.45</td>
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<td>8</td>
<td>QTLF7</td>
<td>-</td>
<td>-</td>
<td>51.33</td>
</tr>
<tr>
<td>9</td>
<td>QTLF8</td>
<td>-</td>
<td>-</td>
<td>37.25</td>
</tr>
</tbody>
</table>

### Cytotoxicity Study by MTT Assay

The raw drug (QTF) and the liposomal formulations (QTLF1-QTLF8) inhibited the growth and produced significant cytotoxicity of leukemic cell lines. Reduction in the mean OD of cells treated with increasing dose of drug was observed as compared to control for 24hrs, 48hrs and 72hrs respectively. The % inhibitions were also plotted against the increasing concentrations of the formulations. On determining the entrapment efficiency, QTLF1 showed the maximum percentage whereas QTLF4 showed the least value. The formulations (QTLF1-QTLF4) showed a satisfactory activity on U937 cell line after 24 hours which indicates proper effect after 48 or 72 hours of exposure. The liposomal formulations have shown a decrease in IC₅₀ values as compared to the free drug in U937. The IC₅₀ value for free Quercetin was 240µg/ml whereas the respective IC₅₀ values of formulations QTLF1-QTLF8 were 106.81µg/ml, 169.32µg/ml at 24 hours, 35.36µg/ml, 10.41µg/ml, 175.95µg/ml at 48 hours, 63.45µg/ml, 51.33µg/ml and 37.25µg/ml at 72 hours respectively. In U937 cells, formulations QTLF5-QTLF8 were found to show gradual release of Quercetin with negligible action after 24 hours but notable effect after 72 hours of treatment whereas QTLF1-QTLF4 showed cytotoxic action right from the very beginning. This proved that in QTLF5-QTLF8 the lipid matrix had kept Quercetin entrapped for a longer span of time. QTLF1 was found to have the best IC₅₀ value among all the eight prepared formulations.
Figure 5: Both the histogram shows the effect of QTF on U937 cell line. Reduction in O.D. value and increase of % inhibition was observed in a time and concentration dependant manner. Data are mean ± S.E.M.

Figure 6: Histograms show the effects of QTLF1-QTLF8 on U937 by MTT Assay after 24, 48 and 72 hours respectively. Reduction in the O.D. values and increase in the % inhibition of cells is observed in a time and concentration dependant manner. Data are mean ± S.E.M. QTLF1-QTLF4 shows marked reduction in O.D. value and notable increase in the % inhibition at 24hrs whereas QTLF5-QTLF8 show delayed action on both O.D. values and % inhibition with maximum effect after 72 hours.

DISCUSSION

Quercetin manifests low solubility which posed a problem in its effectiveness after administration into the body in spite of having strong anti-cancer and antioxidant properties. Liposomes are novel carriers which are known to increase bioavailability of hydrophilic as well as lipophilic components, thereby making Quercetin a proper candidate for incorporation into it. Cancer being one of the biggest causes of mortality is a huge threat to mankind and as a result continuous efforts are being given on
development of anti-cancer drugs and formulations. About 60% of drugs currently used for cancer treatment have been isolated from natural products, majorly from plant sources due to efficacy and reduced side effects.  

Quercetin is a naturally occurring flavonoid which has been used in cancer prevention and to prevent the spread of various cancers, such as lung, prostate, liver, breast, colon, and cervical cancers. This study thereby deals with the tackling of the solubility issues of Quercetin by incorporating it into liposomes and determination of its anti-cancer activities.

On determining the entrapment efficiency, QTLF1 showed the maximum percentage whereas QTLF4 showed the least value. The cytotoxic activity was observed in U937 cell line isolated from the histolytic lymphoma of a 37-year-old male patient. The liposomal formulations have shown a decrease in IC50 values as compared to the free drug in U937. The IC50 value for free Quercetin was 240µg/ml whereas the respective IC50 values of formulations QTLF1-QTLF8 were 106.81µg/ml, 169.32µg/ml at 24 hours, 35.36µg/ml, 10.41µg/ml, 175.95µg/ml at 48 hours, 63.45µg/ml, 51.33µg/ml and 37.25µg/ml at 72 hours respectively. In U937 cells, formulations QTLF5-QTLF8 were found to show gradual release of Quercetin with negligible action after 24 hours but notable effect after 72 hours of treatment whereas QTLF1-QTLF4 showed cytotoxic action right from the very beginning. This proved that in QTLF5-QTLF8 the lipid matrix had kept Quercetin entrapped for a longer span of time. QTLF1 was found to have the best IC50 value among all the eight prepared formulations.

SUMMARY & CONCLUSION

Natural products are of prime importance in the pharmaceutical industries in the current scenario where synthetic drugs have considerable amounts of adverse effects which affect mankind. A wide number of natural drug products are currently under study for their respective pharmacological uses. One such group of active natural products are the flavonoids. Flavonoids are polyphenolic plant extracts present in the daily diet and contribute to the flavour and colour of fruits and vegetables. Quercetin is a flavonoid which bears high antioxidant and cytotoxic activity which can be of much use to fight the battle against the most feared disease of the current century, cancer. However, it belongs to BCS Class IV with solubility and permeability limitations which hamper the effectiveness of the drug. This establishes a need to modify the drug’s solubility by using carriers.

Novel Drug Delivery is a unique approach for preparing drug formulations with better bioavailability and release at the preferred site of action. Novel drug delivery formulations can be prepared by modifying the release kinetics of drug in the body by incorporation into lipid matrices or in suitable polymers. There are quite a number of novel carriers which are in use for creating new formulations of drugs like liposomes, nanoparticles, phytosomes etc. Novel formulations of some drugs like doxorubicin, amphotericin B are already in market, showing good amount of patient compliance. Similarly, the drug Quercetin was considered a good candidate to be converted into a novel formulation by incorporation into a lipid carrier. The choice of novel carrier was Liposome, a lipid matrix composed of phospholipids with a hydrophilic head and a lipophilic tail. Liposomes represent the biological membranes as far as the structure is considered, and as a result is highly compatible for administration into the body. It has another advantage of being able to incorporate both lipophilic and hydrophilic drugs into it, thereby becoming the carrier of choice for the study.

Cancer is a disease characterized by abnormal cell growth and proliferation leading to some serious health hazards. This occurs by various factors like gene mutations, smoking, environmental factors etc. This study focuses on two of the various types of cancer namely leukaemia and ovarian cancer. Leukaemia is a type of cancer characterized by increased number of white blood cells. Synthetic anti-cancer drugs have been proved to be effective for the treatment but alongside the drugs were found to show serious side effects. Hence, approaches were made to increase natural drug formulations in market which can be equally effective but with reduced side effects.

The free drug Quercetin had to undergo initial identification tests wherein standard curves were prepared and FTIR spectra of the drug was analysed. Eight liposomal formulations of Quercetin within different drug and lipid ratios were prepared by hand shaking method and stored for characterization. The entrapment efficiencies of the formulations were determined. The prepared liposomes were then used for in-vitro studies to check the cytotoxic activities on two types of cancer cells namely the monocytic myeloid leukaemia cell (U937).

Hence, it can be concluded that the liposomal preparations of Quercetin showed better cytotoxic activity on U937 cells as compared to free Quercetin showing lower IC50 values. It thereby possesses anti-leukemic activity. A further conclusion can be drawn that by incorporating the drug into the lipid carrier, the activity of the drug was found to improve and hence the solubility enhancement effectively intensifies the cytotoxic activities of Quercetin by correcting the solubility issues.

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REFERENCES


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Conflict of Interest: None declared.

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