IMMUNOSTIMULATORY COMPOUNDS IN NEEM

Overview

Long before ancient healers had any idea of how the human body fought disease, they prescribed neem for disorders as diverse as leprosy, gastro-intestinal problems, malaria, ringworms, diabetes, colic, anorexia, boils, epilepsy and ulcers. The first two books of *Ayurveda*, the *Caraka Samhita* and *Susruta Samhita*, include nearly a hundred references to neem that date back two to four centuries before Christ, making it one of the oldest written documents in the world.

Of course, part of that reliance on neem comes from having a relatively limited repertoire of treatments, but many of those prescriptions are being proven today. And whether they understood immune systems or not, these wise men knew that helping the body's ability to fight off disease and repair injuries is a good first choice in almost any situation.

Beginning about 10 years ago, international researchers began to document how neem boosts immune system activity. It's such a powerful booster that some researchers have attributed its contraceptive properties - for both men and women -- to an enhanced immune system.

While scientists have not yet identified specifically how neem works, they do know it carries a one-two-three punch, boosting both the lymphocytic and cell-mediated immune systems, at the same time it kills or slows the growth of many disease-causing organisms such as bacteria, virus and fungus.

The fact that neem affects the cell-mediated immune system is particularly important to most people. Led by "Killer T" cells, the cell-mediated immune system is the body's first defense against infection. Killer T-cells are able to destroy microbes, viruses and cancer cells by injecting toxic chemicals into the invaders. Neem also boosts the body's macrophage response, which stimulates the lymphocytic system, and boosts production of white blood cells.

One of the first studies showing neem's impact on the immune system was a 1992 report from the National Institute of Immunology in India, reported in the *International Journal of Immunopharmacology*. Mice injected with neem oil showed enhanced phagocytic activity and expression of MHC class-II antigens.

Spleen cells of treated animals showed a significantly higher lymphocyte proliferative response to in vitro challenges. The researchers concluded that neem oil acts as a non-specific immunostimulant and that it selectively activates the cell-mediated immune mechanisms to elicit an enhanced response to subsequent mitogenic or antigenic challenges.

Other researchers in India also have shown that neem leaf extract taken orally produces similar effects, including higher levels of white blood cells, specifically IgM and IgG levels, and anti-ovalbumin antibody titres. They also reported an enhancement of macrophage migration inhibition.

Reporting on the use of neem extracts as contraceptives in Immunology & Cell Biology researchers note that neem increases the TH1 type response. Although they did not discover how neem works, they did show that it boosts level of CD4 and CD8 cells in lymph nodes and spleen. An increase in immunoractive and bioactive TNF-alpha and IFN-gamma in lymph nodes and serum also was observed.

That report also indicates that using neem as a vaginal contraceptive inhibits the spread of micro-organisms including *Candida albicans, C. Tropicalis, Niesseria gonorrhoeae*, herpes simplex-2 and HIV-1, as well as resistant strains of *E. coli* and *Staphylococcus aureus*, in part by boosting immune-system activity in the vagina.

Another report in the *American Journal of Reproductive Immunology* on using neem as a method of birth control indicates that neem initially stimulates TH1 cells and macrophages, and then causes an elevation of both immunoreactive and bioactive TNF-alpha and gamma-interferon in serum and mesenteric lymph nodes.

A follow-up study in the *Journal of Ethnopharmacology* reported that long-term use of neem oil, up to 10% of body weight, showed no apparent toxic effect but completely abrogated pregnancies. Researchers conclude that neem activates cell-mediated immune responses, specifically T lymphocyte and phagocytic cells, followed by an elevation in cytokines gamma-interferon and TNF.

Another study published in the Indian Journal of Experimental Biology looked specifically at neem's modulation of humoral and cell-mediated immune response. It reports that mice treated with 100 mg/kg neem leaf extract showed higher IgM and IgG levels plus increased anti-ovalbumin antibody titres. They also reported enhanced macrophage migration inhibition.

A 1997 report in the *Journal of Ethnopharmacology* also showed an increased macrophage activity and lymphocyte proliferation response at low levels of neem (120 mg per kg of weight). At higher concentrations of neem (300 mg per kg), there was a stimulation of mitogen-induced lymphocyte proliferation.

More recent research focuses on neem's ability to help the body fight off viruses and cancer. Chickens with immunosuppressed conditions that were fed powered dry neem leaves showed significantly enhanced humeral and cell-mediated immune responses to a virus. The scientists concluded that neem leaf could be beneficial in immunosuppressed conditions in poultry.

A 1999 report published in the *Journal of Communicable Diseases* looked at in vitro effects of neem leaf extract on the Coxsackie B group of viruses, which are associated with a host of varied syndromes, including meningitis, pericarditis, myocarditis, upper respiratory illness and pneumonia, rash and hepatitis. It concluded that neem inhibited plaque formation and functioned as virucidal agent.

In 2000, researchers published an article in *Phytotherapy Research* concludes that neem leaf extract significantly alters cancer development at extra hepatic sites by influencing hepatic biotransformation enzymes and antioxidants.

One final study, conducted at Howard University in Washington http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=15138081&query_hl=39&itool=pubmed_docsum, concludes that neem also has antiretroviral compounds that appear to inhibit cytoadhesion of cancer, malaria and HIV.

Although most of this research has been conducted in animals and considers very specific types of antigens and infections, the overall results indicate that neem provides a significant boost to human immune systems. However, it also makes it clear that anyone (male or female) who is pregnant or planning to become pregnant should avoid using neem.

Recent Research

Phytother Res. 2006 Sep;20(9):814-8.

Pretreatment with neem (Azadirachta indica) leaf preparation in Swiss mice diminishes leukopenia and enhances the antitumor activity of cyclophosphamide.

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http://www.ncbi.nlm.nih.gov/pubmed/16807877?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

Cancer chemotherapy is associated with several life threatening complications, including bone marrow suppression and leucopenia. To overcome this problem, colony stimulating factor (CSF), granulocyte colony stimulating factor (GCSF) and granulocyte macrophage colony stimulating factor (GMCSF), can be used, however, these therapeutics are expensive and have several disadvantages, including tumor growth promoting activities. This study attempted to use an immunostimulatory neem (Azadirachta indica) leaf preparation (NLP) to prevent the cyclophosphamide (CYP) induced reduction in the WBC count. Pretreatment of mice with NLP reduced the extent of leucopenia and neutropenia in normal and tumor bearing CYP treated mice. NLP pretreatment enhanced in vitro tumor cell cytotoxicity by peripheral blood mononuclear cells (PBMC) from CYP treated mice in either normal or tumor bearing conditions. Similarly, NLP pretreatment of mice enhanced the CYP mediated in vivo tumor growth inhibition and survivability of the host. Based on these observations, it is concluded that NLP would be an effective tool to reduce CYP-induced hematological complications.

PMID: 16807877 [PubMed - indexed for MEDLINE]

Immunopharmacol Immunotoxicol. 2006;28(1):33-50.

Prophylactic dose of neem (Azadirachta indica) leaf preparation restricting murine tumor growth is nontoxic, hematostimulatory and immunostimulatory.

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http://www.ncbi.nlm.nih.gov/pubmed/16684666?ordinalpos=2&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

Significant restriction of growth of Ehrlich's carcinoma was observed following prophylactic treatment on Swiss albino mice with neem leaf preparation (NLP-1 unit) once weekly for four weeks. Toxic effects of this particular dose (1 unit), along with 0.5 unit and 2 units of NLP doses, were evaluated on different murine physiological systems. One hundred percent of mice could tolerate 4 injections of 0.5 and 1 unit NLP doses. Body weight, different organ-body weight ratios and physical behavior of treated mice remained completely unchanged during treatment with different NLP doses. All of these NLP doses were observed to stimulate hematological systems as evidenced by the increase in total count of RBC, WBC and platelets and hemoglobin percentage. As histological changes as well as elevation in serum alkaline phosphatase, SGOT, SGPT were not observed in mice treated with three different doses of NLP, the nonhepatotoxic nature of NLP was proved. The level of serum urea remained unaltered and normal architecture of the cortical and medullary parts of the kidney were also preserved after NLP treatment. Increased antibody production against B16 melanoma antigen was detected in mice immunized with 0.5 unit and 1 unit of NLP. Number of splenic T lymphocytes (CD4+ and CD8+) and NK cells were also observed to be increased in mice injected with 0.5 unit and 1 unit of NLP. However, NLP dose of 2 units could not exhibit such immunostimulatory changes; NLP mediated immunostimulation was correlated well with the growth restriction of murine carcinoma. In other words, tumor growth restriction was observed only when mice were injected with immunostimulatory doses of NLP (0.5 unit and 1 unit).
PMID: 16684666 [PubMed - indexed for MEDLINE]

Int Immunopharmacol. 2005 Jul;5(7-8):1343-52. Epub 2005 Apr 12.

Immunostimulatory neem leaf preparation acts as an adjuvant to enhance the efficacy of poorly immunogenic B16 melanoma surface antigen vaccine.

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Immunogenecity of the poorly immunogenic B16 melanoma cell surface antigen (B16MelSAg) was enhanced by combining B16MelSAg with NLP in C57BL/6 mice, as evidenced by ELISA and flow cytometry. NLP was as effective as Freund's complete and incomplete adjuvant to generate antibodies recognizing the B16MelSAg. The NLP generated antibody was a gamma globulin with a subtype of IgG1. Splenic lymphocytes from B16MelSAg+NLP treated mice proliferated more rapidly in vitro when stimulated by specific (B16MelSAg) and nonspecific (ConA) stimulators, in comparison to the proliferation detected in B16MelSAg and NLP treated groups. Vaccination of mice with B16MelSAg+NLP more efficiently prevented the growth of B16 melanoma tumor than mice immunized with B16MelSAg or NLP alone. In another experiment, the immune sera (B16MelSAg+NLP) was mixed with B16Mel tumors and injected subcutaneously into syngenic C57BL/6 mice. Tumor burden was less in mice receiving a tumor along with B16MelSAg+NLP generated immune sera than other groups. The B16MelSAg+NLP generated immune sera induced antibody dependent cellular cytotoxicity specifically towards B16Mel tumor cells in vitro. We concluded

that NLP might be a potential immune adjuvant for inducing active immunity towards tumor antigens.
PMID: 15914339 [PubMed - indexed for MEDLINE]

Trans R Soc Trop Med Hyg. 2004 Jul;98(7):435-7.

An antimalarial extract from neem leaves is antiretroviral.

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http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=15138081&query_hl=39&itool=pubmed_docsum

An acetone-water neem leaf extract with antimalarial activity was evaluated in vitro at 5 microg/ml for inhibition of adhesion of malaria parasite-infected erythrocytes and cancer cells to endothelial cells, and at 10 microg/ml for protection of lymphocytes against invasion by HIV. The extract was also evaluated in 10 patients with HIV/AIDS at 1000 mg daily for 30 d. The mean binding of infected erythrocytes and cancer cells per endothelial cell was 15 and 11 respectively in the absence of the extract, and 0 and 2 respectively in with the extract. In the absence and presence of the extract, 0% and 75%, respectively, of lymphocytes were protected. In the treated patients, haemoglobin concentration, mean CD4+ cell count and erythrocyte sedimentation rate, which were initially 9.8 g/dl, 126 cells/microl and 90 mm/h respectively, improved to 12.1 g/dl, 241 cells/microl and 49 mm/h. Mean bodyweight and platelet count, initially 57 kg and 328 x 10(3)/mm3 respectively, increased to 60 kg and 359 x 10(3)/mm3. No adverse effects were observed during the study. The extract showed antiretroviral activity with a mechanism of action that may involve inhibition of cytoadhesion. The results may help in the development of novel antiretroviral and antimalarial drugs.
PMID: 15138081 [PubMed - indexed for MEDLINE]

Phytother Res. 2004 May;18(5):419-24.

Nimbidin suppresses functions of macrophages and neutrophils: relevance to its antiinflammatory mechanisms.

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Nimbidin is a mixture of tetranortriterpenes and is the major active principle of the seed oil of Azadirachta indica A. Juss (Meliaceae) possessing potent antiinflammatory and antiarthritic activities. The present study revealed that nimbidin significantly inhibited some of the functions of macrophages and neutrophils relevant to the inflammatory response following both in vivo and in vitro exposure. Oral administration of 5-25 mg/kg nimbidin to rats for 3 consecutive days significantly inhibited the migration of macrophages to their peritoneal cavities in response to inflammatory stimuli and also inhibited phagocytosis and phorbol-12-

myristate-13-acetate (PMA) stimulated respiratory burst in these cells. In vitro exposure of rat peritoneal macrophages to nimbidin also inhibited phagocytosis and PMA stimulated respiratory burst in these cells. Nimbidin also inhibited nitric oxide (NO) and prostaglandin E2 (PGE2) production in lipopolysaccharide (LPS) stimulated macrophages following in vitro exposure, whereas interleukin 1 (IL-1) was only weakly inhibited. Probing the mechanism of NO inhibition revealed that nimbidin ameliorated the induction of inducible NO synthase (iNOS) without any inhibition in its catalytic activity. In addition, nimbidin also attenuated degranulation in neutrophils assessed in terms of release of beta-glucuronidase, myeloperoxidase and lysozyme. The results suggest that nimbidin suppresses the functions of macrophages and neutrophils relevant to inflammation. Thus nimbidin can be valuable in treating inflammation/inflammatory diseases. Copyright 2004 John Wiley & Sons, Ltd.
PMID: 15174005 [PubMed - indexed for MEDLINE]

Int Immunopharmacol. 2004 Mar;4(3):355-66.

Neem (Azadirachta indica) leaf mediated immune activation causes prophylactic growth inhibition of murine Ehrlich carcinoma and B16 melanoma.

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Conditional growth inhibition of murine Ehrlich carcinoma (EC) and B16 melanoma (B16Mel) was observed, following treatment of mice (Swiss and C57BL/6) with aqueous extract of neem (Azadirachta indica) (1 unit/mice/week for 4 weeks) either before or after inoculation of 1 x 10(6) tumor cells. Tumor inoculation after weekly injections for 4 weeks with neem leaf preparation (NLP) induced significant reduction of tumor growth (both EC and B16Mel) and increased survivability of mice. On the other hand, NLP treatment after tumor inoculation demonstrated no tumor growth inhibition in the NLP treated group in comparison to the PBS treated control. No direct cytotoxic effect of NLP towards EC and B16Mel tumor cells was observed in vitro. The spleen cells of NLP treated mice when mixed with inoculum of B16Mel tumor cells and injected into a group of mice, tumor growth was found to be significantly reduced and survivability of the tumor hosts increased remarkably in comparison to mice inoculated with tumor along with normal spleen cells. Concanavalin A (ConA) induced proliferation of lymphocytes from NLP treated mice was significantly higher than the lymphocytes of untreated mice. In in vitro, NLP by itself had no proliferative effects on lymphocytes but it co-stimulated ConA induced mitogenesis. NLP induced lymphocytosis as evidenced by increased lymphocyte count in blood as well as spleen. Flow cytometric evidence suggested that increase in CD4+ and CD8+ T cells accounted for lymphocytosis. The conditional tumor growth retardation, observed in mice treated with NLP before tumor inoculation, may be regulated by NLP mediated immune activation, having prominent role in the cellular immune function of the tumor host.
PMID: 15037213 [PubMed - indexed for MEDLINE]

J Ethnopharmacol. 1999 Nov 30;67(3):287-96.

Early post implantation contraceptive effects of a purified fraction of neem (Azadirachta indica) seeds, given orally in rats: possible mechanisms involved.

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Neem seed and leaf extracts have immunomodulators that induce cellular immune reactions. These aspects of neem were exploited in earlier studies, where the oral administration of the neem seed extracts in rodents and primates could completely abrogate pregnancy at an early post implantation stage. Complete restoration of fertility was observed in the animals treated in the subsequent cycles. For the purpose of using neem as a long term contraceptive, an activity guided fractionation, followed by identification and characterization of the biologically active fraction from neem seeds was carried out. Sequentially extracted fractions of neem seeds were tested orally at an early post implantation stage in rats. The hexane extract of the neem seeds was found to be biologically active and was the precursor for the final active fraction. The active fraction, identified as a mixture of six components, could completely abrogate pregnancy in rodents up to a concentration of 10%. No apparent toxic effects could be seen following treatment with the fraction. The treatment with the active fraction caused a specific activation of T lymphocyte cells of CD8+ subtype as well as phagocytic cells followed by elevation in cytokines gamma-interferon and TNF. The results of the present study show that a pure active fraction of neem seeds could be obtained for the purpose of early post implantation contraception when given orally, and its mechanism of action seems to be by activating cell mediated immune reactions.
PMID: 10617063 [PubMed - indexed for MEDLINE]

Am J Reprod Immunol. 1997 Jun;37(6):485-91.

Induced termination of pregnancy by purified extracts of Azadirachta Indica (Neem): mechanisms involved.

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PROBLEM: To develop a self-administered, orally delivered method for abrogation of early pregnancy. METHOD: Use of purified Neem extracts containing immunomodulators stimulating Th1 cells and macrophages; test animals, rats, baboons, and monkeys, onset of pregnancy confirmed by surgery and counting of implants on day 7 in rats and by chorionic gonadotropin (CG) and progesterone assays in primates; termination defined by complete resorption on day 15 in rats and by bleeding and decline of CG and progesterone in baboons.

RESULTS: Pregnancy was terminated successfully in both rodents and primates with no significant side effects. Fertility was regained in both species after one or two irregular cycles. Progeny born had normal developmental landmarks and mothered normal litters in the course of time. The active principle in Neem has been partially fractionated by activity-guided purification. A cascade of events are involved in abrogation of pregnancy. In primates, a decrease in progesterone is an early event. A transient increase in CD4 and CD8 cells is noted in spleen at 96 hr and in mostly CD8 cells in mesenteric lymph nodes. Treatment causes an elevation of both immunoreactive and bioactive TNF-alpha and gamma-interferon in serum, mesenteric lymph nodes, and foetoplacental tissue. CONCLUSION: Immunomodulators of plant origin are potentially usable for termination of unwanted pregnancy
PMID: 9228306 [PubMed - indexed for MEDLINE]

Indian J Exp Biol. 1997 Mar;35(3):222-4.

Effects of stress on gamma glutamyl transpeptidase (GGT) activity in lymphoid system of rats: modulation by drugs.

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http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=9332165&query_hl=39&itool=pubmed_docsum

Effects of stress and its modulation by adaptogens were evaluated on gamma glutamyl transpeptidase (GGT) activity in different tissues of the lymphoid system in rats. Restrain stress (RSx5) suppressed the GGT activity in different tissues of lymphoid system viz. the lymphocyte, the spleen, the thymus and the macrophage, and the maximum effect was seen in the spleen. Chlordiazepoxide, a prototype anti-stress agent, which did not alter GGT activity per se, reversed the effect of RS on this enzyme activity in tissues of lymphoid system studied. Azardirachta indica (Al, Neem), an indigenous adaptogen stimulated the GGT activity per se and nearly normalised RS induced suppression of GGT in lymphoid system. The observed suppression of GGT activity in lymphoid system by stress and its modulation by natural and synthetic adaptogens indicates that GGT could be a consistent cellular/biochemical marker of stress responsiveness and stress-induced immunomodulation.
PMID: 9332165 [PubMed - indexed for MEDLINE]

J Ethnopharmacol. 1997 Jan;55(2):133-9.

Immunomodulatory effects of NIM-76, a volatile fraction from Neem oil.

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http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=9032626&query_hl=39&itool=pubmed_docsum

The immunomodulatory properties of NIM-76 have been described in this paper. Pre-treatment of rats with a single i.p. injection of NIM-76 resulted in an increase in polymorphonuclear

(PMN) leukocytes with a concomitant decrease in lymphocyte counts. The immunomodulatory activity of NIM-76 was found to be concentration-dependent. At 120 mg/kg body weight, there was an enhanced macrophage activity and lymphocyte proliferation response, while the humoral component of immunity was unaffected. At higher concentrations of NIM-76 (300 mg/kg body weight), there was a stimulation of mitogen-induced lymphocyte proliferation, while macrophage activity remained unaffected. However, a fall in primary and secondary antibody titres was observed. The study indicates that NIM-76 acts through cell-mediated mechanisms by activating macrophages and lymphocytes.
PMID: 9032626 [PubMed - indexed for MEDLINE]

J Assist Reprod Genet. 1996 Aug;13(7):578-85.

Contraception potential of neem oil: effect on pregnancy success in the mouse.

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PURPOSE: The aim of this study was to find out the role and mechanism of action of neem oil as a postcoital fertility blocker in mouse. METHODS: Female mice were injected with neem oil (20 or 40 microliters) surgically into each uterine horn on day 2 postcoitum (pc). Both the uterine horns of each mouse were injected. Arachis oil served as vehicle control. Pregnancy success was determined by the number of implanted embryos on day 8 pc and the number of live fetuses in the uteri on day 18 pc. Transforming growth factor-alpha (TGF alpha), epidermal growth factor (EGF), and epidermal growth factor receptor (EGFR) were immunolocalized in the paraffin-embedded sections of the uteri at 0600 hr on day 5 pc. The unimplanted embryos were assessed in the uteri at 2000 hr on day 5 pc. Uterine secretions were assessed for the leukocytes infiltration on day 4 through day 8 pc. RESULTS: The number of implantation sites on day 8 pc and the number of live fetuses on day 18 pc were lower in the neem oil-treated animals compared to their respective control animals at both the concentrations of neem oil (20 and 40 microliters/uterine horn). Neem oil also caused resorption of some embryos between day 8 pc and day 18 pc. In neem oil-treated mice, EGFR immunostaining decreased in the luminal and glandular epithelium and increased in the stroma as determined at 0600 hr on day 5 pc. Uterine secretions on day 4 through day 6 pc from the neem oil-treated mice showed massive leukocyte infiltration. Unimplanted preimplantation embryos, underdeveloped, degenerated, or at blastocyst stage, were recovered from the uteri after flushing at 2000 hr on day 5 pc from the neem oil-treated animals. A number of retrieved unimplanted embryos showed the direct attachment of the leukocytes to their zona pellucida. It is believed that the secretions of these leukocytes might be responsible for the underdevelopment of the early embryos and hence inhibition of implantation. The exact interaction of these leukocytes and their secretions with the early embryos is under investigation. CONCLUSIONS: Postcoital intrauterine treatment of neem oil during preimplantation period causes fertility block in mouse by lowering the EGFR localization in the luminal and glandular epithelium, by causing massive leukocytes infiltration into the uteri, by degenerating the early embryos, and by causing the postimplantation embryonic resorptions

in the uteri. The possible mechanism of action of neem oil is discussed.
PMID: 8844316 [PubMed - indexed for MEDLINE]

Planta Med. 1993 Jun;59(3):215-7.

The gastric antiulcer effects of the leaves of the neem tree.

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http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=8316589&query_hl=39&itool=pubmed_docsum

The antiulcer effect of aqueous extracts of the leaves of the neem tree was investigated in rats exposed to 2-h cold-restraint stress or given ethanol orally for 1 h. Extracts were administered in doses of 10, 40, or 160 mg leaf/kg body weight, either as single- or five-dose pretreatment regimens. Neem dose-dependently reduced gastric ulcer severity in rats subjected to stress and also decreased ethanol provoked gastric mucosal damage. The extract appeared to prevent mast cell degranulation and to increase the amount of adherent gastric mucus in stressed animals. These effects may explain, at least in part, the mode of the antiulcer action of neem.
PMID: 8316589 [PubMed - indexed for MEDLINE]

Int J Immunopharmacol. 1992 Oct;14(7):1187-93.

Immunomodulatory effects of neem (Azadirachta indica) oil.

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Immunomodulatory effects of neem oil were studied in mice. The animals were treated intraperitoneally (i.p.) with neem oil; control animals received the emulsifying agent with or without peanut oil. Peritoneal lavage, collected on subsequent days, showed a maximum number of leukocytic cells on day 3 following treatment with neem oil; peritoneal macrophages exhibited enhanced phagocytic activity and expression of MHC class-II antigens. Neem oil treatment also induced the production of gamma interferon. Spleen cells of neem oil-treated animals showed a significantly higher lymphocyte proliferative response to in vitro challenge with Con A or tetanus toxoid (TT) than that of the controls. Pre-treatment with neem oil, however, did not augment the anti-TT antibody response. The results of this study indicate that neem oil acts as a non-specific immunostimulant and that it selectively activates the cell-mediated immune (CMI) mechanisms to elicit an enhanced response to subsequent mitogenic or antigenic challenge.
PMID: 1452404 [PubMed - indexed for MEDLINE]