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Effect of Stitch Types Used in Apparel Production on Aerobic Mesophilic Bacteria Growth

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Bacteria,
Stitch types,
Antibacterial yarn,
Hygiene,
Textiles

Abstract: In this study, the effect of stitch types (those commonly used in apparel production) on antibacterial activity was investigated. Determination of best stitch types through hygienic environments, where dangerous situations exist such as infection was intended. For this purpose, the antibacterial activity of various stitches was tested within the framework of the ASTM E2149 standard. Bleached reusable clinical aprons` fabrics, those comprising 65% polyester – 35% viscon mixture were named as alpaca weave fabric. Onto these alpaca fabrics, 3 different stitches with various yarns (3 threads overlock + chain stitch, lockstitch with lap felled seam and 5 threads overlock) were applied. Evaluation of findings showed that there are no significant differences according to stitch types.

Hazır Giyim Üretiminde Kullanılan Dikiş Türlerinin Aerobik Mezofilik Bakteri Büyümesine Etkisi

Anahtar Kelimeler
Bakteriler,
Dikiş türleri,
Antibakteriyel iplik,
Hijyen,
Tekstil

Özet: Bu çalışmada, hazır giyim üretiminde yaygın olarak kullanılan dikiş çeşitleri arasında antibakteriyel etkinlik bakımından farklılık olup olmadığı araştırılmıştır. Böylece enfeksiyon gibi tehlikeli durumların varlığında hijyenin önemli olduğu ortamlar için en uygun dikiş çeşidine karar verilmesi hedeflenmiştir. Bu amaçla, çeşitli dikişlerin antibakteriyel aktivitesi ASTM E2149 standardı çerçevesinde tespit edilmiştir. Çok kullanımlık klinik önlüklerde kullanılan 65% polyester – 35% viscon karışımlı ağartılmış alpaka dokuma kumaşa antibakteriyel etkinliği olan ve olmayan dikiş iplikleriyle 3 iplik overlok + zincir dikiş, kot dikişi ve 5 iplik overlok dikişleri olmak üzere 3 farklı dikiş uygulanmıştır. Bulgular değerlendirildiğinde dikiş çeşidine göre anlamlı bir farklılık olmadığı belirlenmiştir.

1. Introduction

Microorganisms such as bacteria, viruses, fungi and yeasts are present almost everywhere (on the body, air, soil). Inanimate and common surfaces in hospital areas are metal, glass, plastic, ceramics, and textiles. In the medical, technical, industrial, home furnishing and apparel sector, some of the textiles finishing processes include antimicrobial aiders. When conditions are proper for microbial growth, microorganisms could easily multiply exponentially. Antibacterial clothes are preferable in food or health sectors; i.e. multi-use clinical coats, linens for hospitals, etc. since hygienic conditions are very important. The literature illustrates healthcare textiles, including uniforms or apparel, as a vector for transmission of microorganisms that cause infections and illnesses, patients and the community [1]. Antibacterial fabrics are important not only in medical applications but also in terms of daily life usage. Therefore, textile finishes with added value particularly for hygienic clothes are genuinely appreciated and there is an increasing demand on the global scale. The antibacterial materials like fabrics, clothes are become important to avoid cross-contamination by pathogenic microorganisms, especially bacteria such as *Staphylococcus aureus*, *Escherichia coli* and *Klebsiella pneumoniae*, to restrict the uncontrolled growth of bacterial population and

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to destruct metabolism in microbes (to cut odour formation). *E. coli* is also considered a potential pathogen and resides mainly in the small intestine. However, it can also be found in the inguinal and perineal areas contaminated by urine and feces [2]. Cloths for medical and hygienic use have become important in the textile industry. There are many studies on the association between microorganisms and fabrics, and it is clear that microorganisms can survive on pieces of stuff. People come into contact with Coliform bacteria at various sources sites. It appears that Coliform bacteria can survive on fabrics longer than the values mentioned in earlier studies [3]. Previous papers concluded that apparel is often contaminated with micro-organisms or pathogens that can cause infections or illnesses. There are various studies in the literature on antibacterial containing cloth materials, their safety, sufficiency, etc. Many parameters affect the antibacterial activity of the new textiles developed; application method, materials, used fabric structures, exposed surfaces, environmental conditions (light, temperature, period, etc.) [3-7]. In the apparel industry, there are 3 main stitch types and other methods developed from these types. In order to produce novel products, there is not any common comment about the effect of stitch type on antibacterial activity of fabrics. Due to stitch type, fabric layer thickness, amount of yarn used, stitch volume and densities could vary unpredictably. These parameters may affect antibacterial activity. The studies in the literature were about the examination of the antibacterial properties of the fabric or sewing thread. Differently, in this study, the effect of stitch types of the fabric on the antibacterial property was investigated. The critical focus of this study was the determination of the effect of stitch type on bacterial growth and additionally, determination of most effective stitch type for lowering bacterial growth (if it exerts an antibacterial effect).

2. Materials and Methods

2.1. Materials

Multiuse clinical coats are used widely used in many places, beside hygiene required sectors i.e. medical, food. The garments used in laboratory coats possess diverse characteristics. In this study, a widely used white coat garment was focused on. These garments do not maintain antibacterial activity, bleached previously, comprising 65% polyester – 35% viscon mixture which named as alpaca weave fabric. Fabrics have 202.7 gr/m^2 weights, 22 threads/cm warp density, 19.8 threads/cm weft densities and fabric texture is (1x1) plain weave. Stitches were performed with 24 Tex (yarn counts), 120 tkt (ticket number), having same twist count polyester Core Spun yarns.

In recent years, many antibacterial materials have been developed targeting the textile industry. These materials exhibit many differences, according to their chemical structure, working mechanisms, adhesion characteristics, resistance to external effects. Their price and interactions with microorganisms, effects on people and the environment also may vary. The most common active ingredients in antibacterial applications are triclosan, quaternary ammonium salts, and heavy metals i.e. Ag, Cu, Zn, etc. [8-9]. Antibacterial yarns, used in analyses, were treated with zinc. Table 1 shows the chemical composition of yarns in form of Material Safety Data Sheet (MSDS).

Table 1. The chemical content of the antimicrobial yarn

Active ingredient	% Rate
Zinc. 2-pyridinethiol-l-oxide	48
Non-active substance	52
Total	100

In the scope of material surface preparation processes, stitches widely used in apparel production were applied; those were 3-5 thread overlock, chain stitch and seam margin. Stitch density was set constant. Repetitions of trials were applied in the same machine with the same settings. Stitch density of fabrics is 3 stitch/cm. Yarn and stitch samples used in the study are listed in Table 2 according to their codes.

Table 2. Stitch types

Sample Code	Stitch types	Yarn Types
A1	3 thread overlock + chain stitch (504+101)	antimicrobial yarn
N1	3 thread overlock + chain stitch (504+101)	normal yarn
A2	5 thread overlock (516)	antimicrobial yarn
N2	5 thread overlock (516)	normal yarn
A3	Lockstitch (301, Lap felled seam)	antimicrobial yarn
N3	Lockstitch (301, Lap felled seam)	normal yarn

The fabric was assessed for its antibacterial activity according to the method, ASTM E2149 [10]. Stitched fabrics used in sewing aprons were sampled in form of 2 x 2 cm square shapes. While cutting materials for taking samples, surfaces with a dense amount of stitches were preferred. In Figure 1, stitched materials and square cut fabric samples were shown.

In analyses, to observe microbial growth Escherichia Coli (gram (-) bacteria; RSHM # 4024) was selected. E.coli is a fecal coliform bacteria. Coliform bacteria are frequently used as indicator microorganisms, showing presence fecal contamination within the material (resulting from unhygienic preparation conditions or insufficient sanitary procedures) [11].

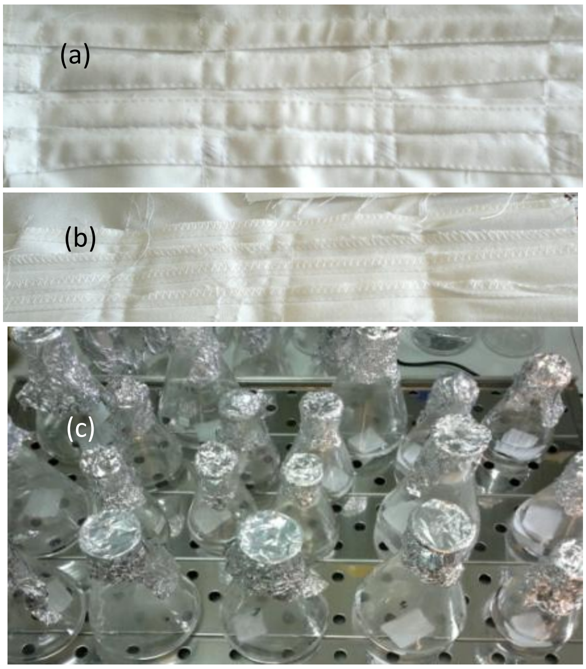

Figure 1. Stitched fabrics (a,b) and square cut samples incubated in Erlenmeyer flasks (c) and at a thermal shaker

2.2. Methods

Various analysis methods are used for the determination of antibacterial activity of textile products. In the study, analyses were performed within the framework of standard ASTM E2149. This test method was developed to detect the resistance of antibacterial treated fabrics against microbial growth under dynamic conditions. The reason for selecting dynamic shake flask method in this study is for antibacterial stitches are in fabric samples.

Foil wrapped samples, and glass materials were sterilized in an autoclave at 121°C and 1.5 atmospheric pressure for 15 min. Antibacterial incorporated fabric sample, sample (having definite antibacterial activity), and non-treated fabric sample were tested all together.

Trials were replicated three times. Fabrics were held in KH_2PO_4 buffer solution rather than a broth medium. *E. coli* bacteria were diluted 10^5 fold in appropriate dilution liquids. The numbers of bacterial colonies were adjusted with the help of Mc Farland. Dilutions were made with 0.1% peptone solution. 50 ml buffer solution (KH_2PO_4, Potassium di-hydrogen phosphate) was used for pH stabilization. Reliability of the dilution was checked with Mc Farland device. The cell concentration of bacteria for this work was 0.5 CFU/ml (colony forming units per one microliter) which is equal to 2.5 x 10^7 CFU *E.coli* / ml. 2 x 2 cm cut stitched samples were inoculated with 10^5 CFU/ml (500 µl densities) inoculum (*E.coli*). Flasks were incubated in a shaking incubator at 37°C/100 rpm/1 h. Broth media was prepared with Spread Plate method. Inoculation was done onto Nutrient agar and Soy agar media in sterile dishes. 100µl liquor was taken with Automatic Micropipette (Finn Pipette, Thermo Fisher, USA) from Erlenmeyer flasks containing fabric samples in 10^5 CFU *E.coli*/ml solution and inoculated onto dishes.

Disk diffusion method was used for antimicrobial susceptibility test (adapted from ASTM 2149 standard and the method used by Bauer et al. 1966). Method's principle was based on evaluating the area of clear zones proving the presence of inhibitory substances preventing microbial growth on media (because of releasing the antibacterial component) [12].

Petri dishes were incubated under aerobic conditions at 37°C for 24 hours. The flasks were put back into the incubator and incubated at 37°C at 100 rpm for 24 hours. 100µl liquor was taken from 24 h incubated solution and inoculated onto dishes. As follows, the growth of bacteria after 24 hours was checked. Petri dishes were incubated for 1 hour and 16-24 hours (overnight), as stated in the standard, and microbial growth was observed. Cut fabric samples taken from Erlenmeyer flask and incubated at 37°C 24 h on dishes.

3. Results

E. coli inoculated on the surface of fabrics those stitched with ordinary and antibacterial yarns, and bacterial growth on those fabrics observed and compared with each other. After, 1-hour incubation in a shaking incubator, there was no significant bacterial growth. After 24-hour incubation, bacterial population extremely increased and reached to uncountable amount; i.e. for the appearances of the overlock stitched samples after 1 hour and 24 hours incubation, see Figure 2.

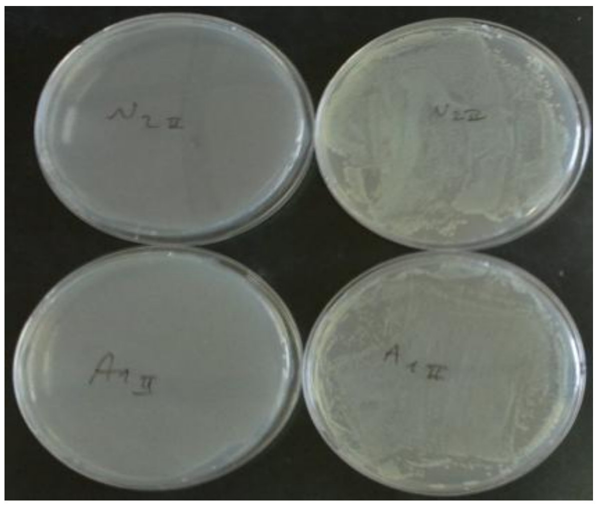

Figure 2. Petri dishes inoculated with *E.coli* after 1 hour (left) and 24 hours (right) incubation.

There was bacterial growth on fabrics -*with both ordinary and antibacterial stitch yarns*-, but the growing population was higher in ordinary stitched clothes (Figure 3).

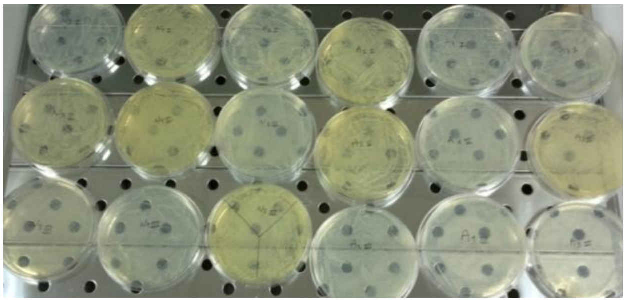

Figure 3. Bacterial growth on Petri dishes (Observed after 24 h incubation)

To detect the presence of bacterial colonies on surfaces, fabrics were removed out of flasks and placed on agar media. Microbial growth was observed on stitched square fabric samples. In antimicrobial effectiveness test in solid media, presence of zones (inhibitory area for microbial growth around antibacterial loaded disc/fabric) proves the inhibiting the effect of the antimicrobial stitches. According to results, no clear zones were observed around antibacterial stitch yarns. So, there is not any significant evidence showing the preventive effect of antibacterial stitches on microbial growth. Numbers of bacteria colonies were very dense and uncountable; as a result, any statement on the effectiveness of different stitch types on antibacterial activity could not be concluded. In all samples, bacterial growth was very high and uncountable. That's why; results did not compare in a mathematical way and did not present in tables or plots.

Stitch types affect growth the pattern of microorganisms on Petri dishes. The differences in growth appearance were sourced from the surface property of the fabrics (the pressure within fabric and stitches) and were not related with an antibacterial property of the stitch yarns, see Figure 4.

The growth of bacteria on fabric surfaces proved the suitability of textile surfaces for bacterial growth.

4. Discussion and Conclusion

There are various studies on antibacterial textiles and products offered to the market, having a limited shelf life and antimicrobial effect. In this study, the effect of different stitch types used in cloth manufacture was investigated. Unlike other researches, this study was focused on cloth and yarn analyses. That's why; ASTM E 2149 method was modified for this study. It was confirmed that bacteria and active antibacterial component were effectively transferred into solution with shaking. Results of analyses proved the growth of *E. coli* on fabrics. The components of cloth structure; fabrics layer and the amount of yarn of the sewing types show the difference. The high amount of yarn and layers of the stitches in the fabric may create a suitable environment for the growth of

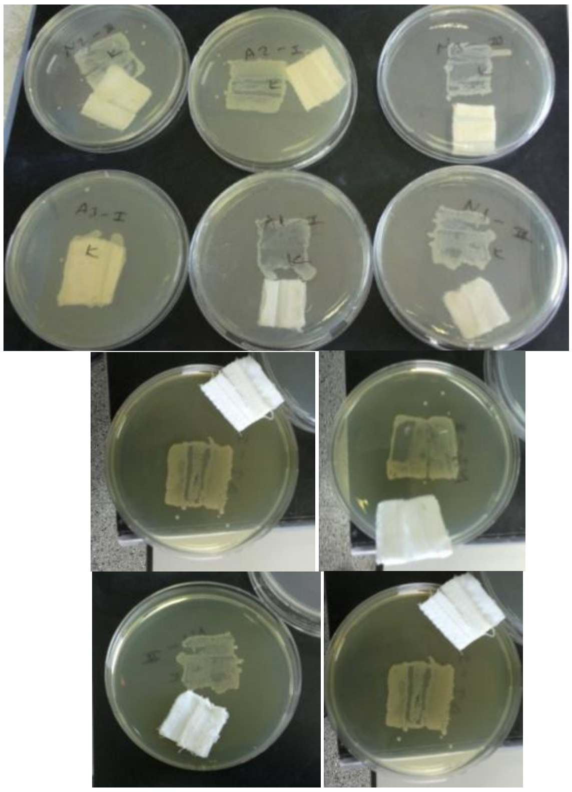

Figure 4. *E.coli* growth on 2x2 cut fabric samples.

bacteria. For this reason, it will be useful to determine the type of stitching that can provide the best hygiene with its structure and shape. Initially, it was aimed to compare stitch types in terms of their antibacterial activity, but in all samples, there was an excess amount of bacterial growth preventing microbial count. That's why any comparison or sorting did not apply between samples. As a result, it could be concluded that any significant difference was not observed in antibacterial properties of stitch types used in this study (within conditions/dilutions applied).

Excess microbial growth might be arising from the insufficient concentration of the active antibacterial components in yarns. Different from the standard method, the effect of stitches in ordinary fabrics was also investigated. It was concluded that bacterial growth might be sourced from a dilute concentration of the active antibacterial components (lower than standard amount) on stitches of fabric. Because the applied standard was about the detection of the antibacterial property of the fabrics. The standard used for the square cut fabric samples and, there is not a standard in literature for investigation of antibacterial activity of stitch yarns on fabrics. It is estimated that antibacterial components will effectively be transferred into solution with shaking and by the time would inhibit the growth of bacteria in buffered solution. Since the fabric samples -in all types of stitches- contain less amount of yarn on the fabric (compared to the target antibacterial fabrics of the standard method), it could be concluded that the amount of applied antibacterial component does not allow evaluation of the antibacterial property. This unexpected result may be explained in long-term and more detailed next coming studies by advanced modified or with a novel experimental method. It is predicted that the level of antibacterial activities within stitch types would be sensitively differentiated with the newly adopted test methods.

Antibacterial stitches could be applied to fabrics during the preparation of samples. However, more detailed analyses need to be done to detect the effect of different stitch types.

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