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EFFICIENCY OF THE WELLISAIR DEVICE FOR THE REMOVAL OF BACTERIA ON TEXTILE SURFACES

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1 INTRODUCTION

The **objective** of this test is to **evaluate the disinfection potential of the WELLISAIR device on different types of textiles offered by INTEXTER (UPC).** The device was tested on textiles using 3 cartridges with 3 different active principles, to compare their effectiveness.

2 METHODS

2.1 Disinfection efficiency tests

The tests were made in the GAIA building at the UPC, more specifically inside the Environmental and Health Microbiology laboratory (MSMLab). The device was tested inside two cabins (dimensions: 1x1x1 meters), using one for tests with the WELLISAIR device and the other cabin for control tests without the device (Figure 1). The frontal side of the cabins was removable and allows the inside access for sampling.

Figure 1: Picture of 1x1x1m cabins used. The cabin on the top was used to make the tests of the WELLISAIR device and the cabin on the bottom was used for CONTROL purpose.

The WELLISAIR device was tested in four different conditions: disposable lab gown textile, linen, polyester and polypropylene; with the different cartridges supplied (limonene, hydrogen peroxide at 4,95% and hydrogen peroxide at 17,5%) for each condition.

2.2 Microbial species used

The disinfection device efficiency on tissues have been tested with *Escherichia coli* (Table 1), using the TBX Agar culture medium (Table 2).

Table 1. Microbial microorganism used for the disinfection test of aerosol and surfaces.

Microorganism	Type	Culture medium	Test
Escherichia coli	Gram + Bacteria	TBX agar	Surface and aerosol

Table 2. Culture medium used in the tests of E. coli.

Microorganism	Culture medium	Reference	Brand
Escherichia coli	Microinstant ®Tryptone Bile Glucuronic A. (TBX Agar)	01-619-500.	Scharlau

Escherichia coli: gram-negative coliform bacteria, anaerobic facultative, rod-shape, included in the *Escherichia* genus that is normally found in the gut of endotherm organisms. Most of the strains of *E. coli* are non-pathogenic, but some serotypes (EPEC, ETEC, etc.) can cause severe food intoxication in their hosts and, sometimes, are responsible of food contamination that cause product withdraws. The non-pathogenic strains are part of the gut microbiota and can benefit their hosts producing K2 vitamin and preventing the colonization of pathogenic bacteria.

E. coli spread to the environment inside the fecal matter and grows massively in fecal matter in aerobic conditions for 3 days, but its number decreases later on. *E. coli* and other anaerobic facultative constitutes around the 0,1% of the gut microbiota and the fecal-oral transmission is the main route that pathogenic strains have to cause diseases.

Cells can survive outside the body for a limited time period, which makes them possible indicators to analyze environmental samples in order to observe fecal contamination. The bacteria can be easily grown in cultures in a laboratory and has been widely investigated for more than 60 years.

E. coli is the most studied prokaryotic model, a prominent bacterium for biotechnology and microbiology fields, where has served as a host organism for recombinant DNA studies. In ideal conditions, the duplication time of *E. coli* is about 20 minutes.

2.3 Test methods

Disinfection test on fabrics. Disinfection test on textiles by the WELLISAIR device were carried out with the inoculation of different normalized pieces (2x2 cm) of each textile used with a normalized suspension of *E. coli*. Inoculated textiles were settled inside the cabin over a metal rack to ensure the contact between the textile with disinfectant (Figure 2 and Figure 3).

Each fabric was inoculated with two different concentrations (**C1** and **C2**) and they were exposed to the WELLISAIR device for each concentration (duplicate). The test with and without (**CONTROL**) the WELLISAIR device were made simultaneously in two cabins with the same characteristics and conditions.

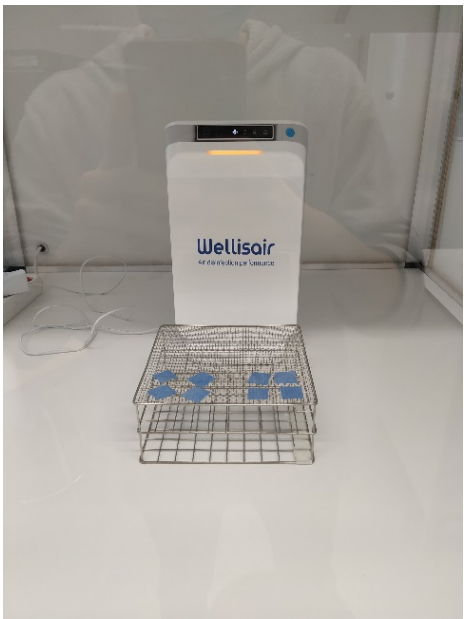

Figure 2: Inside picture of the cabin with the textile standard pieces and the WELLISAIR device. It can be observed the metal rack in which the fabrics were disposed.

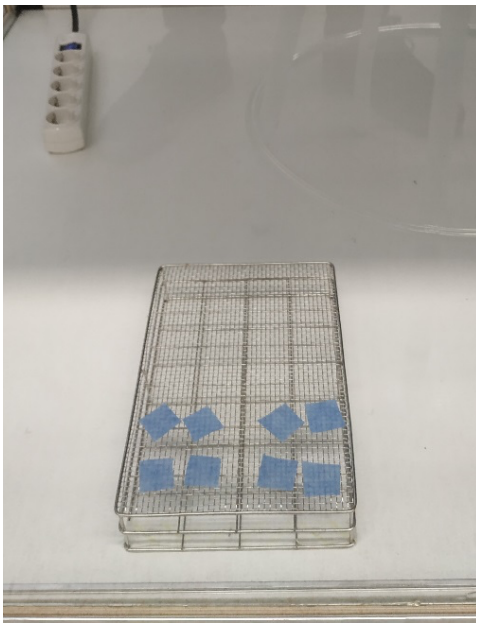

Figure 3: Inside picture of the control cabin with the textile standard pieces and without the WELLISAIR device.

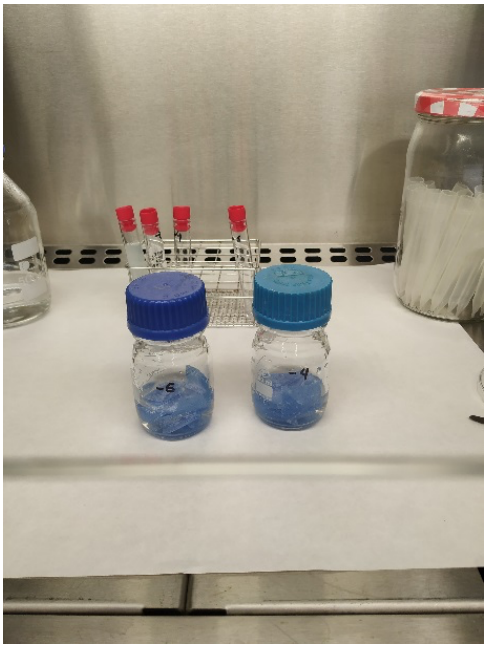

Figure 4: Textiles inoculation with E. coli previous to the disinfection tests.

The bacterial suspension was prepared according to the standard protocols, adjusting the *E. coli* concentration to **$1x10^4$ CFU/ ml (C1)** and to **$1x10^2$ CFU/ ml (C2)** (colony formation unit/milliliter) through serial dilutions. All the process was made under sterile conditions using the Bunsen burner and the laminar flux cabin (microbiology security cabin Telstar Class II).

Firstly, the samples of 2x2 cm textile fabric were submerged inside the *E. coli* suspension (Figure 4) and placed in the metallic rack to expose them to the WELLISAIR. The racks with the inoculated fabrics were introduced inside the cabins (WELLISAIR and CONTROL) and the device was connected to begin the disinfection test.

Samples were collected to evaluate the disinfection on the fabrics previously to begin the tests (time 0), and after 60 and 120 minutes. The inoculated fabrics were extracted from the cabin to each corresponding time to be cultured on the TBX agar medium and incubated during 24 hours at 37ºC to observe the results the following day.

3 RESULTS AND DISCUSSION

3.1 WELLISAIR effectiveness on linen

LINEN FABRIC: A **87,4% bacterial inactivation** with the **H_20_2 at 17,5%** cartridge, **95,81%** for the **H_20_2 at 4,95%** cartridge and **96,5%** for the limonene were observed for C1 after 60 min of Wellisair (Figure 5). A **99% bacterial inactivation** with the **H_20_2 at 17,5%** cartridge, **88%** for the **H_20_2 at 4,95%** cartridge and **82%** for the limonene were observed after 60 min. at C2 (Figure 6). For **both conditions (C1 and C2) and all cartridges, a 99,99% of bacterial inactivation** were shown after **120 minutes**.

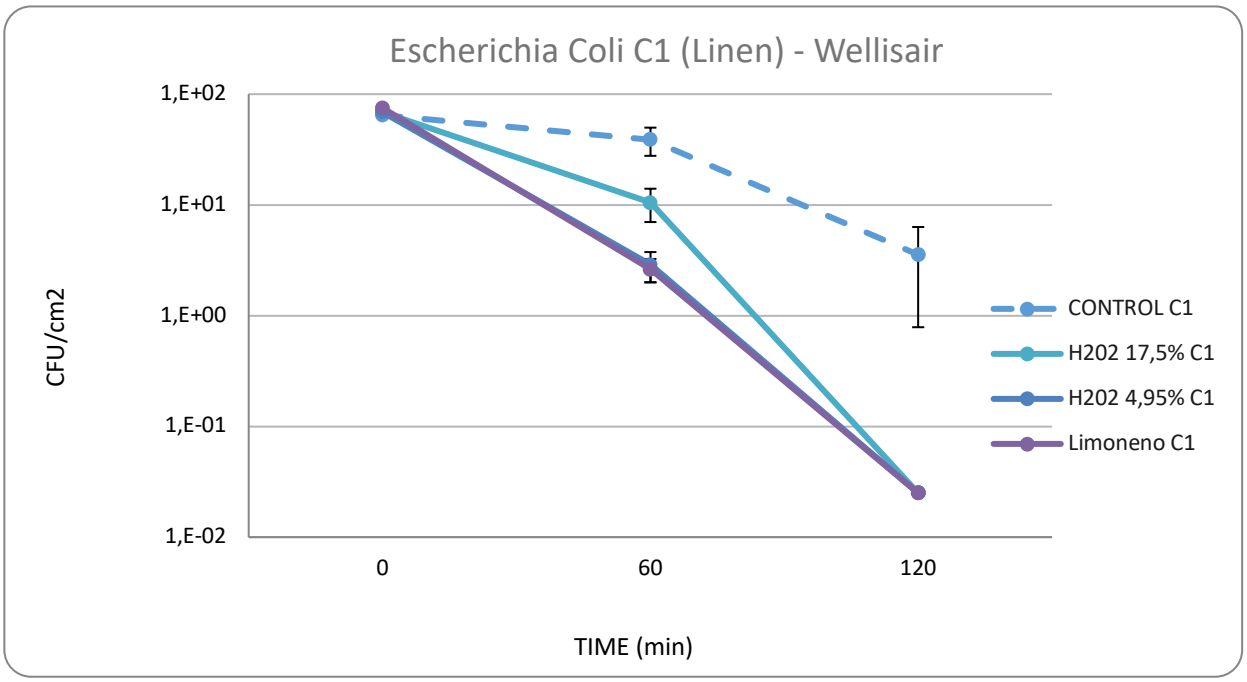

Figure 5: Wellisair reduction of E. coli (results expressed in CFU/cm^2), at 0, 60 and 120 minutes of exposition with the 3 cartridges for LINEN TEXTILES and C1 concentration. .

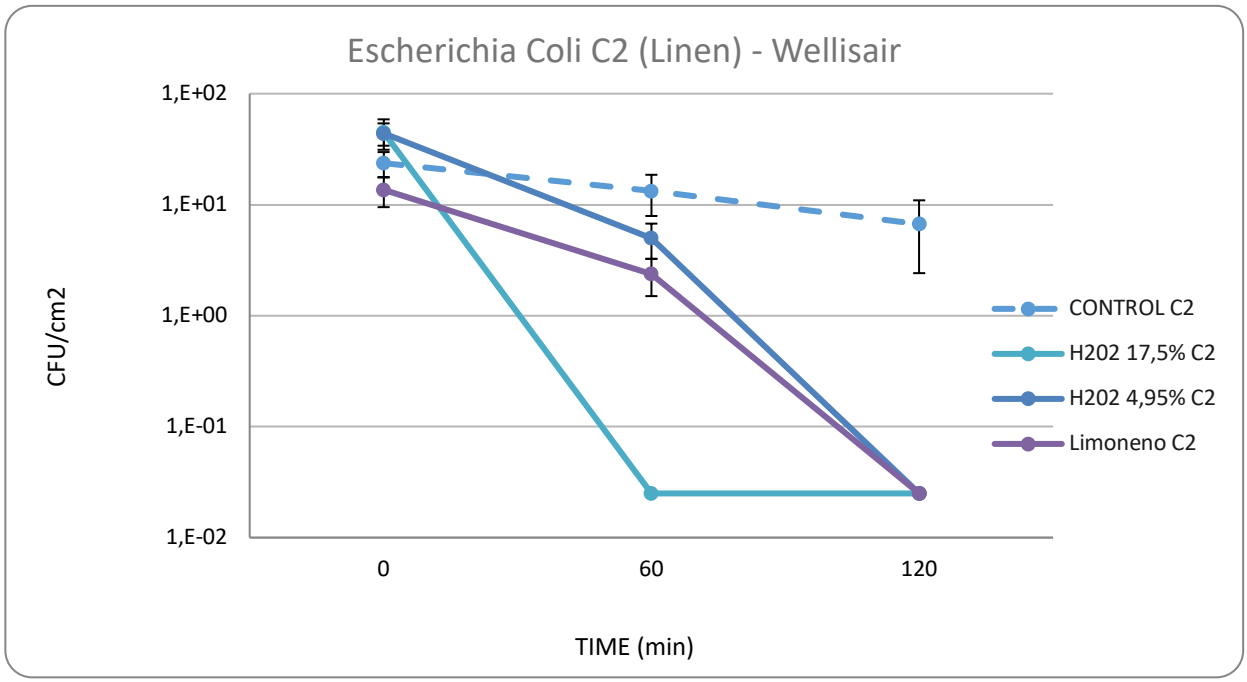

Figure 6: Wellisair reduction of E. coli (results expressed in CFU/cm^2), at 0, 60 and 120 minutes of exposition with the 3 cartridges for LINEN TEXTILES and C2 concentration. .

3.2 WELLISAIR effectiveness on disposable lab gown textile

Disposable lab gown textile: A **79% bacterial inactivation** with the **H_20_2 at 17,5%** cartridge, a **99%** for the **H_20_2 at 4,95%** cartridge and a **99%** reduction for the limonene cartridge were observed after 60 minutes with the WELLISAIR and C1 conditions **C1** (Figure 7). The results with the C2 conditions (Figure 8) were even higher, with a **99% of bacterial inactivation** with the **H_20_2 at 17,5%** cartridge, a **99%** for the **H_20_2 at 4,95%** cartridge and a **99%** for the limonene. For both conditions and all cartridges, a **99,99% bacterial inactivation** were observed after **120 minutes**.

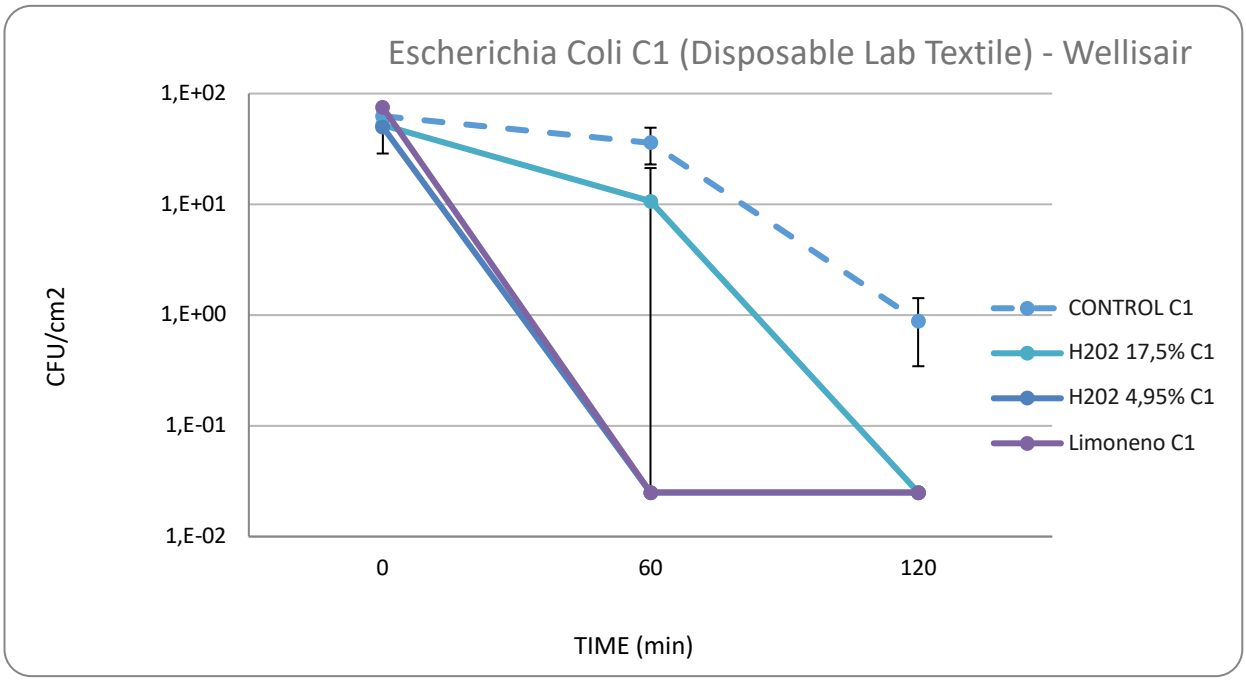

Figure 7: Wellisair reduction of E. coli (results expressed in CFU/cm^2), at 0, 60 and 120 minutes of exposition with the 3 cartridges for Disposable Lab Gown and C1 concentration.

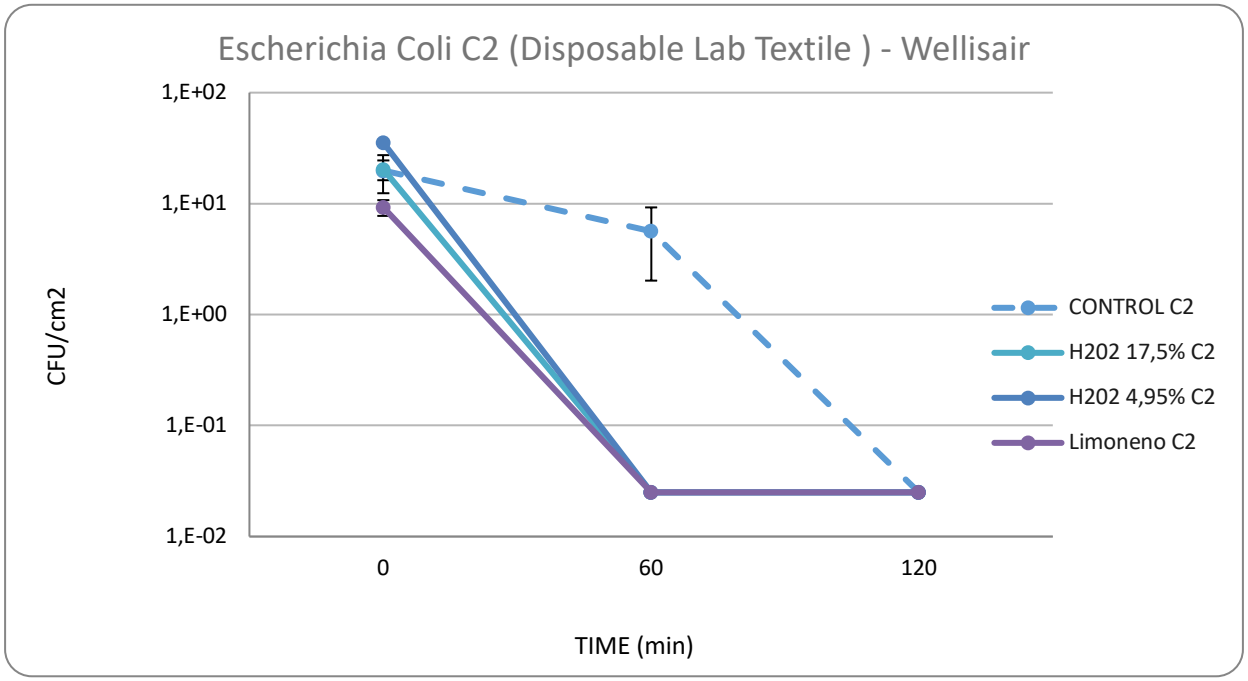

Figure 8: Wellisair reduction of E. coli (results expressed in CFU/cm^2), at 0, 60 and 120 minutes of exposition with the 3 cartridges for Disposable Lab Gown and C2 concentration.

3.3 WELLISAIR effectiveness on polyester

Polyester fabric: A **60% bacterial inactivation** with the **H_20_2 at 17,5%** cartridge was observed, whereas the results were higher for the **H_20_2 at 4,95%** cartridge (82% reduction) and even higher for limonene (**99%** reduction), after 60 min and C1 conditions (Figure 9) **using the WELLISAIR.** For the C2 conditions, a **95% of bacterial inactivation** with the **H_20_2 at 17,5%** cartridge, an **88%** for the **H_20_2 at 4,95%** cartridge and a **99%** for the limonene were observed (Figure 10). For both conditions and all cartridges, a **99,99% bacterial inactivation** was observed after **120 minutes**.

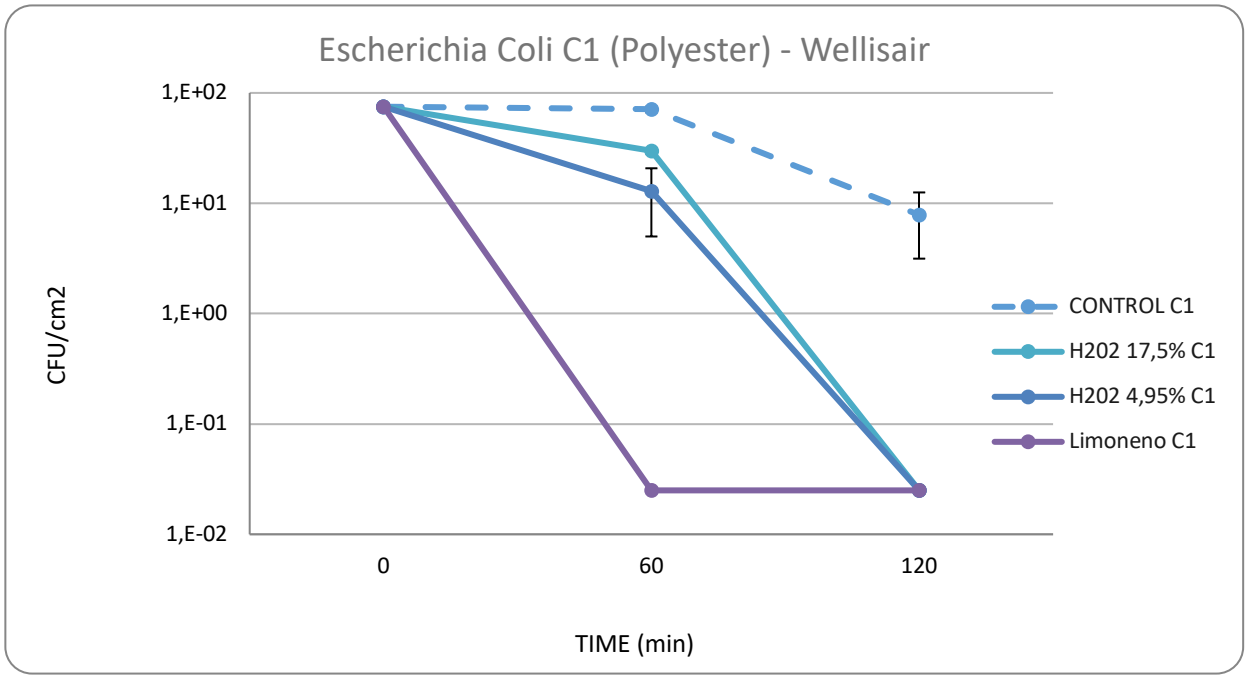

Figure 9: Wellisair reduction of E. coli (results expressed in CFU/cm^2), at 0, 60 and 120 minutes of exposition with the 3 cartridges for Polyester and C1 concentration.

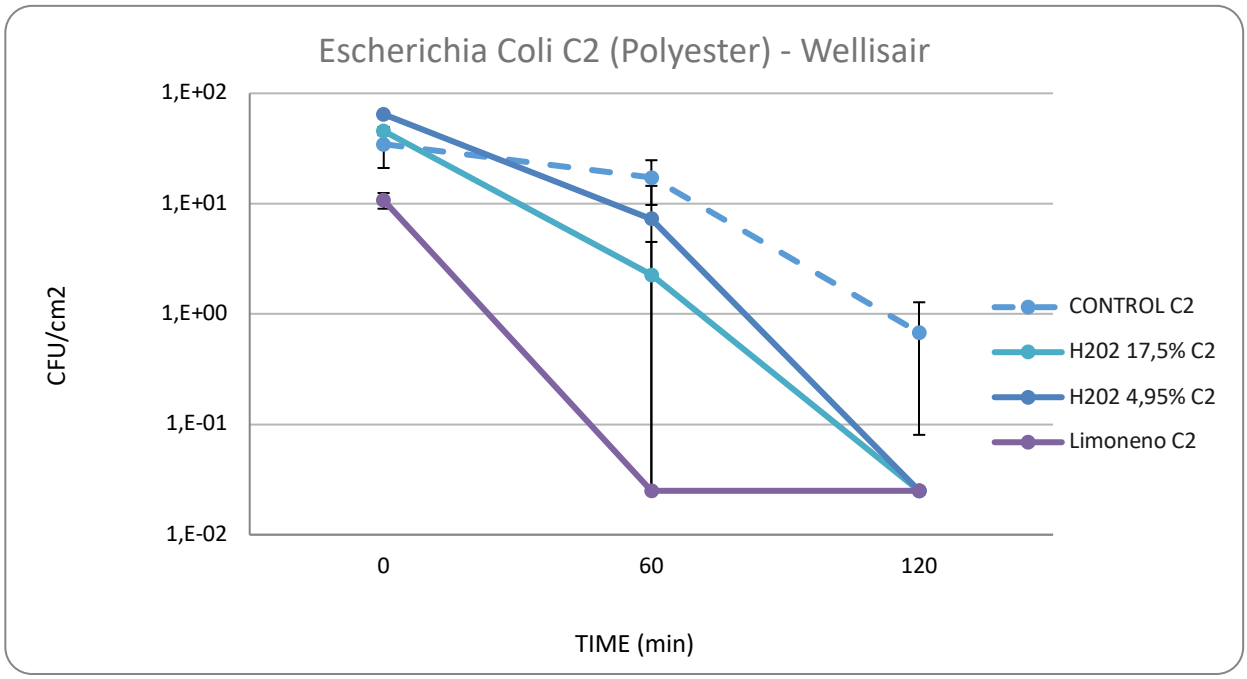

Figure 10: Wellisair reduction of E. coli (results expressed in CFU/cm^2), at 0, 60 and 120 minutes of exposition with the 3 cartridges for Polyester and C2 concentration.

3.4 WELLISAIR effectiveness on polypropylene

Polypropylene fabric: A **84% bacterial inactivation** with the **H_20_2 at 17,5%** cartridge was observed, whereas the results were higher for the **H_20_2 at 4,95%** cartridge (98% reduction) and even higher for limonene (**99%** reduction), after 60 min and C1 conditions (Figure 11) **using the WELLISAIR.** For the C2 conditions, a **99% bacterial inactivation was observed for each case** (Figure 12). For both conditions and all cartridges, a **99,99% bacterial inactivation** was observed after **120 minutes**.

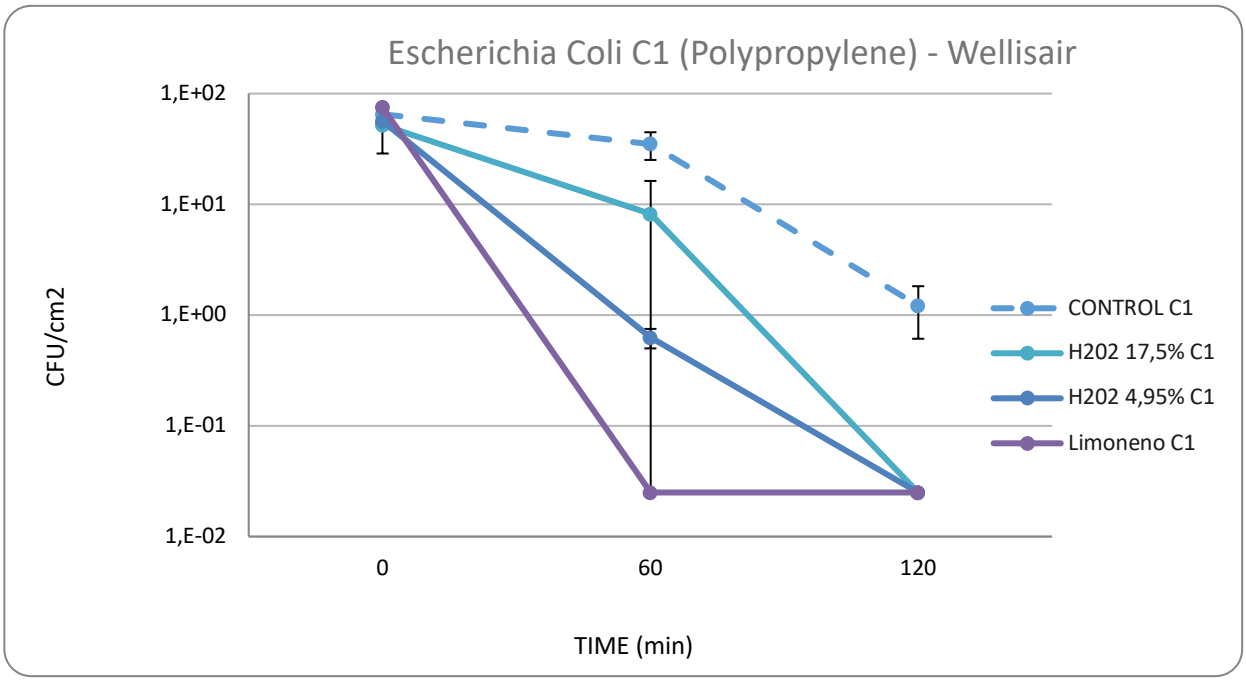

Figure 11: Wellisair reduction of E. coli (results expressed in CFU/cm²), at 0, 60 and 120 minutes of exposition with the 3 cartridges for Polypropylene and C1 concentration.

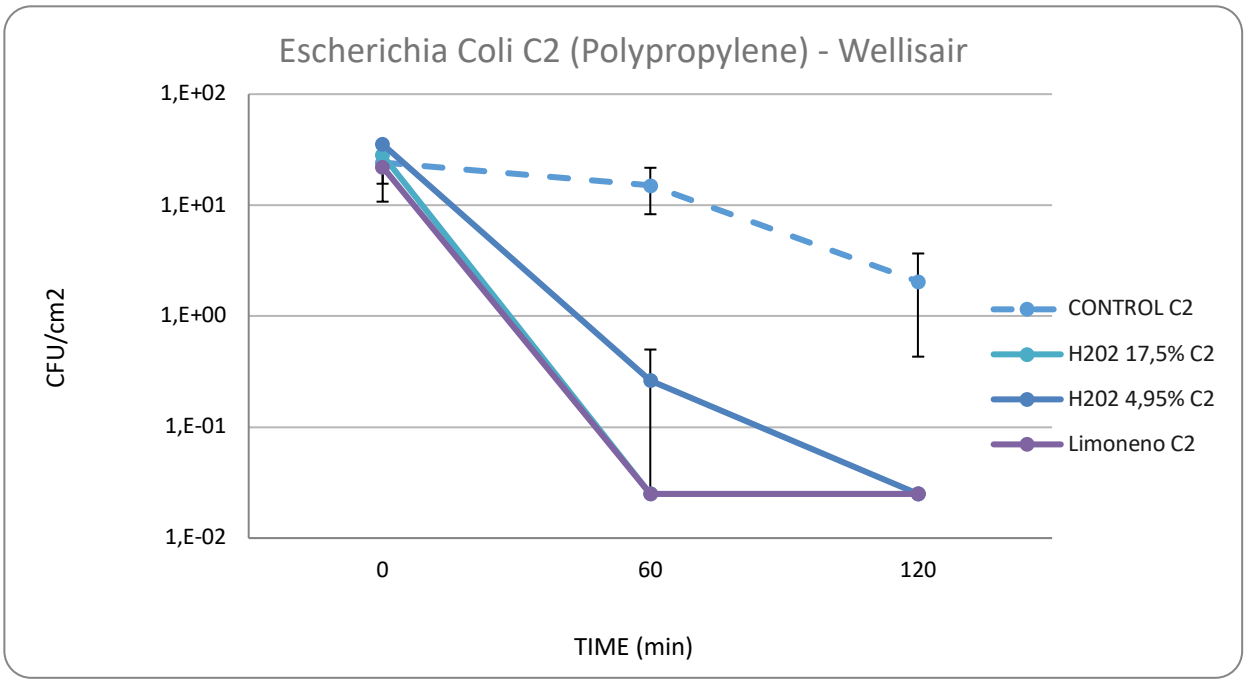

Figure 12: Wellisair reduction of E. coli (results expressed in CFU/cm²), at 0, 60 and 120 minutes of exposition with the 3 cartridges for Polypropylene and C2 concentration.

A summary for all **disinfection efficiencies (expressed in percentages) were shown in** (Table 3).

Table 3. Bacterial inactivation for all textile products with WELLISAIR device, for both concentrations (C1 and C2), at 60 minutes and for all the different cartridges. Results higher than 85% inactivation are shown in green cells; between 79 and 85% inactivation are shown with orange background and below 79% are shown in red background.

Type of cartridges	Disinfection time	Linen		Disposable coat		Polyester		Polypropylene	
		C1	C2	C1	C2	C1	C2	C1	C2
H_2O_2 17,5%	60 min	87,4	99	79	99	60	95	84	99
H_2O_2 4,95%	60 min	95,81	88	99	99	82	88	98	99
Limonene	60 min	96,5	82	99	99	99	99	99	99

4 PRELIMINARY CONCLUSIONS

A) The results showed a **good homogeneity** (with a reduced standard deviation) which indicates a **reliable analytic methodology**.

B) The tests made with the 3 cartridges over the 4 different textiles (linen, disposable coat, polyester, and polypropylene) showed a **good reproducibility**.

C) At 120 minutes, most of the controls showed a 1-log decreased. For this reason, **the results were better compared after 60 min. of exposition.**

D) After 60 minutes of the WELLISAIR function, **80% of the results achieved an efficiency greater that 85% removal.**

E) Comparing the different cartridges, **limonene showed a significant higher efficiency comparing to the H_2O_2 cartridges.**

F) The results for H_2O_2 cartridges showed some variability, depending on the concentration and textiles used. For lower bacterial concentrations (**C2), the 17.5% H_2O_2 showed a higher efficiency for linen textiles**, and the same inactivation on the other textiles. On the contrary, for higher bacterial concentrations (C1), the **4.95% H_2O_2 showed a higher efficiency for all tested textiles**.

G) In summary, the WELLISAIR device demonstrates to have **a high disinfection activity in front the bacterial model** tested for all textile tested in laboratory conditions. Therefore, **the device WELLISAIR device could be a good tool to provide a microbial reduction for different indoor environments.**