Immunomodulatory Activity of Ayurvedic Plant Aparajita (Clitoria Ternatea L.) In Male Albino Rats

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Abstract-the present study was undertaken to investigate immunomodulatory activity of Clitoria ternatea seed and root extracts. Effects on humoral immune response were investigated in SRBCs-sensitized rats. Effects on cell medicated immunity were studied by measuring delayed type hypersensitivity (DTH) response in SRBC-sensitized rats. Neutrophil recruiting and phagocytosis were measured by studying neutrophil adhesion and carbon clearance method respectively. Further the effects on hematological parameters were also studied. C. ternatea seed and root extracts showed significant immunosuppressive effects as evident from significant decrease in primary and secondary antibody titers in SRBCs-sensitized rats, paw thickness in DTH response, and neutrophil adhesion and In vitro Phagocytosis. The immunomodulatory effects of C. ternatea on humoral, cell mediated and non-specific immune response could be attributed to decreased immune cell sensitization, immune cell presentation and phagocytosis. The anti-inflammatory and antioxidant properties of plant might be playing major role in immunomodulatory activity. The present study provided evidence for the traditional uses of the plants in Indian system of medicine.

Keywords-DTH response, Immunosuppressive, Neutrophil index, Phagocytosis, Primary antibody titer.

I. INTRODUCTION

Clitoria ternatea L. belonging to family ‘Fabaceae’, is popularly known as a “Butterfly pea” in western countries and as “Aparajita” in the traditional Ayurvedic system of medicine. Clitoria ternatea (CT) is one of the important plants of Ayurvedic system of medicine and is official in the Ayurvedic Pharmacopoeia of India (Anonymous, 2003). It is reported to have brain tonic activity, and is popularly known as ‘shankhaphushpi’ (Upadhye & Kumbhojkar, 1993) in southern India. In different system of medicine, it is employed against different disease conditions such as cathartic, purgative, demulcent, emetic and anti-inflammatory in swollen joints (Kirtikar & Basu, 1976; Chopra et al. 1956). Ayurvedic system prescribed various part of the plant in inflammation, hepatic disorders and as a brain tonic (Anonymous, 2003). Various parts of CT have been reported to have nootropic activity, anxiolytic activity, tranquilizing property, anti-inflammatory and analgesic activity, antipyretic, and antimicrobial activity (Mukherjee et al., 2008). It is also reported to have immunomodulatory activities in alloxan-induced diabetic rats (Daisy et al. 2004). The plant is found to possess antibacterial activity (Malabadi et al. 2005). The flavonol glycoside present in roots is reported to have antibacterial activity (Yadava & Verma, 2003). CT has been reported to contain kaempferol and related glycosides, aparajitin, anthocyanins (Shrivastava & Pande, 1977), and anthoxanthins (Gupta & Lal, 1968). However, no study had been reported on immunomodulatory activities especially of seeds and roots in animal models. Hence, we conducted the present study to evaluate an immunomodulatory activity of seeds and roots of CT in male albino rats.

II. MATERIALS AND METHODS

A. Plant collection and Identification

The plant is available in two varieties – blue flowered and white flowered. It is climbing vine found on road side and field sides throughout India. Since, the blue variety is medicinally more important, we used only blue variety for the present investigation. The plant was collected in the month of March (2007) from the fields and road side of the Charotar region of the Gujarat state, India. The pods were allowed to dry sufficiently under shade, and finally seeds were collected manually. The plant was botanically identified by Dr. G. C. Jadeja, Professor and Head of Agricultural Botany Department, B. A. College of Agriculture, Anand Agricultural University, Anand, India. The specimens of the sample were stored in the museum of the department (specimen no. 0701). The quality of plant was ascertained as per Ayurvedic Pharmacopoeia of India by determining foreign matters, total ash, acid insoluble ash, alcohol soluble extractive, and water soluble extractive values (Anonymous, 1999)

B. Preparation of extracts

The dry powdered (40#) seeds (1kg) were extracted with petroleum ether by percolation until the percolate was free of green color. The residues were extracted with 50% v/v alcohol by heating on boiling water bath under reflex for 3 h. The solvents were evaporated to have pasty mass, referred as CT seed extract. The dry powdered (40#) roots were directly extracted with 50% v/v alcohol by heating on the boiling water bath under reflex for 4 h. The solvents were evaporated at room temperature to have pasty mass, referred as CT root extract.
C. Preliminary phytochemical screening

CT seed and root extracts were screened for phytochemicals using the method specified by Kokate, (2003).

D. Chemicals and reagents

All the chemicals used in the present study, were of analytical grade and purchased from S. D. Fine chemicals Limited, Mumbai. Dexamethsone (DMS) was obtained from Cadila Zyus Research Centre, Ahmedabad.

E. Pharmacological evaluation

Animals

Male albino rats (Wistar strain) weighing 150-200 g were divided into different groups, each consisting of six animals. Animals were maintained on a commercial chew diet (Pranav Agro Industries Ltd., Sangli, Maharashtra, India) and water at libidum throughout the study period. This study was approved by the institutional animal ethics committee in accordance with the guidelines of Committee for the Purpose of Supervision and Control of Experiments on Animals (CPCSEA) (CPCSEA, 2003). For each experiment outlined below, rats were randomized into various groups that received CT seed extract, CT root extract, vehicle, or dexamethasone (DMS) as a reference immunosuppressive drug.

F. Treatment regimens

CT seed and root extracts were suspended in distilled water using 1% w/v gum acacia. DMS was suspended at a concentration of 0.8 µg/mL in distilled water using 1% w/v CMC. In the studies herein unless elsewise indicated, treatment rats received CT seed and root extracts at 500 mg/kg body weight (BW) in 1 mL doses daily by gavage. The control group rats received vehicle, i.e., a single 2 mL bolus bearing 1 mL each of the 1% w/v gum acacia and 1% w/v CMC solutions, in parallel daily. The rats in the reference drug group received DMS at the dose of 0.25 mg/kg BW in 1 mL volume, daily by gavage.

G. Antigen preparation

Fresh blood was collected from sheep sacrificed in the local slaughter house, and placed in Alsever’s solution. During the experiment, adequate amount of stock solution of sheep red blood cells (SRBC) stored in Alsever’s solution, was taken and allowed to stand at room temperature. It was washed three times with normal saline. The settled SRBC were then suspended in normal saline. The SRBC of this suspension were adjusted to a concentration of 5x10^9 SRBC/mL for immunization and challenge (Bafna and Mishra, 2005).

H. Acute toxicity study

Animals were treated with different doses 250, 500, 750 and 1000 mg/kg, p.o. of each extracts. After single dose administration, animals were observed for death or any other deformities up to 72 h.

I. SRBC–induced humoral antibody (HA) titer

The method described by Atal et al. (1986) was utilized to examine the rats provided CT seed and root extracts once daily by gavage, starting 7 days prior to sensitization and continuing up to the second time of challenge (i.e., Day –7 up to and through Day +14; for a total of 21 d). Control and DMS–treated rats received vehicle or the drug, respectively, in parallel each day.

To specifically assess effects on antibody formation, groups of six rats per treatment were immunized with 20 µL of SRBC suspension (5x10^9 SRBC/mL) injected subcutaneously into right hind foot pad. The day of immunization was referred to as Day 0. Seven days later (Day +7), the rats were challenged by injecting 20 µl of SRBC suspension (5x10^9 SRBC/mL) intradermally into the left hind foot pad. Blood samples were collected from all the animals separately by retro-orbital puncture under light ether anesthesia on Day +7 (after challenge) for assessment of primary antibody titer and on Day +14 (after challenge) for measures of secondary antibody titer. Antibody levels were determined by the method described by Shinde et al. (1999). After allowing the collected blood to clot, serum was isolated and 25 µL was placed into one well of a 96–well microtiter plate. Serial two–fold dilutions of the serum were made using 25 µL of normal saline each time of transfer across the plate. To the 25 µL of diluted serum in each well was then added 25 µL of 1% w/v SRBC suspension in normal saline. The microtiter plate was maintained at room temperature for 1 h and then well contents examined for haemagglutination i.e., until control wells showed unequivocally negative patterns. The value of the highest serum dilution showing haemagglutination was defined as the antibody titer for the given rat.

J. SRBC–induced delayed–type hypersensitivity (DTH) Response

The method of Lagrange et al. (1974) was used to analyze effects on DTH responses in the treated rats. Daily treatment with CT seed and root extracts (500 mg/kg, by gavage) began 14 days prior to the challenge i.e., starting on the same day as immunization with SRBC. Control and DMS–treated rats received vehicle or the drug, respectively, in parallel each day.

On Day 0, all rats were immunized with20 µL SRBC solution (5 x 109 SRBC/mL) injected subcutaneously into their right hind footpad. After 14 days of gavage treatment, the thickness of each rat’s left footpad was measured just before the challenge; using a Schnelltaster caliper (H.C. Kroplin Hessen, Schuchtern, Germany) that could measure to a minimum unit of 0.01 mm. The rats were then challenged by injecting 20 µL SRBC solution (5 x 109 SRBC/mL) intradermally into their left hind footpad (deemed time 0). Foot thickness was the re–measured after 24 h. The difference between the thicknesses of left foot just before and 24 h after challenge (in mm) was taken as a measure of DTH (Doherty, 1981)
K. Neutrophil adhesion test

The method described by Wilkinson (1978), was used for evaluating the effect of CT seed and root extracts on neutrophil adhesion. After 14 days of gavage treatment, blood samples were collected from rats in each group by retro-orbital puncture under light ether anesthesia in heparinized vials and subjected to total as well as differential leukocyte count. After performance of the initial counts, the each blood sample was incubated with 80 mg/mL of nylon fibers at 37°C for 15 min. The incubated samples were again analyzed for total and differential leukocyte count. The product of total leukocyte count and the percentage (%) neutrophil (known as neutrophil index) was determined for each rat of the respective groups (Fulzele et al., 2002). The % neutrophil adhesion for each of the test rat was then calculated as “% Neutrophil Adhesion” =100 x (Nlu – Nlt)/Nlu, Where ‘Nlu’ is the neutrophil index of the blood samples before nylon fiber treatment and ‘Nlt’ the index after nylon fiber treatment.

L. Carbon clearance test

The method of Biozzi et al. (1953) was used to analyze phagocytic activity among the white blood cells in the rats. For each treatment regimen, a total of 6 rats were utilized. Daily treatment with CT seed extract (500 mg/kg, by gavage) occurred for 5 day prior to the assessment of in situ phagocytic activity. Control and dexamethasone – treated rats received vehicle or the drug, respectively, in parallel each day. A colloidal carbon ink suspension was injected via the tail vein into each rat 48 h after the final treatment. From each rat, blood samples (25 µL) were then withdrawn from the retro-orbital plexus under mild ether anesthesia, immediately after the injection and then 5, 10, and 15 min thereafter. Each blood sample was lysed with 2 mL of 0.1% acetic acid and the absorbance of the resulting solution evaluated at 675 nm (Damre et al., 2003). A graph of absorbance vs. time post-injection was prepared for each animal and the in situ phagocytic index calculated using following formula, “Phagocytic Index (PI)” = Ksample / Kstandard, wherein Ksample represents the slope of the absorbance vs. time curve of blood samples from rats in the extract – treated or Dexamethasone – treated group and Kstandard represents the slope of the absorbance vs. time curve of blood samples for the rats in the control group.

M. Hematological profile

After 8 days of the repeated gavage treatment, blood was collected from each rat via their retro-orbital plexus under light ether anesthesia. Various parameters such as total white blood cell (WBC), differential WBC, red blood cell (RBC), platelet counts, as well as hemoglobin (Hb) levels were then evaluated using a Sysmax XS800i automated hematology analyzer (TOA Medical Electronic Co., Tokyo, Japan).

N. Statistical analysis

Statistical analysis was carried out using one way ANOVA followed by Tukey’s test, using the SigmaStat™ 2.03 software and computer with Intel Pentium® dual core™ processor. A value of p < 0.05 was considered a statistically significant difference between analyzed groups.

III. RESULTS

In the present study, the immunomodulatory effect of CT seed and root extracts were investigated using various experimental models. The effect on humoral immunity was estimated by measuring primary and secondary antibody titers in SRBC sensitized rats. Effect on innate or cell mediated immunity was studied against delayed type of hypersensitivity (DTH) response. Further, neutrophil recruiting and phagocytic activity of the reticuloendothelial system were measured by neutrophil adhesion and removal of carbon particles from the blood circulation.

Acute toxicity study showed that CT seed and root extracts were safe up to the dose of 1000 mg/kg, p.o. The preliminary phytochemical screening showed presence of glycosides, tannins, saponins, phenolics, flavonoids, proteins, and carbohydrates.

A. SRBC–induced antibody (HA) titer

In SRBC-sensitized rats, the primary titer was significantly decreased by CT seed (0.05 ± 0.01) and root (0.03 ± 0.01) extracts on day 14 and secondary titer was significantly decreased by both the extract (0.06 ± 0.01 and 0.03 ± 0.01) respectively on day 21 when compared with the control group (3.52 ± 0.76) on day 14 and (5.00 ± 0.76) on day 21. Reference immunosuppressive drug dexamethasone showed significant decrease in primary titer (0.15 ± 0.02) and secondary titer (0.19 ± 0.05) (table 1).

Table: 1 Effects on antibody formation by SRBC-sensitized rats.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Primary titer</th>
<th>Secondary titer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.52 ± 0.76</td>
<td>5.00 ± 0.76</td>
</tr>
<tr>
<td>Dexamethasone</td>
<td>0.15 ± 0.02*</td>
<td>0.19 ± 0.05*</td>
</tr>
<tr>
<td>CT seed extract</td>
<td>0.05 ± 0.01*</td>
<td>0.06 ± 0.01*</td>
</tr>
<tr>
<td>CT root extract</td>
<td>0.03 ± 0.01*</td>
<td>0.03 ± 0.01*</td>
</tr>
</tbody>
</table>

All values represent mean ± SEM; n = 6 per treatment group. Statistical analysis was carried out using One Way ANOVA followed by Tukey’s multiple range test. *: Value significantly different (p < 0.05) compared with the control group. “CT: C. ternatea, treatments began in period starting 7 d prior to sensitization and continuing up to time of challenge (i.e., Day -7 up to and through Day +7)"

B. SRBC-induced DTH response

The cell-mediated immune responses of CT seed and root extracts were assessed by DTH reaction, i.e. foot pad reaction. The DTH response was measured as difference in thickness of hind paw before and after the challenge with SRBC solution. CT seed (0.31 ± 0.01) and root (0.40 ± 0.02) extracts produced significant (p < 0.001) decrease in the DTH response when compared with the control group (0.85 ± 0.02). These effects were comparable with that of reference immunosuppressant drug – dexamethasone (0.36 ± 0.01) (table 2)
C. Neutrophil adhesion test

The % neutrophil adhesion was significantly (p < 0.01) decreased by CT seed (14.32 ± 1.09) and root (8.71 ± 0.81) extracts at the dose of 500 mg/kg, p.o., when compared with the control group (23.33 ± 1.02). These effects were comparable with the reference drug - dexamethasone (14.00 ± 3.07). The finding suggested possible immunosuppressive or immunoinhibitory action of both the extracts (table 3).

Table: 2 Effects on DTH response and the phagocytic index

<table>
<thead>
<tr>
<th>Treatment</th>
<th>DTH Response</th>
<th>Phagocytic index(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.85 ± 0.02</td>
<td>1.00</td>
</tr>
<tr>
<td>Dexamethasone</td>
<td>0.36 ± 0.01(^*) (-57.64%)</td>
<td>0.24 ± 0.005(^*)</td>
</tr>
<tr>
<td>CT seed extract</td>
<td>0.31 ± 0.01(^*) (-63.53%)</td>
<td>0.31 ± 0.005(^*)</td>
</tr>
<tr>
<td>CT root extract</td>
<td>0.40 ± 0.02(^*) (-52.94%)</td>
<td>0.40 ± 0.004(^*)</td>
</tr>
</tbody>
</table>

All values represent mean ± SEM; n = 6 per treatment group. Statistical analysis was carried out using One Way ANOVA followed by Tukey’s multiple range test. \(^*\): Value significantly different (p < 0.05) compared with the control group. CT: C. ternatea. \(^b\): Value in parentheses indicate decrease or increase in DTH response relative to control rat value.

D. Carbon clearance test

The in vivo phagocytic activities were measured by carbon clearance method. CT seed (0.31 ± 0.01) and root (0.40 ± 0.01) extracts produced significant decrease in phagocytic index. The phagocytic index of the control group was considered as unite. The dexamethasone produced significant decrease in the phagocytic index (0.24 ± 0.01) (table 2).

E. Effects on hematological profile

The CT seed and root extracts significantly decreased blood lymphocyte, and RBC counts, as well as Hb content when compared with the control group. The reference drug dexamethasone significantly decreased blood total WBC, neutrophil, RBC counts, and Hb content (table 4).

Table: 3 Effect of CT seed and root extracts on neutrophil index and neutrophil adhesion.

<table>
<thead>
<tr>
<th>Group</th>
<th>TLC (10^3/mm^3) (X)</th>
<th>% Neutrophil (Y)</th>
<th>Neutrophil Index (X x Y) x10^3</th>
<th>% Neutrophil Adhesion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UnB FTB</td>
<td>UnB FTB</td>
<td>UnB FTB</td>
<td>UnB FTB</td>
</tr>
<tr>
<td>Control</td>
<td>6.38 ± 0.57</td>
<td>6.10 ± 0.60</td>
<td>14.34 ± 2.55</td>
<td>11.41 ± 1.85</td>
</tr>
<tr>
<td>DMS</td>
<td>1.42 ± 0.34(^*)</td>
<td>1.43 ± 0.31(^*)</td>
<td>3.51 ± 0.09(^*)</td>
<td>3.10 ± 0.08(^*)</td>
</tr>
<tr>
<td>CT seed extract</td>
<td>6.83 ± 0.66</td>
<td>6.52 ± 0.64</td>
<td>32.83 ± 6.66</td>
<td>30.60 ± 6.55</td>
</tr>
<tr>
<td>CT root extract</td>
<td>4.82 ± 0.43</td>
<td>5.26 ± 0.57</td>
<td>17.60 ± 0.63</td>
<td>14.93 ± 0.91</td>
</tr>
</tbody>
</table>

All values represent mean ± SEM; n = 6 per treatment group. Statistical analysis was carried out using One Way ANOVA followed by Tukey’s multiple range test. \(^*\): P < 0.05 was considered statistically significant. \(^*\): significant when compared with the control group. CT: C. ternatea, DMS: dexamethasone. TLC: total leukocytes count; UnB: untreated blood; FTB: nylon fiber-treated blood.

Table: 4 Effects of CT seed and root extracts on hematological parameters.

<table>
<thead>
<tr>
<th>Group</th>
<th>Total WBC (cells/µL) x 10^3</th>
<th>Neutrophils (cells/µL) x 10^3</th>
<th>Lymphocytes (cells/µL) x 10^3</th>
<th>RBC (cells/µL) x 10^6</th>
<th>Platelets (cells/µL) x 10^6</th>
<th>Hb (g/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>6.14±0.84</td>
<td>0.46 ± 0.15</td>
<td>4.90 ± 0.96</td>
<td>9.16 ± 0.21</td>
<td>813.33 ± 53.48</td>
<td>16.13 ± 0.30</td>
</tr>
<tr>
<td>DMS</td>
<td>0.97 ± 0.04(^*)</td>
<td>0.04 ± 0.04(^*)</td>
<td>0.76 ± 0.07(^*)</td>
<td>7.27 ± 0.17(^*)</td>
<td>940.00 ± 47.84</td>
<td>13.17 ± 0.31</td>
</tr>
<tr>
<td>CT seed extract</td>
<td>6.58 ± 0.59</td>
<td>0.33 ± 0.05</td>
<td>2.11 ± 0.18(^*)</td>
<td>6.77 ± 0.54(^*)</td>
<td>821.08 ± 58.12</td>
<td>14.32 ± 0.34</td>
</tr>
<tr>
<td>CT root extract</td>
<td>4.63 ± 0.39</td>
<td>0.18 ± 0.03</td>
<td>1.95 ± 0.12(^*)</td>
<td>7.12 ± 0.18(^*)</td>
<td>860.55 ± 61.72</td>
<td>13.76 ± 0.45</td>
</tr>
</tbody>
</table>

All values represent mean ± SEM; n = 6 per treatment group. Statistical analysis was carried out using One Way ANOVA followed by Tukey’s multiple range test. \(^*: P < 0.05\) was considered statistically significant. \(^*:\) significant when compared with the control group. CT: C. ternatea, DMS: dexamethasone. WBC: White blood cells, RBC: Red blood cells, Hb: Hemoglobin.
Phagocytosis represents an important innate defense mechanism against ingested particulates including whole pathogenic microorganisms. The specialized cells that are capable of phagocytosis include blood monocytes, neutrophils and tissue macrophages. Once particulate material is ingested into phagosomes, the phagosomes fuse with lysosomes and the ingested material is then digested. Thus, it is not only ingesting and removing microorganisms but also malignant cells, inorganic particles and tissue debrises (Miller, 1991). In general, the rate of in situ carbon particle clearance is frequently used as a measure of reticuloendothelial system (RES) competency. Specifically, a faster removal of particles is correlated with an enhanced phagocytic activity of RES cellular components (Abbas & Litchman, 2001). In the study here, prophylactic treatment with CT seed and root extracts inhibited the rate of carbon clearance seen among control group rats. The neutrophil, an end cell unable to divide and with limited capacity for protein synthesis is, nevertheless, capable of a wide range of responses, in particular chemotaxis, phagocytosis, exocytosis and both intracellular and extracellular killing (Dale & Foreman, 1984). Normally, a more rapid clearance of exogenous particulates from the blood by macrophages would arise from opsonization of the material with antibodies/complement C3b. The decrease in neutrophil function (i.e., adhesion activity) strongly suggests that the function in the treated rats’ phagocytes was inhibited (i.e., immunohibited).

Cell-mediated immunity (CMI) involves effectors mechanisms carried out by T lymphocytes and their products (lymphokines). CMI responses are critical to defense against infectious organisms, infection of foreign grafts, tumor immunity and delayed-type hypersensitivity reactions (Miller, 1991). Delayed type hypersensitivity reaction is characterized by large influxes of non-specific inflammatory cells, in which the macrophage is a major participant. It is a type IV hypersensitivity reaction that develops when antigen activates sensitized TDTH cells. These cells generally appear to be a TH1 subpopulation although sometimes TC cells are also involved. Activation of TDTH cells by antigen presented through appropriate mechanisms for protein synthesis is, nevertheless, capable of a wide range of responses, in particular chemotaxis, phagocytosis, exocytosis and both intracellular and extracellular killing (Dale & Foreman, 1984).
lymphocytes in this reaction, the role of local macrophages (initially) and then recruited monocytes/other phagocytes are critical as well. From the data here, no specific conclusions about the functionality of memory T-lymphocytes can be predicted; however, decreases in anti-SRBC titers in CT seed and root extracts treated rats were suggestive of decreased activation of T-lymphocytes. The decreased phagocytic activities of local/recruited phagocytes would also be a major factor for the substantive decrease observed in DTH among extracts-treated rats.

The majority of the cells involved in the immune system are produced from common hematopoietic stem cells found in the bone marrow. This site also provides a microenvironment for antigen-dependent differentiation of B-lymphocytes (Raphael & Kuttan, 2003). Since CT seed and root extract treatments were seen here to give rise to decreased circulating antibody titers (specifically against the SRBC), it would be expected then that there should have also been decreases induced in levels of one or more of the cell types involved in the humoral response to this antigen. In the present study, the evaluations of peripheral blood of extracts-treated rats confirmed the suppression of total WBC counts. These outcomes suggested strongly that the potential effect of CT seed and root extracts was an impact on hematopoietic processes and on the bone marrow in particular.

Intensity of inflammatory immune responses is controlled by recruitment of inflammatory cells into inflammatory lesions. This process is tightly governed by expression of certain inflammatory chemokines, such as monocyte chemoattractant protein 1 (MCP-1), Macrophage inflammatory protein 1a (MIP-1a), Macrophage inflammatory protein 1h (MIP-1h), and CC Chemokine ligand 5 (CCL5) (Baggiolini & Dahinden, 1994; Kallinich et al., 2005) and adhesion molecules, such as lymphocyte function-associated antigen 1 (LFA-1), L-Selectin, and cluster of differentiation 44 (CD44), by the inflammatory cells, and inter-cellular adhesion molecule 1 (ICAM-1), and vascular cell adhesion molecule 1 (VCAM-1) by the endothelial cells (Cartier et al., 2005). Given the central role of chemokines and adhesion molecules in orchestrating the immune response, interference with the expression of these mediators substantially alter the quality of the immune response, leading to either enhancement or inhibition of the ongoing immune response. Thus, one potential mechanism that might mediate the inhibitory effect of CT on inflammatory immune responses is an alteration of trafficking of the inflammatory cells via modulating expression of chemokines and/or adhesion molecules. Thus, the immunoinhibitory effect of CT can be explained partly by its inhibitory effects on humoral antibody formation, phagocytosis, delayed type hypersensitivity response, and immune cell activities. The anti-inflammatory activity of CT seed and root extracts against carrageenan-induced hind paw edema, pleurisy and cotton pellet granuloma model, suggesting inhibition of inflammatory components of immune response by CT.

V. CONCLUSION

CT seed and root extracts showed profound immunosuppressive activity in male albino rat model. The antioxidant and anti-inflammatory activities of plant may be playing major role in immunoinhibition. The immunomodulatory activity might be attributed to the presence of flavonoid and phenolic compounds. The present study demonstrated and provided evidence for the traditional uses of Clitoria ternatea. Further studies might be required to determine detailed mechanisms and active phytochemicals responsible for immunomodulatory activity.

VI. ACKNOWLEDGEMENT

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VII. REFERENCES


