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HAND SANITIZERS MADE WITH NATURAL INGREDIENTS

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Abstract

Hand hygiene is one of the most important and healthy habits that each of us should practice. The ingredients used in the formulation of hand sanitizers, as well as their concentration, must be chosen carefully not to affect the hand skin. Four sanitizers have been formulated, containing natural products that give a pleasant and moisturizing consistency, a pleasant smell, and an application as easy as possible. Two disinfectants, 96% ethyl alcohol and 99.9% isopropyl alcohol, glycerin, Aloe-Vera pulp and four flavoring substances, tea tree essential oil, lemon essential oil, eucalyptus essential oil, essential oil of lavender, were used. The obtained sanitizers were analyzed from an organoleptic and physico-chemical point of view. The products had a pleasant appearance, a fluid consistency without signs of phase separation, a very pleasant, aromatic odor, a pH around five and, most importantly, an antibacterial effect, along with an effective moisturizing of the skin. The sanitizer solutions were applied to the hands by spraying.

Key words: *alcohol, disinfectant, sanitizer, skin.*

INTRODUCTION

Hand sanitizers are a combination of different types of alcohol (ethyl alcohol, isopropyl alcohol, and/or n-propyl) mixed with moisturizers (glycerin or aloe vera), water and other ingredients such as dyes or perfumes. (Dhifi et al., 2016)

Although alcohol has long been used as an antiseptic, hand sanitizer is a discovery, dating back only a few decades (Gold et al., 2021).

The World Health Organization (WHO) defines the antibacterial product as "a product containning alcohol (liquid, gel or foam) designed to be applied to the hands to inactivate microorganisms and/or temporarily suppress their growth. Such products may contain one or more types of alcohol, other active ingredients with excipients and humectants" (Gold et al., 2021; Jing et al., 2020).

Alcohol-based hand antiseptics contain isopropyl alcohol, ethyl alcohol, n-propanol, or a mixture thereof as the active ingredients (Jing et al., 2020; Lachenmeier et al., 2008). The antimicrobial activity of alcohols is attributed to their ability to denature and coagulate proteins. This causes the microorganisms to lose their protective coatings and inhibit them.

The Centers for Disease Control and Prevention recommends formulations containing 80% (v/v) ethyl alcohol or 75% isopropyl alcohol, however, generally speaking, products containing 60-95% alcohol are accepted (Thaddeus et al., 2018; Jing et al., 2020). The recommended concentrations of ethyl alcohol and isopropyl alcohol are maintained between 80% and 75% (Lachenmeier et al., 2008). Concentrations higher than the recommended ones are, paradoxically, less effective, because the proteins do not denature quickly in the absence of water.

Alcohol concentrations in antiseptics are often expressed as a percentage by volume and rarely as a percentage by weight. A study of 85% (w/w) ethyl alcohol showed that a contact time of 15 seconds is enough to reduce gram-positive and gram-negative bacteria by more than 5 log10 steps (Golin et al., 2020). Research suggests that alcohols are fast germinators when applied to the skin but have no persistent residual activity (CDC, 2002).

The addition of chlorhexidine, octenidine, or triclosan to alcohol-based products may also lead to longer-term protection; 4% chlorhexidine demonstrated persistent bactericidal activity against methicillin-resistant *Staphylococcus aureus* for up to 4 hours after application (Grayson et al., 2008; CDC, 2002).

Ethyl alcohol seems to be the most effective alcohol against viruses, while propanol is

considered a better bactericidal alcohol (Cartner et al., 2017; Meyers et al., 2021). The combination of alcohols can also have a synergistic effect. Studies have shown that rubbing hands with an 85% ethanol solution significantly reduced bacterial populations compared to 60%-62% solutions (Edmonds et al., 2010). Disinfectants may also contain emollients and/or moisturizers, such as glycerin and aloe vera, which help prevent dry skin (Hamman, 2008; Javed et al., 2014).

None of the alcohols mentioned above have shown any potential for bacterial resistance and are therefore considered to be highly effective for medical use (Gold et al., 2021).

Hand hygiene products affect the skin by causing corneal layer proteins to distort, changes in intercellular lipids (depletion or reorganization of lipid fragments), decreased cohesion of corneocytes and decreased ability to bind water to the stratum corneum. Of these, the main concern is the depletion of the lipid barrier, which may be the consequence of contact with lipid emulsifying detergents and lipid dissolving alcohols (Plessis et al., 2013; Pendlington et al., 2001).

Disinfectants affect the skin's balance and cause burns and injuries, and contact dermatitis (García-Gavín et al., 2011).

Dermatologists warn that the number of dermatitis cases has increased alarmingly since the onset of the Covid 19 pandemic. The symptoms of patients who already had various dermatological conditions have worsened due to these products (Azelee et al., 2020; Rundle et al., 2020).

In addition to disinfectants, hand sanitizers also contain ingredients for skin protection and / or fragrances (Fallica et al., 2021; Javed et al., 2014).

The hand sanitizer should be used in urgent conditions where there is no availability of soap and water, which can offer a short-term solution. It can be considered only as a temporary standby solution (Singh et al., 2020; Edmonds et al., 2013).

MATERIALS AND METHODS

Four hand sanitizers were formulated, two based on 96% ethanol and the other two based on 99.9% isopropyl alcohol. The obtained products were analyzed organoleptically and physico-chemically.

Formulation of hand sanitizers

The solutions were made according to our own recipe, respecting the European rules on ingredients and concentrations allowed (EU Parliament, 2012).

The raw materials used were taken from the Guide to Local Production (2010), World Health Organization - recommended Handrub Formulation (WHO/IER/PSP/2010.5; Golin et al., 2020).

Four solutions were formulated, two of them based on 96% ethyl alcohol, labeled AE_{T+L} and AE_{Eu+Lv}, and the other two, based on 99.9% isopropyl alcohol, labeled AIz_{T+L} and AIz_{Eu+Lv}. The ingredients used to prepare the hand sanitizers were divided into three categories (A, B, C), depending on their role and importance (Table 1).

Table 1. Ingredients used to formulate the hand sanitizers

Phase	Ingredients
A	Ethanol 96%
	Isopropyl alcohol 99.9%
	Hydrogen peroxide 3%
	Glycerol 99.5%
B	Distilled water 99.98%
	Aloe Vera pulp
C	Tea tree essential oil
	Lemon essential oil
	Eucalyptus essential oil
	Lavender essential oil

The first solution, marked AE_{T+L}, consists of ethyl alcohol, hydrogen peroxide, glycerin, distilled water, aloe vera pulp, tea tree and lemon essential oils. The concentrations and quantities of all ingredients are presented in Table 2.

Table 2. Composition of AE_{T+L} hand sanitizer

Cat.	Ingredient	Concentration (% w/v or v/v)	Quantity/ UM for 100 ml
A	Ethanol 96%	83.33	83.33
A	Hydrogen peroxide 3%	4.17	4.17
A	Glycerol 99.5%	1.45	1.45
B	Distilled water 99.98%	5.05	5.05
B	Aloe Vera pulp	4	4
C	Tea tree essential oil	1	1
C	Lemon essential oil	1	1

The second solution, AE_{Eu+Lv}, consists of ethyl alcohol, hydrogen peroxide, glycerin, distilled water, aloe vera pulp, eucalyptus and lavender essential oils.
The concentrations and quantities of all ingredients are shown in Table 3.

Table 3. Composition of AE_{+Eu+Lv} hand sanitizer

Cat.	Ingredient	Concentration (% g/v or v/v)	Quantity/ UM for 100 ml
A	Ethanol 96%	83.33	83.33
A	Hydrogen peroxide 3%	4.17	4.17
A	Glycerol 99.5%	1.45	1.45
B	Distilled water 99.98%	5.05	5.05
B	Aloe Vera pulp	4	4
C	Eucalyptus essential oil	1	1
C	Lavender essential oil	1	1

AIz_{T+L}, the third hand sanitizer, contains isopropyl alcohol, hydrogen peroxide, glycerin, distilled water, aloe vera pulp, and tea tree and lemon essential oils.
Also, the concentrations and quantities of all ingredients of this product are shown in Table 4.

Table 4. Composition of AIz_{T+L} hand sanitizer

Cat.	Ingredient	Concentration (% g/v or v/v)	Quantity/ UM for 100 ml
A	Isopropyl alcohol 99.9%	75.15	75.15
A	Hydrogen peroxide 3%	4.17	4.17
A	Glycerol 99.5%	1.45	1.45
B	Distilled water 99.98%	13.23	13.23
B	Aloe Vera pulp	4	4
C	Tea tree essential oil	1	1
C	Lemon essential oil	1	1

AIz_{+Eu+Lv} hand sanitizer contains isopropyl alcohol, hydrogen peroxide, glycerin, distilled water, aloe vera pulp and eucalyptus and lavender essential oils.
Concentrations and quantities of all ingredients are shown in Table 5.

Table 5. Composition of AIz_{+Eu+Lv} hand sanitizer

Cat.	Ingredient	Concentration (% g/v or v/v)	Quantity/ UM for 100 ml
A	Isopropyl alcohol 99.9%	75.15	75.15
A	Hydrogen peroxide 3%	4.17	4.17
A	Glycerol 99.5%	1.45	1.45
B	Distilled water 99.98%	13.23	13.23
B	Aloe Vera pulp	4	4
C	Eucalyptus essential oil	1	1
C	Lavender essential oil	1	1

Obtaining alcohol-based hand sanitizers

Hand sanitizers were obtained considering the properties of all the ingredients and the general methods of obtaining these solutions.

- The ingredients of phase A, representing the active substances for all 4 product variants, are weighed, and placed in a graduated container, after which they are homogenized on a magnetic stirrer.
- The components of phase B, which play a role in hydrating the skin, are weighed, and added to the mixture obtained later.
- The ingredients of phase C with a flavoring role, represented by the essential oils, are incorporated in the obtained solution.

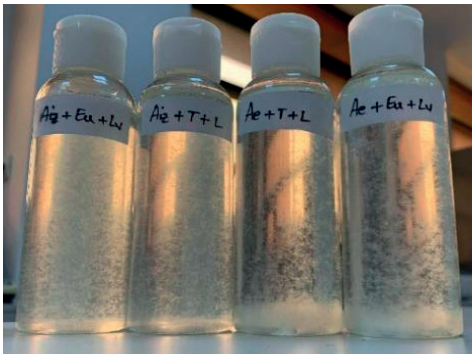

Figure 1. Hand sanitizers before maceration

The samples were soaked in the refrigerator at 4ºC for 14 days.
The solutions were then filtered on filter paper to remove aloe vera pulp.

Evaluation of hand sanitizers - Performing qualitative analyzes

Quality analyzes for disinfectants in the form of gels or solutions are divided into two categories:
a) Organoleptic analysis (appearance, smell, color);
b) Physico-chemical analysis (pH).

All these physico-chemical analyzes were performed according to the requirements of the European Pharmacopoeia (EDQM, 2017).

To determine the appearance of the solutions, 10 mL of each sample were taken and placed in glass tubes to check that they were clear (by comparison with water), transparent, opalescent or cloudy. They must not have solid particles in suspension.

To determine the odor, a piece of filter paper was soaked with 1 ml of samples and smelled from a distance of about 2-4 cm. Samples must not have a musty or rancid odor, must have a specific odor of ethanol/isopropyl alcohol or essential oil. Among the organoleptic characteristics, the determination of the smell is the one that allows the differentiation of the products.

The pH was determined for the final product, after maceration and filtration. The determination was made using pH-indicator paper.

RESULTS AND DISCUSSIONS

Qualitative evaluation of hand sanitizers was performed by physico-chemical and organoleptic (appearance, odor, color) analyzes, 14 days after their formulation (Figure 2).

Figure 2. The four hand sanitizers

Homogeneity, lack of crystalline solid particles, but also lack of phase separation are important indicators that reflect the good homogenization of the solution.

Due to the high quality of the active ingredients and the essential oils used, valuable products were obtained both in terms of antimicrobial efficacy, the degree of skin softening, but also the specific smell, which had a positive effect after use (Dhifi et al., 2016; Javed et al., 2014).

Following the organoleptic analyzes, it was found that the products obtained based on ethyl alcohol were very well homogenized, did not show phase separations, and the smell was much more pleasant than the other two solutions, based on isopropyl alcohol. The specific smell of alcohol has been faded by essential oils, resulting in two moisturizers with antimicrobial action and a fresh smell.

Both ethyl alcohol solutions had a slightly yellowish color, due to the aloe vera pulp, but also to the essential oils.

The smell was very pleasant, specific to the essential oils used in the preparation. Ethanol played a very important role, so that the solutions AE_{T+L} and AE_{Eu+Lv} did not present a pronounced alcoholic odor.

Following the organoleptic analyzes performed on the solutions based on isopropyl alcohol, it was found that they homogenized very well, showed no signs of phase separation, and the smell was much stronger, specific to isopropyl alcohol. The specific smell of alcohol could not be completely blurred by the essential oils used, which slightly reduced the quality of the product. The latter two solutions also showed a slightly yellowish color, due to the aloe vera pulp and essential oils.

The disinfectant solutions were preliminarily tested for five days. Our tests have confirmed the scientific research on the effect of aloe vera on human skin (Vogler et al., 1999; Dal'Belo et al., 2006). Due to their aloe vera content, hand sanitizers protected the hands from the aggressive effect of alcohol and had a moisturizing effect, so the skin did not suffer any injury.

CONCLUSIONS

Following the research carried out in this study, the following main conclusions could be drawn:

- The natural ingredients used to make hand sanitizers are accessible to all and the formulation was easy;

- Organoleptic determinations confirmed the obtaining of high quality products, with a pleasant appearance, a fluid consistency, easy to apply, without signs of phase separation and a very pleasant smell;
- The smell of alcohol-based products is much more pleasant than that of isopropyl alcohol, due to the alcohol used. The pungent odor of isopropyl alcohol persisted in hand sanitizers, which could lead to a lower degree of acceptance by users;
- Due to their aloe vera content, hand sanitizers protected the hands from the aggressive effect of alcohol and had a moisturizing effect.

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