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Review Article

Contemporary pursuits of vinegar from scullery to dermatology

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ABSTRACT

Vinegar is widely available as a food ingredient for flavouring and as a preservative. It is one of the oldest skin remedy known to mankind. However, its status in treatment regimens has declined over the decades. This article is an attempt to highlight its therapeutic armamentarium in dermatology, venereology and leprosy. Acetic acid in vinegar has antibacterial, antifungal and antiviral properties. This review talks about various studies of acetic acid for various indications, such as screening for cervical cancer, healing of chronic wounds, atopic dermatitis, onychomycosis, marine dermatoses, acne vulgaris, warts, in sclerotherapy and many others dermatoses. Combination therapies and newer indications are also described in this article. Recently, its antiviral action in vitro has been demonstrated against the ongoing coronavirus disease of 2019 (COVID-19) pandemic.

Keywords: Vinegar, Acetic acid, Dermatoses, Vital staining, Black peel, Dermatology

INTRODUCTION

The word "vinegar" is derived from two French words, *Vin* and *Aigre* meaning sour wine[1]. In England vinegar was first made from soured malt liquors and for this reason it was also known as alegar. Based on the raw materials used, the vinegar produced may be classified into grain vinegar and fruit vinegar. Apple cider vinegar is produced from red apples. It is a two-stage fermentation process, first the conversion of fermentable sugars to ethanol by yeasts, usually Saccharomyces species, and the second the oxidation of ethanol by bacteria, usually *Acetobacter* species (Figure 1).

Possibly vinegar was the first antibiotic known to man. Hippocrates applied it to his patients in 400 B.C. For treatment of "lichen" and warts, he recommended concentrated vinegar in the form of washes and vapor, In cases of vitiligo, leprosy, and psoriasis, he recommended use of concentrated vinegar.[2] It is well documented that thieves had used vinegar during the great plague of Europe, in order to avoid contracting an infection while vandalising and stealing valuables from the dead corpse of the plague victims. Fetzer reports that vinegar was employed in the civil war with considerable success to prevent an incipient attack of scurvy among soldiers. It was employed during the First World War in the treatment of wounds. Jarvis discusses the use of vinegar as liniment to treat lameness, poison ivy, shingles, night sweats, burns, varicose veins, impetigo, and ringworm. Kromer records the use of vinegar as a beautifier. Lucrezia Borgia is said to have bathed in vinegar daily to keep herself fresh and well-groomed.[1]

The ingestion of vinegar is reported to be associated with satiety and decreased intake of subsequent meals; hence it can contribute to weight loss and control obesity. Vinegar has positive influence in cardiovascular diseases, seen as a significant reduction in systolic blood pressure. It induces apoptosis of leukemia cells and inhibits the proliferation of the cancer cells. The antiglycemic effect

of vinegar is explored and vinegar is reported to alter the blood glucose concentration.[3]

Therapeutic effects of vinegar arising from the inherent bioactive components including acetic acid, gallic acid, catechin, ephicatechin, chlorogenic acid, caffeic acid, p-coumaric acid, and ferulic acid. Out of all these components, acetic acid is primarily responsible for its ant oxidative, antidiabetic, antimicrobial, antitumor, antiobesity, antihypertensive, and cholesterol-lowering responses.[4]

This is the first such review in English literature. This article is an attempt to conceptualize the various therapeutic and diagnostic uses in a plethora of skin conditions.

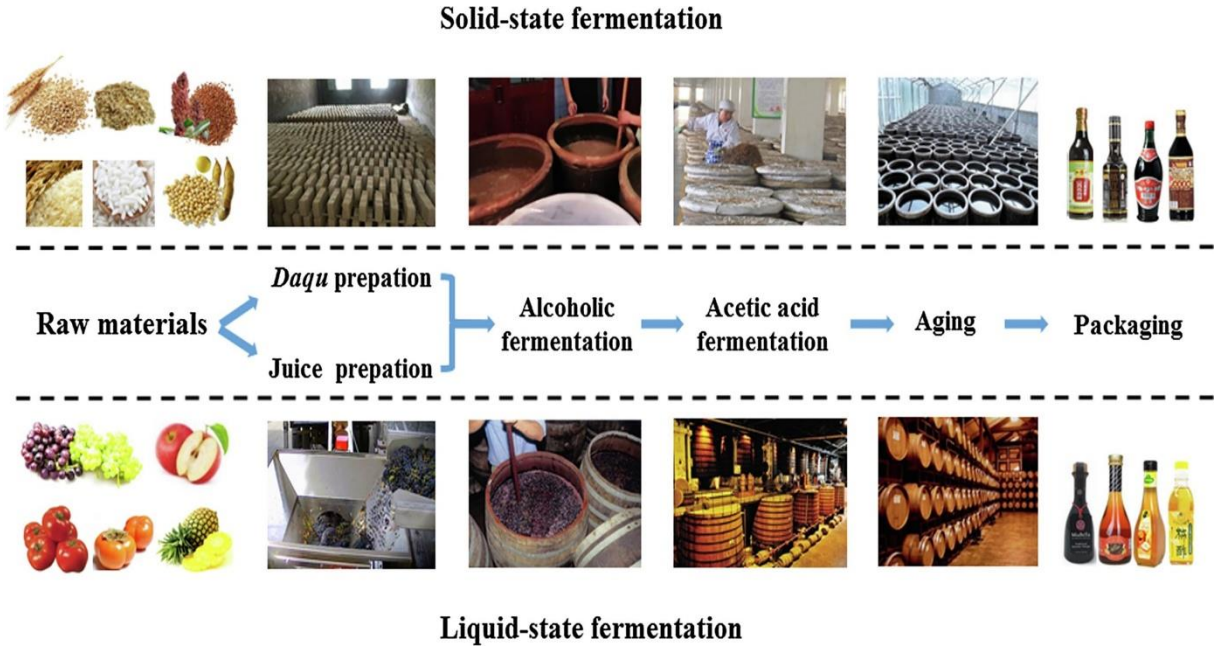

Figure 1: Production process of vinegar.

METHODS

As this is an old drug which was forgotten over the years, there are only a few randomized, placebo-controlled or double-blind studies on its use. This makes it difficult to carry out meta-analysis studies. The present review aims to explore the various uses of vinegar in the field of dermatology. For this purpose, we searched PubMed, Google Scholar and Cochrane library database using the following keywords "vinegar in dermatology," vinegar in skin disease" and "acetic acid in dermatology." Review articles, original articles and case reports were included in the search.

CHEMISTRY AND PHARMACOLOGY

Acetic acid is a weak organic acid with the chemical formula CH_3COOH. Glacial acetic acid is the trivial name used to refer to pure acetic acid in an anhydrous state. It is a colourless, hygroscopic, weak acid that is available in concentrations of 99.5% to 100%. A number of acetic acid products are commercially available.[5]

After oral administration, acetic acid is readily absorbed, uptake then occurs in liver and peripheral tissues. It is metabolized via acetyl-CoA in the tricarboxylic acid cycle in liver and skeletal muscle.

The acetic acid concentration typically ranges from 4% to 8% by volume for commercially available vinegar.

MECHANISM OF ACTION

Acetic acid being a weak organic acid can readily cross cell membranes. Because of the equilibrium between their ionised and non-ionised forms, the latter of which freely cross hydrophobic membranes. This leads to the collapse of proton gradients which are necessary for ATP synthesis and result in death of the micro- organism.[6,7] There are *in vitro* and *in vivo* studies showing its effect against various microorganisms.

Antibacterial

Acetic acid alters the pH and makes micro environment hostile for the growth. Also it decreases induced inflammatory cytokine release and increases monocyte phagocytic capacity. Yagnik et al in their study, cultured *E. coli* and *S. aureus* in presence of acetic acid to determine the anti-microbial activity. They found the inhibitory concentration for S. aureus to be 2.5% and for *E. coli* 0.1% acetic acid.[8] Another study by Halstead et al revealed good activity of acetic acid against the majority of the organisms were *Proteus vulgaris*, *P. aeruginosa*, *A. baumannii*, ß-haemolytic *Streptococci* A and B, S. epidermidis, *S. aureus*, and *Enterococcus faecalis*; which

eradicated after just 30 minutes of exposure.[7] Bjarnsholt et al found that *P. aeruginosa* and *S. aureus* biofilms were completely eradicated by the 0.5% and 1% acetic acid respectively.[9] Cortesia et al. have shown acetic acid to be an effective tuberculocidal disinfectant, with 30 minutes of exposure to 6% acetic acid resulting in an 8-log10 reduction in viable *Mycobacterium* tuberculosis.[10]

Antifungal

In an infection induced model of denture stomatitis, acetic acid resulted in anti-fungal activity against *Candida* Spp which was comparable to nystatin in terms of reducing microbial adherence and destruction.[11] Yagnik et al found that 5% acetic acid restricted growth for *C. albicans* on culture plates.[8] On disc diffusion assay, *Aspergillus niger* and *Saccharomyces cerevisiae* have shown high susceptibility to 25% acetic acid.[12]

Antiviral

Vinegar and its active component acetic acid has shown remarkable antiviral activity against severe acute respiratory syndrome (SARS) CoV-2 virus. Acetic acid causes inactivation and dis-aggregation of haemagglutinin glycoproteins (found on the surface of infuenza viruses) by generating a low pH-dependent conformational change. It destroys the viral envelope and inhibits viral transmission.[13,14] Vinegar is effective in inhibiting the infectivity of virus by lowering the titer by 90% in the nasopharyngeal swab. Also, fumigation of vinegar at low concentration (0.34%) ameliorated the symptoms of mild SARS-CoV-2 infection at a faster rate.[14,15]

INDICATIONS IN DERMATOLOGY

Acetic acid in different concentrations has been used for a variety of indications; diagnostic as well as therapeutic.

Diagnostic indications

As a vital staining agent to look for suspicious areas of malignant change.

A piece of gauze soaked with the acetic acid (3-5%) is applied to a cleaned and dried mucosa/lesion. The effect of vital stain is recorded as positive if the lesion changed its colour to opaque white and negative if no change or change to transparent white. Acetic acid removes the glycoprotein layer and increase the visibility of epithelial cell nuclei by dehydration. Normal cells absorb the light and don't change colour, whereas abnormal cells with a higher nucleus: cytoplasm ratio appear acetowhite with brighter, more marked and more distinguishable borders.

Cervical cancer: The application of 3%–5% acetic acid, which might cause affected areas to turn white, has been used by various authors to detect genital mucosa with dysplastic changes. Studies of cervical cancer screening with acetic acid in India and western countries have shown sensitivity ranging from 49% to 92% and specificity from 49% to 90%.[16,17]

Oral mucosal cancer: Vinuth et al studied the dysplastic changes in normal looking mucosa in tobacco users with 5% acetic acid as the vital staining agent. The sensitivity and specificity were 97% and 50% respectively.[18] Bhalang et al found the sensitivity, specificity, and accuracy of using acetic acid for oral cancer examination were 83.33%, 84.21%, and 83.64%, respectively (Figure 2). Also the results of clinical examination using 5% acetic acid correlated with the expression of p53 in the cellular level.[19]

Basal cell cancer: In Mohs micrographic surgery, after excision the tissue is immersed in acetic acid to look for the acetowhitening and then visualized with confocal microscope to look for atypia.[20]

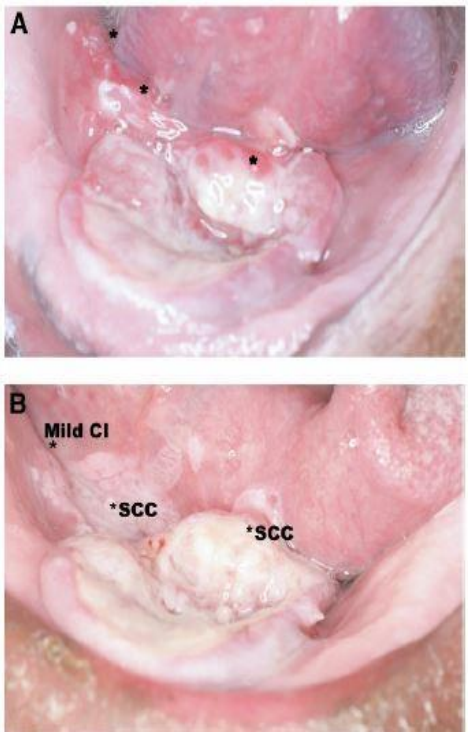

Figure 2: (A) lesion on the floor of the mouth of a patient before acetic acid application(asterisks), (B) The same lesion as in A after the application of acetic acid. Mild chronic inflammation, squamous cell carcinoma.[19]

Therapeutic indications

Chronic wounds: Wound healing is a complex process influenced by intrinsic and extrinsic factors. The pH of the wound affect oxygen release, angiogenesis, protease activity and bacterial toxicity. Chronic non-healing wounds have an alkaline pH and most pathogenic bacteria require a pH value higher than 6. Healing occurs more readily in an acid environment.[21]

Acetic acid lowers the pH of the wound, reducing bacterial protease activity.[22,23] It also leads to increase in macrophage fibroblast activity and reduces toxicity of bacterial end products.[23,24] All these actions collectively lead to rapid decontamination with improved granulation. Also, due to its action on biofilm, it accelerates wound healing by reducing wound contamination and infection and having therapeutic efficacy against multi-drug resistant *Pseudomonas aeruginosa* and *Staphylococcus aureus.*[25]

Acetic acid soaks in the concentration of 0.1-5% has been used in the management of ulcers of varying etiology; traumatic, venous, diabetic, decubitus, IV drug abuse, fracture and open reduction associated ulcers, neuropathic ulcers, erosions and ulcers associated with epidermolysis bullosa (Table 1).

Atopic dermatitis (AD): It is a chronic disorder with defect in epidermal barrier. There is increase in epidermal pH, high transepidermal water loss and skin colonization with S. aureus. Lim et al. in a study found comparable efficacy of bleach and apple cider vinegar compresses when locally applied to eczematous skin of AD patients.[27] Diluted acetic acid baths decreases epidermal pH and has action on S. aureus superinfection, reducing the courses and duration of systemic antibiotics. However, it has no role in improving the skin barrier in atopics.[28]

Table 1: Vinegar soaks for wound irrigation.

Acetic acid (vinegar) soak solution[26]
Sterile normal saline (0.9% Nacl) and white vinegar
Preparation method:
Mix one part vinegar with four parts normal Saline. (0.9% NaCl)
Wet a sterile gauze pad with the vinegar mixture. Place on the wound and soak the wound for 10-15 minutes, twice a day before you shower/wound cleaning regime.

Inflammatory acne: Black peel is a new chemical composition based on black acetic acid mixed with jasmonic acid, salicylic acid, potassium iodide and biosulfur. Acetic acid has a role in pustular and nodulocystic acne. It produces frosting on the acne lesions within minutes of application. It acts on *Propionibacterium acnes* biofilm and decreases inflammation by reducing cytokine release.[29]

Pediculosis capitis: It is an ectoparasitic disease caused by an infestation of Pediculus humanis capitis. Prior priming of nit infested hair with vinegar(4% acetic acid) for 3 minutes dissolves the cementing substance that attaches nits to hair shaft and can make combing easier for removal of nits.[30]

A randomized controlled trial compared the effect of coconut oil, vinegar plus coconut oil versus 1% permethrin shampoo in the treatment of pediculosis. Permethrin shampoo and vinegar plus coconut oil had cure rates of 98% and 94%, respectively. They found that coconut oil with vinegar can be used as an alternative therapy to permethrin.[31]

Aquatic and marine dermatoses

All Cnidarians possess highly coiled hollow harpoon like microtubules called nematocysts on their tentacles that inject a toxin into the skin upon contact.

Jelly fish dermatoses: Presentations in humans range from local reactions, a whip like sting pattern, bulla formation, urticaria, allergic contact dermatitis, erythema nodosum, and granuloma annulare to life threatening anaphylaxis, haemolysis, cardiac arrhythmias, and renal failure, especially with stings of the Portuguese man of war (*Physalia physalis*) and box jellyfish (*Chironex fleckeri*). Irukandji syndrome results from contact with another variety of box jellyfish *Carukia barnesi.* In suspected cases, vinegar is poured on the areas of tentacle contact for atleast 30sec to stop further nematocysts discharge.

Corals and coral cuts: Coral injuries may be caused by nematocysts stings and lacerations. Coral cuts harbor a potential for infection, foreign body granulomas, and delayed wound healing. Lacerations from the calcium carbonate exoskeleton of hard corals introduce debris, bacteria, and nematocysts into the wound. Soft corals harbour a potent neurotoxin known as palytoxin. Fire coral stings should be rinsed with seawater to remove undischarged nematocysts. Then the sting area be compressed with 5% acetic acid for 15-30 min.

Sponges dermatitis: Marine sponges *Neofibularia nolitangere* ("touch me not" sponge) and *Tedania ignis* (fire sponge) may cause fiberglass dermatitis like irritant skin lesions. *Microciona prolifera* (red moss sponge) may cause immediate stinging, burning, and erythema due to the effect of the crinotoxin The use of adhesive tape is recommended for spicule removal, while acetic acid compresses followed by topical steroids aid in treating the effects of the crinotoxins.[32,33]

Fungal infections

Acetic acid soaks for 10-15min before applying topical antifungals resulted in faster clearance in toe nail onychomycosis due to its action on biofilm and better penetration of antifungals.[34] Eertmans et al in their study compared acetic acid based nail polish with 5% amorolfine for onychomycosis and found comparable efficacy of both the products. There was significant improvement in dystrophy, discolouration and thickening with 6 months of daily application.[35] The efficacy and safety of apple cider vinegar as an adjunct to 2% ketoconazole shampoo compared to 2% ketoconazole shampoo alone in treating tinea versicolor was studied. It was found that the symptoms resolved faster in the and

percentage of treatment success favored the apple cider vinegar-ketoconazole group compared to the control group.[36]

Warts

The successive topical application of highly concentrated acetic acid solutions (up to 99%) alleviated warts, presumably due to the mechanical destruction of wart tissue.[37]

Chronic papillomatous dermatitis

Warty excrescences around urostomies resulting from leaks and pooling of urine. Acetic acid soaks (4-6%) of the local area at each bag change have found to be effective, by neutralizing ammonia from urea splitting bacteria.[33]

Alkali burns

Acetic acid is used as neutralizing agent in case of burns caused by alkali solutions. It reacts with alkalis with the carboxyl group, neutralizing their action.

Photodamaged skin

40% acetic acid peel has shown to act as an exfoliant and it decreases melanin content in the horny layers of epidermis.[38] Acetic acid, being hygroscopic can be used in different dilutions for skin rejuvenation.

Hair growth

Since ancient times, vinegar has been used as a hair cleanser and conditioner, as it smoothens the cuticles and unclogs the pores by restoring acidic pH. It has also been thought to increase scalp blood flow and thereby promoting hair growth. Lee et al showed vinegar induced telegen-to-anagen conversion and size of hair follicle increase was observed in gross and histological examinations. Also, the RT-PCR revealed a dose-dependent increase in the expression level of IGF-1, KGF and VEGF mRNA by vinegar in mice skin. The results obtained were comparable to that of the positive control minoxidil 3% group.[39]

Sclerosant

Acetic acid readily cross lipid membranes and causes denaturation at 40-50% concentration. There are studies showing its efficacy as sclerosant in lymphangiomas, renal cysts and hepatocellular carcinoma.[40,41]

Melasma

Elghblawi has shown marked response with black peel in melasma due inhibition to tyrosinase activity.[42]

CUTANEOUS ADVERSE EFFECTS OF ACETIC ACID

Irritant contact dermatitis: patch tests were applied to the upper back with serial dilutions of acetic acid. Patch test reactions to acetic acid were of a primarily irritating nature rather than of an allergic genesis. It was seen to be well tolerated up to 20% dilutions, beyond this level incidence of irritant reactions are high. Most common reaction include erythema with and without edema.[43]

Patients with atopic dermatitis showed a significantly lessened skin tolerance for acetic acid and higher incidence of irritant reactions.[28, 43]

Chemical burns: partial or complete thickness burns have been reported on application of glacial acetic acid or undiluted acetic acid.[5] Vaginal burns, bleeding and blistering if accidently high concentration is applied.[3]

CONCLUSION

Traditionally vinegar has been used as a food flavouring agent and preservative. Despite being used as a medicine for over a century, vinegar remains a good therapeutic option for the treatment of several dermatoses as a drug of choice or as an adjunct to the therapies for various dermatoses. The advantages of using vinegar are its easy availability, cost effectiveness, convenient preparation method, makes it a sustainable choice of drug. This article is an attempt to summarize the various dermatologic indications of this drug. Studies should be carried out in order to establish naturally occurring, low-cost and effective herbal remedies as prophylactic and/or complimentary measures in preventing metabolic disorders in both developing and under-developed countries.

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