

- Southeast Asian J Trop Med Public Health. 2007 Mar;38(2):343-8

A comparative assessment of the antimicrobial effects of garlic (*Allium sativum*) and antibiotics on diarrheagenic organisms.

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Antimicrobial sensitivity tests were carried out on *Escherichia coli*, *Shigella* sp, *Salmonella* sp, and *Proteus mirabilis* using standard procedures. Significant differences ($p < 0.01$) were seen in the effect of the antimicrobial agents (garlic, ciprofloxacin and ampicillin), and in the sensitivities of the microbial species ($p < 0.01$) to the antimicrobial agents were observed. The gram-negative diarrheagenic pathogens from the stool samples were highly sensitive to garlic, while ciprofloxacin (CPX) was most effective against *E. coli*. The differences were inferred to result from genetic differences among the organisms and differences in the modes of action of the antibiotics. No isolates were resistant to garlic, making it a promising antimicrobial agent. It appears that antibiotics that interfere with DNA and RNA syntheses, such as garlic does, could constitute an effective partner in the synergic effect of garlic currently being investigated worldwide.

PMID: 17539285 [PubMed - in process]

- Yeast. 2007 Aug;24(8):695-706

Diallyl disulphide depletes glutathione in *Candida albicans*: oxidative stress-mediated cell death studied by two-photon microscopy.

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Using two-photon scanning laser microscopy, we investigated the effect of an *Allium sativum* (garlic) constituent, diallyl disulphide (DADS), on key physiological functions of the opportunistic pathogen *Candida albicans*. A short 30 min exposure to 0.5 mM DADS followed by removal induced 70% cell death (50% necrotic, 20% apoptotic) within 2 h, increasing to 75% after 4 h. The early intracellular events associated with DADS-induced cell death were monitored with two-photon fluorescence microscopy to track mitochondrial membrane potential ($\Delta\psi(m)$), reactive oxygen species (ROS) and NADH or reduced glutathione (GSH) under aerobic conditions. DADS treatment decreased intracellular GSH and elevated intracellular ROS levels. Additionally, DADS induced a marked decrease of $\Delta\psi(m)$ and lowered respiration in cell suspensions and isolated mitochondria. In vitro kinetic experiments in cell-free extracts suggest that glutathione-S-transferase (GST) is one of the intracellular targets of DADS. Additional targets were also identified, including inhibition of a site or sites between complexes II-IV in the electron transport chain, as well as the mitochondrial ATP-synthase. The results indicate that DADS is an effective antifungal agent able to trigger cell death in *Candida*, most probably by eliciting oxidative stress as a consequence of thiol depletion and impaired mitochondrial function. (c) 2007 John Wiley & Sons, Ltd.

Publication Types: Research Support, N.I.H., Extramural

PMID: 17534841 [PubMed - in process]

- J Interferon Cytokine Res. 2007 May;27(5):377-82

Systemic production of IFN-alpha by garlic (*Allium sativum*) in humans.

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The effect of foods on the production of interferon-alpha (IFN-alpha) is currently unknown. Garlic (*Allium sativum*) used as a folk medicine is reported to stimulate nitric oxide (NO) production. We investigated the systemic increase of NO due to the ingestion of garlic on the plasma IFN-alpha level in normal volunteers. Normal volunteers (10 groups, 10 in each group) ate 2 g fresh garlic, and plasma NO and IFN-alpha levels

were determined after 2 and 4 h. The participants were also asked to eat garlic for various periods of time, and plasma NO and IFN-alpha were similarly assayed. Ingestion of 2 g fresh, but not boiled, garlic was found to increase the basal plasma level of NO from 2.7 +/- 0.1 microM to 8.76 +/- 0.21 microM at 2 and 4 h, respectively. The basal plasma IFN-alpha level increased from 9.51 +/- 0.26 nM to 46.3 +/- 1.2 nM in normal volunteers (n = 10) at the same time. The chronic eating of garlic was found to maintain IFN-alpha at high levels for at least 7 days. The exposure of neutrophils to garlic in vivo or in vitro, which also stimulated synthesis of NO in these cells, was found to stimulate IFN-alpha synthesis as measured by the stimulation of IFN-alpha mRNA synthesis. Thus, consumption of garlic resulted in stimulated synthesis of NO and, in turn, IFN-alpha in humans, which could be beneficial in viral or proliferative diseases.

Publication Types: Comparative Study
PMID: 17523869 [PubMed - indexed for MEDLINE]

- Ethiop Med J. 2006 Oct;44(4):385-9

An in vitro assessment of the antibacterial effect of garlic (*Allium sativum*) on bacterial isolates from wound infections.

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BACKGROUND: Garlic (*Allium sativum*) has come to be seen as an all rounded treatment for preventing wound infection, common cold, malaria, cough and lung tuberculosis, hypertension, sexually transmitted diseases, mental illness, kidney diseases, liver diseases, asthma, diabetes. **OBJECTIVE:** The main objective of this study was to assess the antibacterial effect of crude preparation of garlic on bacterial isolates from the wound infections. **METHODS:** An experimental study was conducted in Gondar University Teaching Hospital School of Medical Laboratory Technology, Microbiology Laboratory from June 2004 to April 2005 by agar dilution technique. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of garlic to control strains of *Staphylococcus aureus* ATTC 25923 and *Escherichia coli* ATCC 25922, as well as to clinical isolates of *S. aureus*, *E. coli*, *Proteus mirabilis*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* were determined using agar dilution method. The data was collected in triplicate. **RESULTS:** All the tested organisms were inhibited by 33.75 mg/ml of the crude preparation of garlic except control organism and clinical isolates of *S. aureus*, which were inhibited by 11.25 mg/ml of crude garlic. Garlic did not reveal bactericidal effect up to a concentration of 37.5 mg/ml against all the tested organisms. **CONCLUSION:** Crude preparation of garlic could be used as an effective antibacterial agent for the tested organisms. Nevertheless, clinical trial on the effect of garlic is essential before advocating large-scale therapy.

PMID: 17370439 [PubMed - in process]

- J Egypt Public Health Assoc. 2003;78(5-6):361-72

The inhibitory effect of garlic (*Allium sativum*) on growth of some microorganisms.

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The aim of the present study was to compare between the anti-microbial activity of fresh garlic bulbs and that of its water extract against the potent food pathogens *Staphylococcus aureus*, *Escherichia coli*, *Salmonella typhi* and *Bacillus cereus*. Garlic segments with different concentrations (1%, 5%, and 10%) were used. Another 100 gms of garlic segments were weighed and mixed with 100 ml distilled water to prepare water extract of garlic, then 1000, 500 and 100 microg/ml were prepared. These concentrations of garlic were mixed with prepared cultures of *E. coli*, *Staph. aureus*, *Bacillus cereus*, and *Salmonella typhi*. The inhibitory effect of garlic was determined using Spectrophotometer for garlic segments and by comparing with control

plates for the water extract of garlic. Results showed that the higher the garlic concentration, the higher was the microbial reduction percent. Water extract of garlic exhibited a higher microbial reduction percentage than fresh garlic.

PMID: 17219900 [PubMed - indexed for MEDLINE]

- Phytomedicine. 2006 Jun;13(6):394-400. Epub 2005 Nov 2

Antifungal effects of the volatile oils from Allium plants against Trichophyton species and synergism of the oils with ketoconazole.

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In an attempt to develop stable and safe antifungal agents from natural products (daily foodstuffs in particular), the activities of essential oils from *Allium sativum* for. *pekinense*, *A. cepa*, and *A. fistulosum* against three *Trichophyton* species responsible for severe mycoses in humans were investigated and compared with activity of allicin in this study. The fungistatic activities of *Allium* oils were evaluated by the broth dilution method and disk diffusion assay. The combined effects of *Allium* oils with ketoconazole were tested by the checkerboard titer test. Among the tested oils, *A. sativum* for. *pekinense* oil exhibited the strongest inhibition of growth of *T. rubrum*, *T. erinacei*, and *T. soudanense* with MICs (minimum inhibiting concentrations) of 64microg/ml, while the activities of *A. cepa* and *A. fistulosum* were relatively mild. The inhibiting activities of the oils on Sabouraud agar plates were dose dependent against *Trichophyton* species. Additionally, these oils showed significant synergistic antifungal activity when combined with ketoconazole in the checkerboard titer test and disk diffusion test.

Publication Types: Research Support, Non-U.S. Gov't

PMID: 16716908 [PubMed - indexed for MEDLINE]

- Fitoterapia. 2006 Jun;77(4):321-3. Epub 2006 May 11

In vitro antifungal activities of Allium cepa, Allium sativum and ketoconazole against some pathogenic yeasts and dermatophytes.

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By using an agar dilution assay, the antifungal activity of aqueous extracts prepared from *Allium cepa* (onion; AOE) and *Allium sativum* (garlic; AGE) were evaluated against *Malassezia furfur* (25 strains), *Candida albicans* (18 strains), other *Candida* sp. (12 strains) as well as 35 strains of various dermatophyte species and compared with the activity of a known antifungal drug, ketoconazole (KTZ). All the AOE, AGE and KTZ were found to be able to inhibit growth of all fungi tested in a dose-dependent manner with maximum of 100% at defined concentrations. The results indicate that onion and garlic might be promising in treatment of fungal-associated diseases from important pathogenic genera *Candida*, *Malassezia* and the dermatophytes.

PMID: 16690223 [PubMed - indexed for MEDLINE]

- Microbiology. 2005 Oct;151(Pt 10):3257-65

Allyl alcohol and garlic (*Allium sativum*) extract produce oxidative stress in *Candida albicans*.

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Both the growth and respiration of *Candida albicans* are sensitive to extracts of *Allium sativum* and

investigations into the anticandidal activities are now focussing on the purified constituents to determine the targets of inhibition. Of particular interest is allyl alcohol (AA), a metabolic product that accumulates after trituration of garlic cloves. Putative targets for AA were investigated by monitoring changes in intracellular responses after exposure of *C. albicans* cells to AA or a commercially available garlic extract. Two-photon laser scanning microscopy and other techniques were used. Changes typical of oxidative stress--NADH oxidation and glutathione depletion, and increased reactive oxygen species--were observed microscopically and by flow cytometry. Known targets for AA are alcohol dehydrogenases Adh1 and 2 (in the cytosol) and Adh3 (mitochondrial), although the significant decrease in NAD(P)H after addition of AA is indicative of another mechanism of action.

PMID: 16207909 [PubMed - indexed for MEDLINE]

- Arch Oral Biol. 2005 Jul;50(7):645-51. Epub 2005 Feb 5

Inhibitory effect of garlic extract on oral bacteria.

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Garlic (*Allium sativum*) has long been known to have antibacterial, antifungal and antiviral properties but there are few data on its effects against oral bacterial species particularly putative periodontal pathogens or their enzymes. Filter sterilised, aqueous extract of garlic was tested for ability to inhibit the growth of a range of oral species and to inhibit the trypsin-like and total protease activity *Porphyromonas gingivalis*. The garlic extract (57.1% (w/v), containing 220 microg/ml allicin) inhibited the growth and killed most of the organisms tested. In general, the minimal inhibitory and minimum bactericidal concentrations for the Gram-negative strains (garlic MIC range 35.7-1.1 mg/ml; allicin mean MIC 4.1 microg/ml; mean MBC 7.9 microg/ml) were lower than those for the Gram-positive strains tested (garlic MIC range 142.7-35.7 mg/ml; allicin mean MIC 27.5 microg/ml; mean MBC 91.9 microg/ml). Also, of the organisms tested, the putative periodontal pathogens had among the lowest MICs (17.8-1.1 mg/ml garlic) and MBCs (35.7-1.1 mg/ml garlic). Time-kill curves for *Streptococcus mutans* and *P. gingivalis*, showed that killing of the latter started almost immediately, whereas there was a delay before *S. mutans* was killed. The garlic extract also inhibited the trypsin-like and total protease activity of *P. gingivalis* by 92.7% and 94.88%, respectively. These data indicate that garlic extract inhibits the growth of oral pathogens and certain proteases and so may have therapeutic value, particularly for periodontitis.

PMID: 15892950 [PubMed - indexed for MEDLINE]

- Ethiop Med J. 2002 Jul;40(3):241-9

Investigation on the antibacterial properties of garlic (*Allium sativum*) on pneumonia causing bacteria.

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The antibacterial activity of the crude aqueous extract of garlic was investigated against some pneumonia causing bacteria by an agar dilution technique. The results revealed that *Streptococcus pneumoniae* standard test organism was completely inhibited by 7.8 mg/ml of media and the clinical isolate of *Klebsiella pneumoniae* was completely inhibited by 24.38 mg/ml of media, indicating that *Streptococcus pneumoniae* is the most sensitive and *Klebsiella pneumoniae* the least. Garlic could be used as an effective antibacterial agent for these pathogenic microorganisms.

Publication Types: Research Support, Non-U.S. Gov't
PMID: 12602248 [PubMed - indexed for MEDLINE]

- J Appl Microbiol. 1998 Feb;84(2):213-5

Sensitivity of food pathogens to garlic (*Allium sativum*).

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The inhibitory activity of garlic (*Allium sativum*) against *Staphylococcus aureus*, *Salmonella typhi*, *Escherichia coli* and *Listeria monocytogenes* was measured by the 'turbidity' method. Minimum inhibitory concentration (MIC) of garlic at 80% inhibition level was calculated for these bacteria. All bacterial pathogenic strains tested were inhibited by garlic; *E. coli* was most sensitive and *Listeria monocytogenes* was least sensitive. Therefore, garlic has potential for the preservation of processed foods.

PMID: 9633635 [PubMed - indexed for MEDLINE]