

Overview

STUDY AND APPLICATION OF HERBAL DISINFECTANTS IN CHINA ZHAO-BIN CHEN

*Shenzhen Nanshan District Sanitary and Anti-epidemic Station,
Shenzhen 518054, Guangdong, China*

Disinfection means killing or removing pathogenic microorganisms in media to realize a harmless process. A disinfectant, which is also referred to as a disinfection medicine in relevant regulations, is the medicine used to kill microorganisms for the purpose of disinfection. The disinfectants prepared from plants (including traditional Chinese herbal medicines) and the extracts thereof are called herbal disinfectants^[1]. China has a long history of using herbal disinfectants. As early as in 533 A.D., the use of Cornel to sterilize well water was recorded in *Necessary Techniques for Qi People* by Jia Enxie of the Beiwei Dynasty^[2]. During the Dragon Boat Festival, people often use fumigants made of traditional Chinese herbal medicines like Chinese Atractylodes, Argy Wormwood Leaf and Red Arsenic Sulfide to smoke their houses, so as to ward off plagues and drive away evils^[3]. In fact this is now a kind of disinfection practice.

Medicinal Herbs Used for Disinfection and Their Effects

The commonly used herbal disinfectants are *Eucalyptus robusta*, *Senecio scandens*, *Callicarpa nudiflora*, *Rhodomyrtus tomentosa*, *Loropetalum chinense*, and *Mosla chinensis*, etc. The skin and mucosa disinfectants made from medicinal herbs are also referred to as plant antiseptics which are of strong bacteriostasis (Table 1). Some of the disinfectants are proved reliable in terms of their effects on skin disinfection. Their decocted fluids are generally applied to disinfect skin, hand and external wound, etc. Taking *Eucalyptus robusta* as an example, when it is used for skin disinfection, 15%-20% of its decocted fluid has been used to disinfect the skin before injection in more than 12 000 cases. 20% of its decocted fluid could kill 70.9% of bacteria on the skin in 5 seconds and 76.9% in 10 seconds. 10% of its decocted fluid or crystal solution has been used to disinfect the hand in 217 cases before surgery, with good healing after the surgery. In the case of external application in curing wound, 10% of its milky solution has been used in taking out the stitches after operation or rinsing the wound with good results in controlling infections^[3].

The Antimicrobial Mechanism of Herbal Disinfectants

The bactericidal effect and bacteriostatic effect of plant medicines are generally called antibacterial effects. A single plant medicine itself contains a lot of components which result in various medical effects. A compound plant medicine composed of different kinds of plant medicines contains more effective components than the single plant medicine, and interaction

Biographical note of the first author: Zhao-Bin CHEN, born in 1963, Medical Master and Ph. D. candidate, deputy director of Shenzhen Nanshan District Sanitary and Anti-epidemic Station, vice chief technician, vice pluralistic professor in Sichuan University, majoring in disinfection and management.

TABLE 1
Bacteriostatic Effects of Several Common Plant Antiseptics

| Name of Drug | Bacteriostasis on Various Bacteria | | | | | | | | Practical Test |
|---------------------------------|------------------------------------|----------------|------------------|-----------------------------------|-----------------------|-----------------|-----------------------|------------------------|----------------|
| | Staphylococcus aureus | <i>E. coli</i> | Anthrax bacillus | β -haemolytic streptococcus | <i>C. diphtheriae</i> | <i>S. typhi</i> | <i>Ps. aeruginosa</i> | <i>Sh. dysenteriae</i> | |
| Eucalyptus Robusta | +++ | + | +++ | ++ | ++ | ++ | + | + | Performed |
| Herba Senecionis | +++ | +++ | +++ | ++ | ++ | ++ | + | + | Performed |
| Scandentis Callicarpa Nudiflora | +++ | +++ | +++ | ++ | ++ | ++ | + | + | Performed |
| Rhodomyrtus Tomentosa | + | + | ... | ... | ... | ... | ... | + | Performed |
| Loropetalum Chinense | +++ | + | + | ++ | ++ | ++ | ++ | ++ | Performed |
| Mosla Chinensis | +++ | + | +++ | ++ | ++ | ++ | ++ | ++ | Performed |
| Mosla Scabra | +++ | + | +++ | ++ | ++ | ++ | ++ | + | Not Performed |
| Eucalyptus Tereticomis | +++ | +++ | +++ | ++ | ++ | ++ | ++ | ++ | Not Performed |
| Eucalyptus Citriodora | ++ | ... | ... | ... | ... | ++ | ... | ++ | Not Performed |

Resources: Page 127 of the Manual of Disinfection, Disinfestation and Deratization Published by Beijing People's Health Publishing House, May 1982.

Note: +++ intensive bacteriostatic effect of plant antiseptics; ++ moderate bacteriostatic effect of plant antiseptics; + mild bacteriostatic effect of plant antiseptics.

of different components is more complex. The antibacterial mechanism of plant medicine relies on its action on bacteria metabolism. For example, Huanglian (*Rhizoma Coptidis*) can fiercely inhibit breath of *Staphylococcus aureus*, and synthesis of protein, nucleic acid in it. Huangbo (*Cortex Phellodendri*) can fiercely inhibit breath of bacteria, and synthesis of nucleic acid. The inhibition of Dahuang (*Radix et Rhizoma Rhei*) to lactate dehydrogenase (LDH) is the strongest. Liquorice remarkably inhibits synthesis of DNA. The effect of the compound plant medicine includes synergetic, enhancive, and antagonistic actions. Plant medicines have the property of bacteriostatic effects at low concentration, while demonstrating bactericidal effect at high concentration or extending the disposal time. They have different effects by different components to bacteria, virus, spirochaeta, mycoplasma, chlamydiae, rickettsia, fungus, and protozoa^[5].

The Main Components of Plant Medicines Commonly Used as Herbal Disinfectants

The plant medicines used as herbal disinfectants are illustrated in Table 2.

TABLE 2

Main Components of Plant Medicines Commonly Used as Herbal Disinfectants^[4]

| Name of Plant Medicine | Main Components |
|--|---|
| Dayean (<i>Eucalyptus robusta</i>) | α -pinene, cineole, α -phellandrene |
| Zizhucao (<i>Callicarpa nudiflora</i>) | Flavonoid Glycosides, Hydroxybenzene, tannins |
| Jimu (<i>Loropetalum chinense</i>) | Tannins, Gallic Acid, Flavone |
| Changshu (<i>Atractylodes</i>) | β -eudesmol, Atractylol, Atractylolone |
| Aiye (<i>Folium Artemisiae Argyi</i> or Argy Wormwood Leaf) | Thujone, Thujyl Alcohol, Cadinene |
| Daqingye (<i>Indigofera tinctoria</i>) | Isatin B, Glucobrassicin, Neoglucobrassicin |
| Niubangzi (<i>Fructus Arctii</i>) | Arctiin, Arctic Acid, Phlegm |
| Danggui (<i>Radix Angelicae Sinensis</i> , angelica) | n-but-ylidene Phthalide, Bergapten |
| Baizhi (<i>Radix Angelicae Dahuricae</i>) | Angelicin, Angelicol |
| Kushen (<i>Radix Sophorae Flavescentis</i>) | d-matrine, Oxymatrine, Cytisine |
| Ganjiang (<i>Rhizoma Zingiberis</i>) | Zingiberone, Zingiberol, Zingiberane |
| Shiwei (<i>Folium Pyrrosiae Linguae</i>) | Isomangiferin, Fumaric Acid, Caffeic Acid |
| Baitouweng (<i>Pulsatilla chinensis</i> , pasqueflower) | Protoanemonin, Triterpenoid Saponin |
| Gangbangui (<i>Herba Polygoni Perfoliati</i>) | Indican, Anthra glycosides, Cardiac Glycosides |
| Chishao (<i>Radix Paeoniae Rubra</i>) | Paeoniflorin, Benzoic Acid, Hydroxybenzene |
| Guanzhong (<i>Rhizoma Cyrtomii Fortunei</i>) | Isoquercitrin, Cyrtomin, Cyrtopterin |
| Jinyinhua (Honeysuckle) | Luteolin, Chlorogenic Acid, Isochlorogenic Acid |
| Banlangen (<i>Radix Isatidis</i>) | Sinigrin, Isatin, Indoxyl |
| Zhizi (<i>Gardenia</i>) | Gardenin, Gardenoside, Gardoside |
| Yinchen (<i>A. capillaries Thunb</i>) | Capillarin, Scoparon, Capillon |
| Huangbo (<i>Cortex Phellodendri</i>) | Berberine, Phellodendrine, Magnoflorine |
| Huangqin (<i>Radix Scutellariae</i>) | Baicalin, Baicalein, Wogonoside |
| Juhua (<i>Chrysanthemum</i>) | Borneol, Stachydrine, Buddleoglycoside |
| Zicao (<i>Radix Lithospermi</i> , Redroot Gromwell) | Shikonin, Acetyl Shikonin, Deoxyshikonin |
| Qianliguang (<i>Herba Senecionis Scandentis</i>) | Alkaloid, Flavone, Tannins |
| Changpu (<i>Calamus</i>) | α -, β -asarone, Caryophyllene |
| Sechuangzi (<i>Fructus Cnidii</i>) | 1-pinene, 1-camphene, Bornylisovalerate |

Herbal Fumigants

Herbs usually used for herbal fumigants are Chinese atractylodes, argy wormwood leaf, Mosla chinensis oil, fir wood, pine wood and so on. The fumigants are, for convenient application, usually made in the form of incense or smoke agent whose major components are plant medicines, adhesive materials, combustibles, perfumes, pigments, etc. Coil and bar incenses are mostly used for air disinfection to prevent respiratory infectious diseases like common cold and flu. Smoke guns or tanks containing large amount of smoke can be used for terminal disinfection in epidemic foci or big public places. For example, the formula of mother chrysanthemum and argy wormwood leaf incense contains 40% powder of mother chrysanthemum, 10% powder of argy wormwood leaf, 42% powder of sticky wood flour, 8% powder of wood flour, perfume and a little potassium chlorate. The natural bacteria, after the incense is burned, are dramatically reduced. The maximum number of bacteria (plate method) before burning the incense was 142, and 27 after its burning^[3].

Study and Application of Compound Herbal Disinfectants in Recent Years

Air disinfection According to the reports by Su-Zhen WANG and her colleagues,

the herbal medicine Chinese atractylode was used for air fumigation disinfection after it had been soaked with 95% alcohol in hospital wards. The results of the experiments showed that there was no obvious difference in the effect between the air fumigation disinfection by Chinese atractylodes and the disinfection by ultraviolet radiation. The average amount of bacteria in the air, however, was reduced by 68%, and this was quite different from the results produced by disinfection by "84" disinfection solution ($P < 0.05$) in which the average amount of bacteria in the air was reduced by 81.7%^[6]. Qi-Yun SHI and her colleagues studied the effect of compound Chinese atractylodes disinfectant in killing microbes in the air. They heated and evaporated it within a 1 m³ testing cabinet at the rate of 240 mg/h for 90 minutes, and 100% of staphylococcus aureus in the air were killed. In a house of 70 m³, the medicinal solution was evaporated at the aforesaid rate for 60 minutes, and 69.73% of natural bacteria in the air were killed^[7].

Xian-Yu LU and his colleagues reported the effect of traditional Chinese medicine as an air disinfectant, which was prepared as follows: soaking herbs like dyers wood root, indigowood, Cyrtomium, honeysuckle flower, baikal skullcap root etc, in alcohol, removing the alcohol by distilling at low temperature, and having it concentrated to 1 g/mL. After filtration, the bacteria were removed by pouring into G_Bsintered glass filter. The original solution was diluted in 1:20 with 50% ethanol, and suitable amount of essence was added to form the application solution. The germicidal effect and virostatic effect *in vitro* test proved that it was effective in killing staphylococcus and influenza viruses, and it produced certain effects on destroying the *Escherichia coli*. After the disinfectant was sprayed in the room, 50.8%-70.89% of bacteria were killed^[8]. Dong-Mei SU and her colleagues used 4 Chinese medicinal herbs of argy wormwood leaf, great burdock achene, calamus, Chinese atractylodes, which were divided into 4 groups with different components to sterilize the rooms. The colony number before and after the sterilization was compared and the indoor colony number after the room was sterilized by the 4 groups of medicines met the hospital sanitary standard (≤ 200 cfu/m³). Furthermore, it was fragrant and stimulus-free to the puerpera and the baby. Therefore, it was suitable for sterilizing the ward with inmates^[9]. The comparison of the experiment by Lei DING showed that after having applied ultraviolet light through the wind tank, triatomic oxygen, ultraviolet radiation, air disinfectant made from Chinese medicinal herbs, and compound glutaraldehyde smoke for 60 minutes, the bacteria in the room were killed respectively by 86.87%, 52.67%, 75.30%, 52.52%, and 87.46%. The fully natural air disinfectants made from Chinese medicinal herbs are mainly the ethanol extract liquid dominated by dahurian angelica root, densefruit pittany root-bark, costusroot, Radix Sophorae Flavescentis, etc^[10].

Skin and Mucosa Disinfection

Qun-Sheng WEI and his colleagues reported that the JIEFUKANG skin-protecting lotion (Skin Cleaning and Caring Solution) mainly consisting of Chinese angelica, dahurian angelica root, red gromwel root and so on, was distilled into 0.125% solution. The solution was applied to *Escherichia coli* and *Neisseria gonorrhoeae* for 1 minute, to *Staphylococcus aureus* for 2 minutes, to *Candida albicans* for 7 minutes, and all of them were killed by over 99.9%. The organic substance could greatly affect bactericidal activity. After the original solution was stored for 2 weeks at 56°C, there was no obvious change in its bactericidal effect^[11]. The load venom compound (bufonid compound) disinfectant contains bufonid, Radix Sophorae Flavescentis, Fructus cnidii, etc. Qing-Zeng MENG and his colleagues applied two solutions which contained 67.5% *Candida albicans* for 2 minutes and 45.0% *Staphylococcus aureus* for 2 minutes, respectively. The results showed that all the bacteria in

the solutions were killed by 100%. The bactericidal effect was enhanced as the temperature went up, and was only weakly affected by 20% calf serum. After it was stored at room temperature for 10 months, its bactericidal effect remained nearly the same^[12]. Li-Jun QU and his colleagues applied Baileijing Disinfectant (consisting of extracts of gardenia, *A. capillaries* Thunb, *Radix Sophorae Flavescentis*, etc) to *E.coli* and *Staphylococcus aureus* for 1 minute, to *Candida albicans* for 3 minutes, and 99.99% bacteria were killed. When it was applied to HBsAg for 2 minutes, its antigenicity could be damaged^[13]. Han-Ming GUO and his colleagues applied the traditional Chinese medicine in the form of tincture and paste to 9 types of bacteria, and found that it was good at inhibiting and killing the bacteria. It could replace the clinical liquid disinfectants and hollow tube paste agents like formaldehyde and cresol. The traditional Chinese medicine can be widely applied since it does not result in hypersensitivity and drug-resistance, and furthermore it is reliably effective^[14]. WENXIN Disinfectant, a kind of skin disinfectant, is made of extracts from 7 medicinal plants (including *Radix Sophorae Flavescentis*, *Chrysanthemum*, *Rhizoma Zingiberis*, etc) and plant oil. According to the experiments by Qing YANG and his colleagues, this disinfectant showed a light stimulation to the eye mucosa of the animals. when it was orally given to mice with $LD_{50} > 5000$ mg/kg, after applying it to the skin of rabbit for several times, they classified the skin stimulation index of the rabbit as 9.5 per *Technological Specification of Disinfection*, and the disinfectant was judged to be of light stimulation^[15]. Huatuo Disinfectant is a pure traditional Chinese medicine made from common oral medicines like *Cyrtomium fortunei*, *chrysanthemum*, hawthorn fruit, etc. It is capable of clearing heat and detoxicating xeransis and eliminating stagnation, promoting the circulation of Qi and soothing the liver, and killing bacteria and viruses. Jin-Xian LIU and his colleagues applied it to *Escherichia coli* 8099 for 15 minutes and 99.94% bacteria were killed. When it was applied to *Staphylococcus aureus* ATCC6538 for 30 minutes, 99.9% bacteria were killed. When it was applied to *B. subtilis* var. *niger* ATCC9372 for 60 minutes, 99.82% bacteria were killed. Its quantitative damage to HBsAg reached up to 95.64%^[16]. Wei-Guo YIN and his colleagues carried out experiments to observe the effect of Fukangle, a Chinese herbal disinfectant on killing microbes, and its toxicity and stability. The disinfectant is a compound containing Chinese medicinal herbs like *Radix Sophorae Flavescentis*, *Folium Pyrrosiae Linguae*, *Radix Paeoniae Rubra*, etc. It is a light yellow liquid with fragrance and refreshing effect. The original disinfectant consists of 0.2 g/mL crude drug, and its pH is 6.8. The results of the experiment showed that after the solution containing 50% original disinfectant was applied to *Escherichia coli*, *Staphylococcus aureus*, *B. subtilis var.niger* for 30 minutes, the bacteria were killed by 50%, 46.67%, and 71.11%, respectively. It could also kill *Candida albicans*. Its bactericidal effect was enhanced as time went on. 20% calf serum could only weakly affect its effect on killing *Candida albicans*. It was concluded that the disinfectant which had strong bactericidal effect, was stimulation-free to skin mucosa, and showed neither poisonous nor ill effect on the human body^[17]. Jian-Yong SONG and his colleagues observed the compound disinfectant extracted from argy wormwood leaf to test its bactericidal effect and the effect on organic substances. After the disinfectant was applied for 5 minutes, 99.99% *Neisseria gonococcus*, *Escherichia coli*, *Staphylococcus aureus*, *Ps. aeruginosa*, and *Candida albicans* were killed. The organic substance could only weakly affect the disinfectant. Spraying the disinfectant on the surfaces of telephone and doors of refrigerators, over 99.83% natural bacteria could be killed. The compound argy wormwood leaf disinfectant was therefore considered good at killing bacteria^[18]. Meng-Gang RAN and his colleagues mentioned in their report the Kangjielu liquid disinfectant made from all kinds of Chinese medicinal herbs. Their experiments and sterilization effect on site showed that after Kangjielu liquid disinfectant

was applied to Gram-positive and Gram-negative bacteria for 1 minute, all the bacteria were killed. It is poison-free and stimulation-free to the skin of the experimental animals and its effect is stable^[19]. Jile Disinfectant is prepared from extracts of Chinese medicinal herbs like Cortex phellodendri, Pulsatilla chinensis, Herba polygoni perfoliati, etc, Po-Ping DU, and his colleagues applied the original solution of Jile Disinfectant to *Escherichia coli*, *Staphylococcus aureus* and *Candida albicans* for 5 minutes, and 99.99% bacteria were killed. The organic substance can only weakly affect the effect of the disinfectant. It is good at disinfecting the skin of hand. It can, however, lightly stimulate the eye^[20]. Jian-Zhong SHEN and his colleagues applied the original compound disinfectant made from Chinese medicinal herbs like Jiulongguang etc. to staphylococcus aureus for 5 minutes, and all bacteria were killed. HBsAg antigenicity can be damaged after applying 75% solution of the disinfectant for 5 minutes. The smoke agent is also good at killing natural bacteria indoors and on the surface of items^[21].

On the whole, herbal disinfectants have obvious advantages such as easier application and preparation, little damage to items to be disinfected and less drug-resistance. The disadvantages are their weaker germicidal effects and the difference in medicinal elements, and their coarse preparations. Fortunately, some researchers have paid attention to these disinfectants and we are confident that there will be more and more studies in this field.

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