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Original article

A need to combat COVID-19; herbal disinfection techniques, formulations and preparations of human health friendly hand sanitizers

Huda Ahmed Alghamdi

Department of Biology, College of Sciences, King Khalid University, Abha, Saudi Arabia

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ABSTRACT

Indigenous medicinal plants enriched with flavonoids, alkaloids, poly-phenolic compounds carry antiseptic, disinfectant and antimicrobial activities. During old era, plant extracts were used as strong antiseptics and disinfectants to get ride from microbes. We aimed to present the herbal formulations and preparations for human health hazards free hand sanitizers based on indigenous medicinal plants with reported effective results against infectious microbes along with least toxic impact on environment. Easily available plants formulations safe to human health and environment are presented with easy procedure for their preparations. Data have been collected from literature for dissemination to scientific community and common society. A recent report published on human health hazards linked with the frequent use of alcohol based hand sanitizers provoked the scientific community to prepare safe hand rubs. National Poison Data System, USA revealed 36.7% increase in alcoholic hand sanitizer exposure and toxicity in first three months of 2020 as compared to 2019. Adaptation of alternative preparations of hand sanitizers based on natural and plant resources are the possible solution to get ride off toxicity problem. There should be more detailed screenings of indigenous plants with enriched flavonoids contents for their antiseptic properties and to develop eco-friendly and effective hand sanitizers as compared to chemical formulations.

1. Introduction

Novel corona virus (COVID-19) pandemic disease blowout by new corona virus 2 (SARS-CoV-2) from People Republic China (Huang et al., 2020). Infection by this disease may leads to fever and body pain, dry cough, pneumonia, acute respiratory disorder with increased death rate in old age people, particularly those with primary health disorders (Lai et al., 2020). World Health Organization (WHO) has been declared COVID-19 as pandemic on 11th of March 2020 and till March, 23 2021 confirmed infections are 123,419,065 with 2,719,163 deaths across 216 countries (WHO, 2020). Interaction among human has been declared the source of transmission of COVID-19 specifically, if an infected person with no symptom or mild indications came in interaction/contact with healthy person (Kratzel et al., 2020). Till today, no medication has been found to treat this disease through, various researchers and pharmaceutical companies are putting their efforts to discover vaccine and medicines. In this situation protective measures and energetic life style with effectual immune system have been advocated by WHO to combat and stay insipid from this pandemic. Hand hygiene with alcoholic hand sanitizer or washing with soap has been reported effective to combat this pandemic (Rehman et al., 2021; Mahmood et al., 2020a). Currently, people across the globe are using alcohol based hand sanitizers on massive scale to stop or reduce the spread of coronavirus.

Most of the available hand rubs used as sanitizers composed up of isopropyl alcohols, H_2O_2 and ethanol in different combinations. Misuse of these provisions may leads to the toxicity in human well beings and to environment (Mahmood et al., 2020a). American Association of Poison Control Center (AAPCC) has testified a total of 11,324 cases of alcoholic hand sanitizer's exposure in children below age of 12 Years during the early six months of 2020. AAPCC reported that aforesaid exposure was responsible for nausea and lethargy, confusion, respiratory arrests and even death in children (AAPCC, 2020). Frequent use of hand sanitizers has also been reported for possible chance of other viral diseases and increased chance of anti-microbial resistance (Tachikawa, 2020; Morgan,

E-mail address: hudaghamdi@kku.edu.sa
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2020; Mahmood et al., 2020b). A recent report has been published on human health hazards and environmental risks associated with the frequent use of alcohol based hand sanitizers (Mahmood et al., 2020a). National Poison Data System, USA revealed 36.7% increase for alcoholic hand sanitizers exposure and toxicity in primary months of 2020 as compared to 2019 (Chang et al., 2020).

Adaptation of alternative preparations of hand sanitizers based on natural and plant resources can be the possible solution to get ride off toxicity problem. During COVID-19, reported medicinal plants with known anti-viral and disinfection properties can be used as alternatives of alcohol based hand rubs. Till date, numerous plants have been reported and published with broad-spectrum anti-viral properties (Mahmood et al., 2012). As an example, quinine is a vital drug discovered from plant origin (from the barks of Cinchona tree) and characterized by long use history (Ganjhu et al., 2015; Mahmood et al., 2015; Mahmood and Malik, 2014). Formulations and preparations of hand sanitizers by herbal plants have been proved effective against pathogens and results have also been compared and fond effective with alcoholic based formulations of hand sanitizers. These herbal formulations have been considered safe for human health as far as to environment (Kalaivani et al., 2018; Acharya et al., 2018; Yaun and Vasquez, 2017).

This article was aimed to present the formulation and preparations of human health hazards free hand sanitizers with reported effective results against infectious microbes along with zero toxic impact on environment.

2. Formulation and preparations of natural hand sanitizers

2.1. Hand sanitizer by leaf extract of Psidium guajava L. (guava)

Psidium guajava L. belongs to family Myrtaceae. Phytochemicals extracted from the leave extract of guava showed a potential against bacterial pathogens activity (Guintu and Chua, 2013). Guava leaves have bio-active chemical constituents like flavonoids, saponins, tannins, triterpenoids and eugenol, where flavonoids and poly-phenolic compounds dominate over other (Mailoa et al., 2013). Phenolic compounds are responsible to inhibit microbial growths, and leaves of guava process strong anti-microbial properties due to enrichment of phenolic compounds.

2.1.1. Preparation and formulation

200 g of fresh guava leaves deliquesced with 95% ethyl alcohol. Mixture obtained after 72 h was filtered and dried from alcohol by evaporation process. Solvent free mixture was mixed with distilled water to liquidity. This extract was used in the formulation of guava hand sanitizer gel by adding gelatin and glycerin in small proportion of alcohol (Yaun and Vasquez, 2017).

2.2. Herbal hand sanitizer of Matricaria chamomilla

German Chamomile (*Matricaria chamomilla*), a member of Asteraceae family is enriched with blue oil and flavonoids. It has been reported that flowers extract of German chamomile is more effective to kill hand microbes, compared with the commercial hand sanitizer (Singh et al., 2011). Extract from chamomile flowers contain 0.4 to 2% of essential oil with active antimicrobial properties; in addition, flower extract contain more than 120 chemical compounds identified as secondary metabolites, including 36 flavonoids and 28 terpenoids, α-bisabolol, cyclic ethers, chamazulene, flavonoids and umbelliferone etc. α-bisabolol and chamazulene exhibit antiseptic properties (Saad et al., 2011).

2.2.1. Preparation and formulation

200 g fresh flowers of Chamomile were homogenized and mixed in a mixer with ethanol (70%), followed by extensive maceration with alcohol (70%). Filtrate of this extract was evaporated through rotary evaporator and final residue (solvent free) was suspended in water (12.5 g in 40 ml distilled water) (Joshi et al., 2008: Sing et al., 2011). Aqueous extract can be mixed with glycerin to convert into hand rub.

Investigators of this finding used above prepared extract to prepare antiseptic soap by mixing 4 ml of this extract in 3 g of sodium lauryl sulphate and solution was homogenized at room temperature and used for antimicrobial screening (Saad et al., 2011; Tilton and Howard, 1987).

2.3. Hand sanitizer by extract of azadirachta indica, Ocimum sanctum and Citrus limon

Azadirachta indica L. is highly medicinal plant with all parts reported to be used for medicinal purposes e.g. antiviral, anti-cancer, immune-modulator, skin disorders, liver function improvements, blood detoxifier and anti-inflammation (Pai et al., 2004). *Ocimum sanctum* is another important plant reported for anti-microbial properties. *Citrus limon* has been reported as enriched source of vitamin C along with antiviral, anti-diabetic, antimicrobial properties and high alkaloids, flavonoids contents (Harsha et al., 2016; Hammer et al., 1999).

2.3.1. Preparation and formulation

Fresh plant material was shade dried and grinded into powder form. 50 g of each plant material was soxhelt extracted with 400 ml of water (temperature 100 °C) for 6 h per plant sample. Plant extract was dried using rotary evaporator, then carbapol 940 plus EDTA (Ethylene diamine tetraacetic acid) was added to deionize the water. After uniform mixing of all plant material, glycerin was added with addition of 0.3% perfume and mixed thoroughly to achieve a uniform aqueous material.

Hand sanitizer prepared by *Azadirachta indica, Ocimum sanctum* and *Citrus limon* showed great antimicrobial activities. Statistical analysis performed by investigators, reported that aforesaid herbal formulation exhibited broad spectrum antimicrobial activities. Investigations proved/reported that this hand rub was equally effective with alcoholic hand sanitizer (Acharya et al., 2018).

2.4. Hand sanitizer by multiple herbal plants

2.4.1. Formulation No. 1

Seven herbal plants viz; *Trachyspermum copticum* (Omum seed), *Acorus calamus* (Sweet flag; Vasambu), *Coleus aromaticus* (Karpooravalli), *Piper nigram* (Milagu), *Mentha piperita* (Peppermint), *Aloe barbadensis (*Aloe*)* and *Elatteria cardamomum* (Ellam) were used for herbal hand sanitizer preparation by Kalaivani et al., 2018. Hand sanitizer was compared with commercial hand sanitizer by screening the microbial load before and after its application to hands. It was observed that herbal hand sanitizer considerably lower the microbial load after application and the maximum 75% reduction in microbial load was observed (Kalaivani et al., 2018).

2.4.1.1. Preparation and formulation. T. copticum, P. nigrum, A.calamus, E. Cardamomum, M. piperita and *C. aromaticus* were collected and dried carefully. Extract of these plants material was prepared by methanol and extract was dried to eliminate solvent. 3% *T. copticum, 5% P. nigrum, 15 A.calamus, 2% E. Cardamomum, 5% M. piperita* and *3% C. aromaticus* extracts were mixed/added together. 15% of *Aloe barbadensis,* 10% almond aqueous and 30% of menthol was added in above prepared mixture, where finally citric acid was

used as preservative and make the final volume up to 100 ml by using distilled water (Kalaivani et al., 2018).

2.4.2. Formulation No. 2

Herbal hand sanitizer was prepared by *Coleus vettiveroides, Coriandrum sativum, Vetiveria zizanioides, Citrus limon* and *Melia azadirachta. Coleus vettiveroides* has been reported as antibacterial, emollient and deodorant; *Coriandrum sativum* has broad spectrum anti-microbial properties; *Citrus limon* extract carry antimicrobial properties with ability to restore skin from oxidative damages; *Vetiveria zizanioides* extract has soothing, astringent and antimicrobial properties and *Melia azadirachta* contain a chemical constituents named nimbin, nimbinin and nimbidin with antiviral properties (Herraiz and Galisteo, 2003; Mondal and Kolhapure, 2004).

2.4.2.1. Preparation and formulation. Fresh plant material was extracted in ethyl alcohol (60% w/w) and dried through rotary evaporator to achieve solvent free extract. Plant extract and glycerin can be mixed with distilled water to prepare aqueous hand sanitizer (Mondal and Kolhapure, 2004).

2.4.3. Formulation No. 3

Aloe vera, Hamamelis, Amorphophallus konjac, sweet orange essential oil, eucalyptus essential oil and tea tree essential oil are used for herbal hand sanitizer preparation.

2.4.3.1. Preparation. 51.40% of *Aloe vera,* 40% of *Hamamelis* (Witch hazel), 0.50% panthenol and 0.10% of dermofeel PA3 as chelator were blended together and stored in a beaker. Glycerine, *Amorphophallus konjac* (konjac gum) and xanthan gum (3.50%, 1.0% and 0.25%, respectively) were mixed separately in a second beaker. Add this new preparation in former preparation and keep stirring slowly and regularly with magnetic stirrer. In this mixture add another mixture of sweet orange essential oil, eucalyptus essential oil, tea tree essential oil, preservative and cocamidopropyl betaine (solubiliser) (0.20%, 0.15%, 0.10%, 0.80% and 2.0%, respectively), adjust the pH of whole formulation to 5 and store in proper container to use as hand sanitizer (Khanam and Afsar, 2013).

2.5. Formulation and preparation of poly-herbal hand sanitizer

Polyherbal hand sanitizers are mixture of low dose of alcohol (40%) and herbal extracts. Low concentration of alcohol is considered safe or less harmful for skin when used with herbal extracts.

Ethanolic extracts of *Zingiber officinale, Citrus limon* and *Andrographis paniculata* were prepared and to get solvent free extract rotary evaporator was used. Carbapol-940, glycerine, polysorbate-20, perfume, alcohol, water and preservative (Ratio, 1:5:1:1:40:2:1, respectively) were mixed in 30% herbal extract (10% of each plant) (Grace and Sowmya, 2015). Mixture prepared can be used as hand sanitizer.

3. Discussion

Cleaning along with disinfection is a finest practice to prevent COVID-19 and other viral respiratory illnesses in households and community settings (CDC, 2020). To lessen the threat of disease spread in the community, it is recommended to prioritize better hygiene practices including washing and sanitizing hands frequently and thoroughly. Individually, people are observed to be using alcohol based hand sanitizer with 60–70% alcohol as suggested by CDC (2020), regularly upon meeting other individuals outside or on return back to home. It is reported that spraying of individual with substances such as alcohol, chlorine is responsible for the toxic influence on entities and lead towards eye and skin irritation, bronchospasm due to inhalation, and possibly gastrointestinal effects such as vomiting and nausea (Mahmood et al., 2020a; 2020b). In starting six months of 2020, AAPCC stated 10,824 hand sanitizer's (alcoholic) exposure cases in children under 12 years age and acknowledged that even a minor dose of alcohol may results alcohol poisoning in/among children which is liable for confusion, nausea and lethargy, and in extreme cases, respiratory seizure and death (Table 2) (AAPCC, 2020). Center for Disease Control and Prevention (CDC) and American Association of Poison Control Centers surveillance published a comparison report on number of exposure to chemicals during first three months of 2020 with exposure data from same three months in 2018 and 2019. Published data showed overall increase of 20.4% as compared to first three months of 2019 and 16.4% as compared to first three months of 2018. Though, National Poison Data System did not provided any evidence or linkage between chemical exposure and COVID-19 cleaning practices, there seems to be a strong temporal link with amplified usage of such products. Daily reports of call to poison center increased abruptly in early March 2020 (Fig. 1). Among these chemical exposure 36.7% increase of calls reported alcoholic hand sanitizer exposure while inhalation was reported major route of exposure that increased 35.3% (Table 2) (Chang et al., 2020).

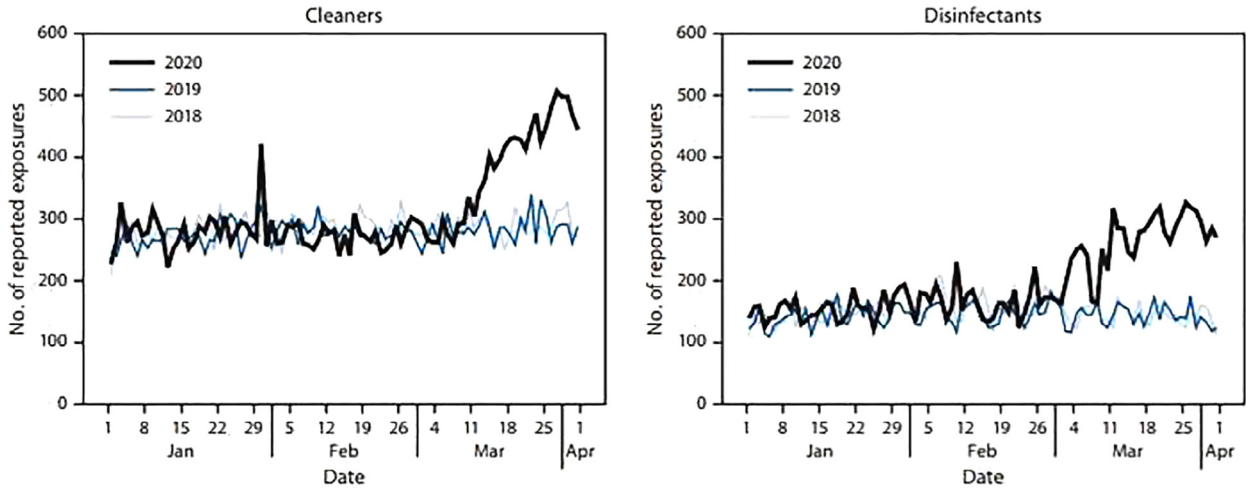

Fig. 1. Number of exposures to cleaners and disinfectants in USA comparison between 2018, 2019 and 2020.

Table 1
Active compounds of reported herbal plants with disinfectant properties (Khanam and Afsar, 2013).

Plant Name	Active Compounds Detected
Azdirachta indica	Triterpenes, Azadirachtin
Anethum gravveolens	Essentialoils, Phellandrene, limonene, anithofuran
Anthemis Nobilis	Terpenoids, Flavonoids, Coumarins
Andrographis paniculata	Andrographolides, Arabinigalactan proteins.
Aegle marmelos	Essential oil, Terpenoids.
Arctium lappa	Polyacetylene, Tannins, Terpenoids
Allium sativum	Allicin, Ajoene, Sulfoxide sulfated Terpenoids
Allium cepa	Allicin
Artemisia dracunculus	Caffeic acids, Tannins, Terpenoids
Berberis vulgaris	Berberine Alkaloid
Cassia fistula	Anthraquinones, Fistulic acid
Cinnamomum verum	Essential oils, Terpenoids, tannins
Capsicum annuum	Capsaicin, Terpenoids
Cassia angustifolia	Rhein, Anthraquinones
Curcuma zedoaria	Curcuminoids, Demethoxycurcumin, Terpenes
Carum carvi	Coumarins
Centella asiatica	Terpenoids, Asiaticoside
Camellia sinensis	Flavonoids, Catechin
Citrus paradise	Terpenoids
Eucalyptus globulus	Tannins, Polyphenols, Terpenoids
Ficus religiosa	Tannins, Saponins, Flavonoids, Terpenoids
Gaultheria procumbens	Tannins, Polyphenols
Glycyrrhiza glabra	Glabrol, Phenolic alcohol
Garcinia mangostana	Xanthone derivatives, Mangostins
Galium odoratum	Coumarins
Hibiscus sabdariffa	Flavonoids, Polyphenols
Hydrastis Canadensis	Alkaloids, Berberine, Hydrastine
Hypericum perforatum	Anthraquinones, Hyperecin
Lawsonia inermis	Phenols, Gallic acid
Matricaria chamomilla	Phenolic acid, Anthemic acid
Matricaria recutita	Terpenoids, Flavonoids, Coumarins
Mentha piperita	Terpenoids, Menthol
Nelumbo nucifera	Quercetin, Myricetin, Kaempferol, Luteolin
Ocimum basilicum	Terpenoids, Essential oils
Olea europaea	Aldehyde Hexanal
Panax notoginseng	Saponins
Piper nigrum	Piperine Alkaloid
Piper betel	Catechols, Eugnol, Essential oils
Punica granatum	Organic acids, Phenolic compounds
Quercus rubra	Tannins, Polyphenols
Rhamnus purshiana	Tannins Polyphenols, Anthraquinones
Rosmarinus officinalis	Essential oils, Terpenoids
Salix alba	Salicin, Tannins, Phenolic glucosides
Syzygium aromaticum	Eugenol, Terpenoids
Thymus vulgaris	Caffeic acid, Terpenoid Thymol, Phenolic alcohol, Tannins, Polyphenols, Flavones
Valeriana officinalis	Essential oils, Terpenoids
Withania somniferum	Lactone, Withafarin A

Table 2
Total case reported to NPDS for alcoholic and non-alcoholic hand rubs exposures in children under age of 12 years during 2011–14.

Year (s)	Alcoholic	Non-alcohol	Total
2011	15,971	1286	17,257
2012	16,571	1355	17,926
2013	16,423	1338	17,761
2014	16,328	1397	17,725
Total	65,293	5376	70,669

In current situation the adaptation of alternative preparations of hand sanitizers based on natural and plant resources can be the possible solution to get ride off toxicity problem. Historically, indigenous medicinal plants have been proved and provided the best source of anti-infectious agents. Plants based anti-microbial and antiviral constituents signify a broader source of antiseptics and disinfectants, and exhibit the effectiveness against infectious diseases with mitigating a number of side effects linked with synthetic antiseptic products. Plants with enriched flavonoids and polypeptides have been reported as broad spectrum antimicrobial and antiviral agents (Saad et al., 2011; Abbiw, 1990). A list of medicinal plants with reported authenticated antiseptic and disinfectant properties is presented in Table 1.

4. Conclusions

During COVID-19 pandemic hand hygiene considered prime among preventive measures. WHO recommended alcoholic hand sanitizers have been reported to cause hazard to environment and human health. CDC has raised a serious concern on alcoholic hand sanitizers exposure and 36.7% increased alcoholic hand sanitizers exposure cases have been noticed in USA as compared to early three months exposure in 2018 and 2019. Similarly, alcoholic hand sanitizer exposures to children under age of 12 years have also been raised considerably. Hand hygiene is basic need during COVID-19, especially during outdoors hand sanitizers meet this need. Alcohol free and herbal hand sanitizers are easy to formulate and have better results compared with the alcoholic hand rubs. Easily available herbal plants used to prepare hand sanitizers with accurate efficacy to reduce microbial load from hands are reported in this article. Formulations and preparations of human health and environmental friendly hand sanitizers are communicated to scientific society and common people for benefits. There should be detailed investigation on eco-friendly/herbal sanitizers based on their antiseptic properties to replace the existing chemical based hand rubs.

Declaration of Competing Interest

The author declares no conflict of interest.

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