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Original Research Article

Quality control of hydroalcoholic products on the Senegalese market using densimetry and UV-visibility

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Abstract

To ensure the safety and effective disinfection of these hydroalcoholic products, their formulation must meet quality standards. Our study is based on quality control of the physico-chemical parameters of several products available on the national market. Our tests on seven samples revealed that products C and D have density values of 0.84 and 0.80 respectively, and do not comply with the standards set by the World Health Organization (WHO). The pH values of the products analyzed ranged from 5.5 to 6.6, with only A failing to meet WHO standards. The UV-visible method presents alcohol contents ranging from 65% to 100% and shows that products B and D do not meet WHO recommendations. Given the results obtained, it would be useful to introduce control techniques for hydroalcoholic products in the Senegalese market.

Keywords:
Hydroalcoholic products, quality control, Degree of alcohol

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1. Introduction

The COVID-19 pandemic has reminded us of the importance of hand hygiene, which is an essential element in contributing to and reducing the risks of germ, micro-organism and dirt transmission. Indications are that the virulent SARS-CoV2 virus is transmitted by respiratory droplets or by simple contact. Contact transmission occurs when contaminated hands touch the mucous membranes of the mouth, nose or eyes. It can also be easily transferred from one surface to another by contaminated hands, facilitating transmission by indirect contact [1]. To stop it spreading, it's important to follow good hygienic practices and strictly maintain hand hygiene. However, the use of hydro-alcoholic products helps to limit the risk of transmitting germs to other people [2]. To this end, various forms of hydroalcoholic products and a multitude types of these products have been placed on the market due to deficient regulations concerning the acquisition and distribution of antiseptics and disinfectants. Hydroalcoholic product must have their ethanol content accurately determined in order to evaluate their safety and effectiveness as well as to identify the fraudulent use of other alcohols (methanol), which are harmful to humans. Recently, various techniques have been used, such as gas chromatography coupled with mass spectrometry [3] and 1H NMR spectrometry [4]. Other techniques exploited include near-infrared spectrophotometry [5], the membrane-free gas-liquid separation system [6], and colorimetric oscillating signals (COS) [7]. However, these techniques are costly and access to them is very limited. UV-visible and densimetric methods have proved to have several interesting applications in the environmental and industrial fields. As a result, these experimental methods are very simple, fast, inexpensive, accessible, and reliable [8, 9].

In Senegal, no studies have been carried out to assess the efficacy of hydroalcoholic products [3]. Users are faced with many questions when choosing a hydroalcoholic product, and the question of the real efficacy of these products is increasingly being asked.

In this work, we will study the quality of hydroalcoholic products on the one hand, and their effectiveness on the other. To carry out this work, we will first review current knowledge on the formulation of hydroalcoholic gels before looking at the standards and recommendations governing their use. In Senegal, weak regulations governing the acquisition and distribution of antiseptics and disinfectants have led to a proliferation of these products on the national market. As a result, during this pandemic period, the Senegalese population finds itself exposed to hydroalcoholic products of all kinds, which may even constitute a health threat. To counter these dangers, we studied the quality of several hydroalcoholic products manufactured by Senegalese companies and available on the market, using physicochemical and UV-visible methods.

2. Products, materials and methods

2.1 Products

Distilled or deionized water was used to dilute ethanol samples in order to vary the alcohol content. Ethanol (96%) was purchased from Sigma Aldrich and samples of hydroalcoholic products were collected from various locations (Table 1) and their compositions are shown in Table 2.

Table 1. List of hydroalcoholic products collected.

Number	Names	Provenance
1	Product A	Supermarket Auchan (parcelles assainies)
2	Product B	Pharmacy Ndoss (fann)
3	Product C	H&D Industries.SA
4	Product D	Pharmacy of Soumbédioune (gueul tapé)
5	Product E	Pharmacy of soumbédioune (gueul tapé)
6	Product F	Pharmacy of soumbédioune (gueul tapé)
7	Product G	University of Cheikh Anta Diop of Dakar (UCAD) (fann)

Table 2. Characteristics of collected products

Products	Composition on the label	Percentage on the label
Product A	Ethanol Propanol Glycerol Water Carbomere	No information
Product B	Ethanol Propanol Glycerol Water Carbomere	No information
Product C	No information	No information
Product D	No information	No information
Product E	No information	No information
Product F	No information	No information
Product G	Ethanol Propanol Glycerol Water carbomere	No information

2.2 Materials

UV/vis spectra and absorbance values as a function of wavelength were recorded using Fisher scientific model G10S UV-Vis spectrophotometry. pH measurements of the different hydroalcoholic products were carried out by a pH meter H/ mV/°C/°F. This consists of an electronic box that displays the

pH value and an electrode that measures this value. All the masses were measured using a PPS213 precision electronic balance, a device for weighing masses, with an accuracy of around 0.001g.

2.3 Quality control methods for hydroalcoholic products

This section summarizes the experimental work and research methodology to determine the physico-chemical characteristics of a few samples of hydroalcoholic products sold on the national market, using the UV spectroscopy and density techniques.

2.3.1 Densimetry method

Using this method, we carried out quality control of hydroalcoholic products based on their density. It consists in determining the alcoholic strength (proportion of ethanol contained in a hydroalcoholic product at a temperature of 20°C) using a precision balance, by measuring the mass of hydroalcoholic product samples for a specific volume [1]. The density of each sample is equal to the ratio of its specific mass to that of pure water measured under the same conditions [2,10].

To measure the densities of hydroalcoholic products, we performed the calculations without the mass of glycerol, which represents 1.5% of the gel mass. Density is measured with a pycnometer using the following procedure:

- Wash and dry the pycnometer, then weigh it using a precision balance to within 0.001g to determine its empty weight.
- Fill the pycnometer with distilled water to 5ml, and determine the apparent mass of its water content.
- Empty, wash and dry the pycnometer, refill it with the sample to be examined to the same quantity, and in the same way, determine the mass of its product content.

Density is determined using the formula

$$D= (M_3-M_1) / (M_2-M_1) \quad (1)$$

Where:

D: density

M_1: Mass of pycnometer (g)

M_2: Mass of pycnometer filled with distilled water (g)

M_3: Mass of pycnometer filled with product to be analyzed (g)

2.3.2 UV-visible analysis method

UV-visible absorption spectra were recorded for samples containing 50 mL of water-ethanol mixture in the range 0-80% ethanol by volume (Table 3). This method is considered a simple model for the UV-visible determination of alcohol content in hydroalcoholic products [11]. The Uv-visible measurement process is carried out by injecting the water-ethanol mixture into the cuvette using a syringe up to two-thirds full.

After this measurement, the cuvette was rinsed with de-ionized water several times to ensure that there were no residual particles from the previous sample.

Table 3. Percentage of water-ethanol mixture in %vol

Ethanol content (%vol)	Volume of water(mL)	Volume of ethanol (mL)
0.00	50	0.00
0.8	49.50	0.50
8	45.00	5.00
20	37.50	12.50
40	25.00	25.00
80	0.00	50.00

3 Results and discussion

3.1 Densimetric method

Table 4 shows the density and alcohol range of several hydroalcoholic products on the national market. It can be seen that the products have density values between 0.8 and 0.87.

According to the formulation guide for hydroalcoholic products recommended by the WHO, the density values of the majority of our products are compatible and within the standard range of 0.85 to 0.89 [10]. However, some products fail to meet the density standards set by the WHO, as in the case of products C and D, which have density values of around 0.84 and 0.80, respectively. These results could be due to faulty preservation or production of these gels, and may lead to insufficient efficacy and antimicrobial activity.

On the other hand, the other density values in the table show that the hydroalcoholic products (product A, product B, product E, product F and product G) analyzed by the density method are fully compliant with WHO standards. To support these results, we determined the alcohol range using the Gay Lussac table, and confirmed these values using the UV-visible method.

Table 4. Range of alcoholic strengths of gels with their corresponding densities

hydroalcoholic products	Densities at 25°C	Alcoholic strengths
Product A	0.85	75-80%
Product C	0.84	80-85%
Product B	0.85	75-80%
Product D	0.80	90-95%
Product E	0.85	75-80%
Product F	0.87	70-75%
Product G	0.85	75-80%

3.2 UV-visible method

3.2.1 Ethanol absorption spectrum (v /v)

Figure 1 shows the results of the absorption spectrum of the ethanol-water mixture with alcohol contents ranging from 0.8% to 80%. It can be seen that all absorption spectra of the ethanol-water mixture with varying proportions absorb at the same wavelength λ = 280 nm (figure 1). This figure shows an increase in absorbance intensity as a function of alcohol content. These results show that alcohol content is proportional to absorbance intensity, and are due to interactions between water and ethanol molecules [13-15]. This is reflected in the bond between the oxygen of the water molecule and the hydrogen of the hydroxyl group (-OH) of the ethanol molecule [16-19]. Figure 2 shows the absorption intensity variation of the water-ethanol mixture as a function of alcohol content. This figure shows a progressive increase in absorption intensity as a function of alcohol content, and exhibits good linearity with a correlation coefficient R^2 = 99.9%.

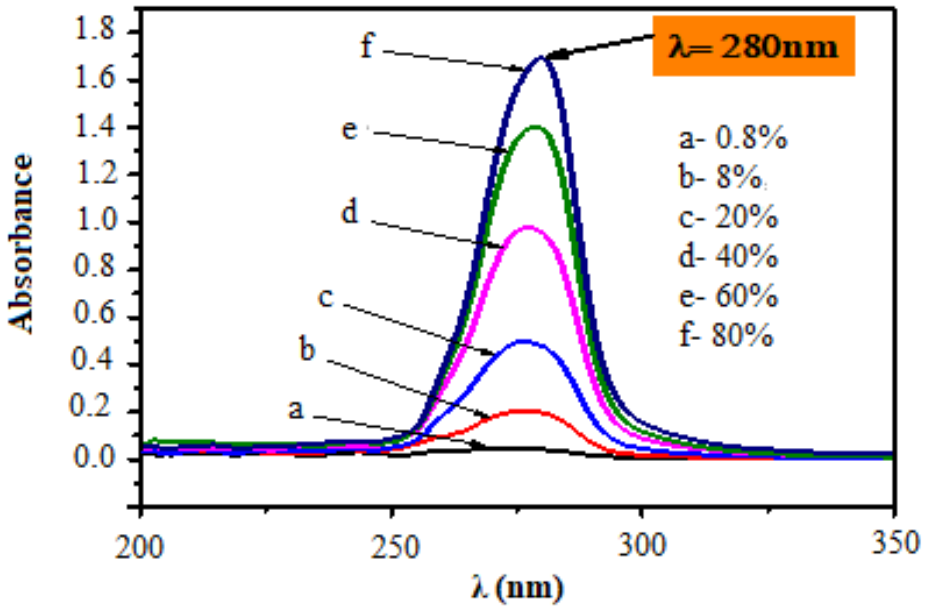

Figure.1. UV-visible absorption spectrum of the ethanol-water mixture (%vol).

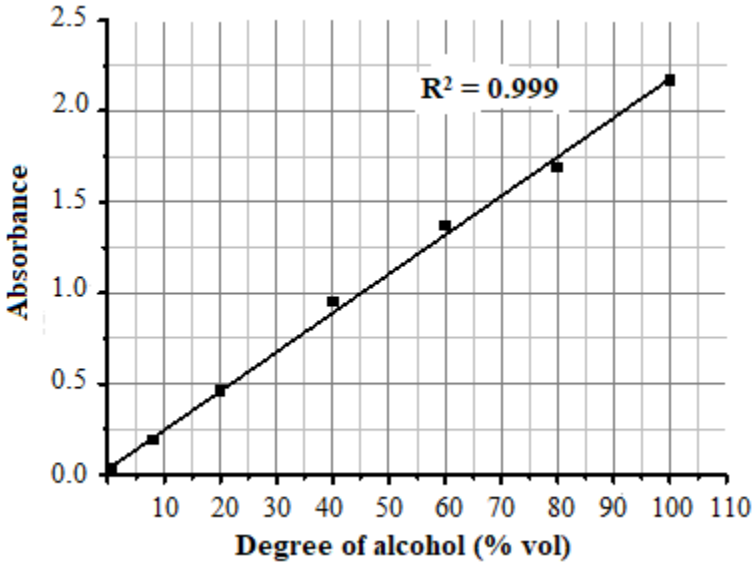

Figure. 2. Absorption intensity curve as a function of alcohol content (0.8% -100%).

3.2.2 Determination of the alcohol content of hydroalcoholic products on the national market

UV-visible analysis of some hydroalcoholic products available on the national market was carried out under the conditions described above. The absorption spectra of the various products studied show the appearance of absorption bands at wavelengths around λ=280nm, except in the case of product B, where the absorption band appears around 287nm (figure. 3). These bands are attributed to the absorption of the ethanol molecule present in hydroalcoholic products. However, in the case of product B, this length shift could be due to the interaction of the ethanol molecule and the gel additives [11].

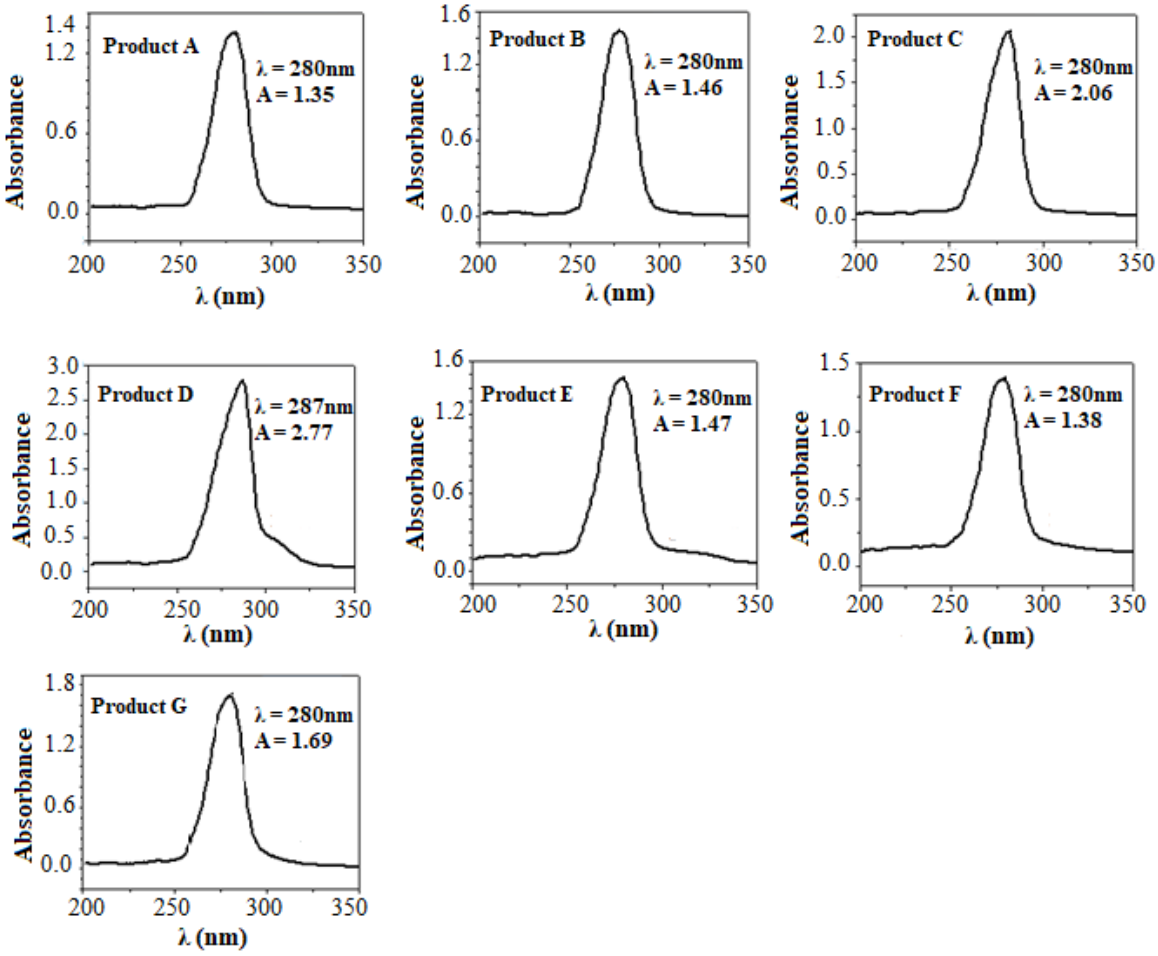

Figure. 3. UV-visible absorption spectrum of hydroalcoholic products on the national market.

Figure 4 shows the extrapolation of absorbance intensity for the hydroalcoholic products shown in figure 3. The results show that products A, E, F, and G have degree values between 60-80% alcohol and comply with the WHO standard norm [20]. This shows that these products can exhibit highly effective antimicrobial activity. On the other hand, products B and D have an alcohol content of 100% and 95% respectively, which leads to overdosing of the product and may affect the antimicrobial activity of the hydroalcoholic product. These results show that the effectiveness of hydroalcoholic products during formulation requires the presence of a certain quantity of water. Indeed, alcohol acts by denaturing microbial proteins, and this will be facilitated by the presence of water, in order to obtain degrees between 60 and 80% alcohol [21].

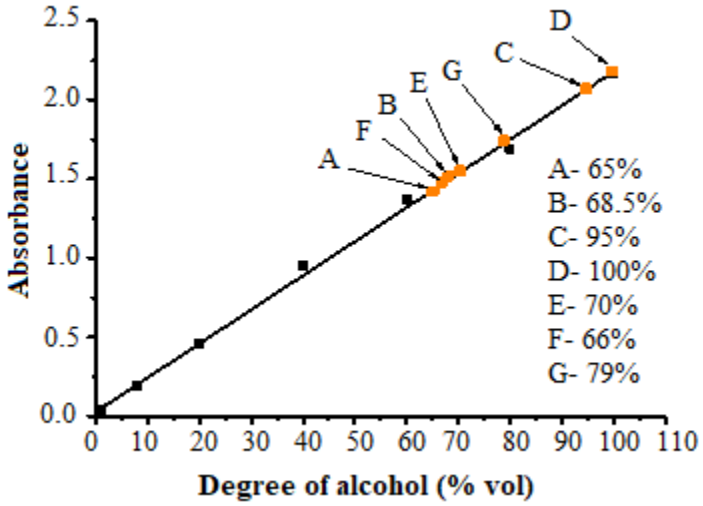

Figure. 4. Determination of the degrees of the hydroalcoholic products studied from their absorbances in the UV wavelength region.

Table 5 shows the physico-chemical parameters of some samples of hydroalcoholic products available on the market in Senegal. According to the formulation guide for hydroalcoholic products recommended by the WHO, the pH values of almost all the products analyzed are not compatible with the standards, which range from {6.0-7.0} [11]. According to Goetz and Busse [22, 23], skin pH determines the ionization and absorption capacity of active ingredients. From a dermatological point of view, the pH of hydroalcoholic products should not approach the skin pH of 5.5. These results may be due to conservation reasons. On the other hand, this preliminary work revealed that hydroalcoholic products with alcoholic strengths of between 60 and 80% are within the range of standard values set by the WHO. In addition, some of the products analyzed have density values outside the norms set by the WHO (0.85 - 0.89), as in the case of products C and D.

In view of the results obtained, it would be useful to set up control and monitoring techniques for hydroalcoholic products on the Senegalese market. This would enable us to broaden and deepen our investigation by significantly increasing the number of samples and diversifying the collection points for hydroalcoholic products available on the national market. In addition, we will be able to find out more about how hydroalcoholic products are stored. These results will provide much more exhaustive data on the quality of hydroalcoholic products consumed in Senegal.

Table. 5. Results of physico-chemical parameters (alcoholic strength, pH and density) of hydroalcoholic gel samples.

GHA	Mass 5 mL	pH	Degrees	density	Standard Norm
Product A	4.3	6.6	65 %	0.85	
Product C	4.22	5.88	68.5 %	0.84	✓ degree of alcohol (%) 60-80 % (OMS)
Product B	4.19	5.94	100 %	0.85	
Product D	4.024	5.58	95 %	0.80	✓ pH (6 - 7)
Product E	4.27	5.73	70 %	0.85	✓ Densité 0.85 - 0.89
Product F	4.38	6	66	0.87	
Product G	4. 29	5.5	79%	0.85	

4. Conclusion

In this work, we carried out quality control on hydroalcoholic products used as hand disinfectants to combat Covid-19. Experimental results showed that some of the products analyzed have a slightly acidic character. By UV-visible analysis, the hydroalcoholic products showed that they contained the necessary and sufficient quantity of alcohol, although some products did not have the recommended water content. In addition, the determination of physico-chemical parameters revealed that the density of some available hydroalcoholic products did not comply with WHO standard norms. All the results obtained, compared with those in the literature, show that products B and D may present problems with antibacterial activity. Of the 07 samples analyzed, 02 products did not comply with the standards recommended by the WHO in terms of ethanol-water content. This observation suggests that more than 28% of the hydroalcoholic products used as disinfectants are of poor quality. Given their great usefulness in our lives, particularly in the fight against bacteria, the market of hydroalcoholic gels or any other disinfectant deserves to be taken with more serenity.

However, it would still be interesting to check the quality of hydroalcoholic gels through other aspects such as microbiological activity, their composition in additives and humectants (glycerol, triethanolamine, etc) or even the chronic toxic effects of ethanol, paying particular attention to children and people with genetic deficiencies in ethanol metabolism.

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