(REFEREED RESEARCH)

INVESTIGATING THE EFFECTS OF DIFFERENT SOFTENERS ON PILLING PROPERTIES AND DURABILITY TO WASHING OF BAMBOO KNITTED FABRICS

BAMBU ÖRME KUMAŞLARDA FARKLI YUMUŞATICILARIN PİLLİNG ÖZELLİKLERİ ve YIKAMA DAYANIKLILIĞI ÜZERİNE OLAN ETKİLERİNİN İNCELENMESİ

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ABSTRACT

Fuzzing and pilling problems are one of the main problems of knitted fabrics. The softeners have various effects on pilling resistance of the fabrics. The aim of this study is to investigate systematically the effect of different softeners on pilling property of bamboo knitted fabrics. Furthermore, the washing durability of the used softeners after 5, 10 and 20 washing cycles was also examined. For this purpose, firstly 100% bamboo knitted fabrics were produced. After the fabrics were pre-treated and dyed, seven different softeners were applied to these fabrics by padding method. Then, all untreated and treated fabrics were laundered in Wascator. Washed cycles were being selected as 5, 10 and 20. In conclusion, it was found that the softeners generally decreased the pilling formation on bamboo knitted fabrics and the effect of softeners was positive. Among the softeners, before washing Softener S4 (cationic softener) and Softener S6 (mixture of carbamino derivative and micro silicone) were the best. The multiple washings caused increases in pilling formation due to the intensive mechanical effect during laundering on bamboo knitted fabrics.

Keywords: Bamboo, Softener, Pilling property, PillGrade

ÖZET

Havlanma ve boncuklanma problemleri, örme kumaşların başlıca problemlerinden birisidir. Kumaşlardaki boncuklanmayla ilgili olarak yumuşatıcıların çeşitli etkileri bulunmaktadır. Bu çalışmanın amacı, bambu örme kumaşlarda farklı yumuşatıcıların boncuklanma özellikleri üzerine etkisini sistematik bir şekilde araştırmaktır. Ayrıca, 5, 10 ve 20 kez yıkamalardan sonra kullanılan yumuşatıcıların yıkamaya karşı dayanıklılıkları da incelenmiştir. Bu amaçla, öncelikle % 100 bambu örme kumaşlar üretilmiştir. Ön terbiye işlemleri ve boyamadan sonra yedi farklı yumuşatıcı emdirme yöntemiyle kumaşlara aktarılmıştır. Daha sonra, tüm işlem görmemiş ve işlem görmüş kumaşlar Wascator'de yıkanmıştır. Yıkama döngüleri 5, 10 ve 20 olarak seçilmiştir. Sonuç olarak, yumuşatıcıların genel olarak bambu örme kumaşlarda boncuk oluşumunu azalttığı ve yumuşatıcıların etkisinin olumlu olduğu bulunmuştur. Yıkama öncesinde yumuşatıcılar arasında yumuşatıcı S4 (katyonik yumuşatıcı) ve yumuşatıcı S6 (karbamino türevi ve mikro silikon karışımı) en iyi sonuçları vermiştir. Bambu örme kumaşlarda yıkama sırasındaki yoğun mekaniksel etki sebebiyle çoklu yıkamalar, boncuk oluşumunda artışa sebep olmuştur.

Anahtar Kelimeler: Bambu, Yumuşatıcı, Boncuklanma özelliği, PillGrade

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1. INTRODUCTION

Bamboo fiber is obtained from the bamboo plant, which is an abundant and cheap natural resource. Bamboo, as a regenerated cellulosic fiber, is being more widely used in the textile industry due to its features such as being antibacterial, soft feeling, easy dyeability, proper moisture absorbency, breathability and having a smooth texture. This fiber has wide prospects in the field of hygiene products, medical suppliers, such as wet wipe, household wipes, sanitary napkin, medical bandage, disposable sheet, inside lining, base cloth, nonwoven textiles, nano technological products. Furthermore, it is the 100% biodegradable textile material which does not cause any environmental pollution naturally recycling itself. In this sense, it is praised as the new environmentally friendly textile material (1-3).

Products of knitted fabric are characterized as being elastic, resilient, and soft, they have good draping properties, and cling well to body to inhibit movement. However, during using, pills form on the surface of the knitted fabric, remaining on the surface of the product and worsening its exterior. The development of pills on a fabric surface, in addition to spoiling the original appearance and hand, initiates garment attrition and reduces serviceability. Pilling is preceded by fuzz formation. Pilling is defined as the entangling of fibers during washing, dry cleaning, testing, or wearing to form balls or pills that stand proud of the surface of a fabric. The process of formation of pills consists of three stages: Firstly, due to mechanical impact to the surface of rasped products, the tips of several fibers of fiber are pulled out creating a fuzzy surface. Secondly, broken fibers grip to felt tips and forms separate, gradually growing pills. Later, fibers holding these pills are griped strongly, however, due to the further mechanical impact (attrition, washing and other) they may run away and fall off (4-7).

Fabric pilling is influenced by a variety of factors. These factors are fiber type and cross-sectional shape, yarn type and construction, and fabrication type. Fabric finishes also play an important role in pilling by affecting some of these textile parameters. For example, singeing and thermosetting reduce fabric pilling and have been used for many years to minimize pilling in fabrics. Moreover, the softeners may cause to change pilling property (8,9).

Softening is one of the most common finishing treatments. In different commercial types of softeners, applications are available with different concentration and proportions of ingredients such as amphoteric, anionic, cationic, non-ionic and silicone softeners (10,11,1).

The hydrophilic parts of the **cationic softener** contain quaternary ammonium, which adsorb readily on negatively charged fiber surfaces. The long aliphatic chains are then oriented towards the outside of the fiber and act as excellent boundary lubricants between yarns and fibers. **Anionic softeners** have nowadays only a very limited use in textile processing, due to their low substantivity and minor softness. Some examples of their uses include raising and sanforizing processes, which result in improved smoothness/antistatic and rewetting properties, respectively. **Non-ionic softeners** theoretically have no electric charge and for that reason show no significant substantivity. They can easily be combined with other active agents or products, are stable against high temperatures and are non-yellowing. For that reason, this product group is ideal for the finish of optically-brightened white textiles (12,13). **Silicones** were classified as a separate class of man-made polymer more than 50 years ago. The better performance of siloxanes is due to their extremely flexible backbone structure, high heat stability, and reduced friction. Silicones are polymers with backbones that consist of alternating oxygen and silicon atoms. Nowadays, micro emulsion and macro emulsion silicones are used widely. While macro-silicone has milky white appearance and its particle size is between 150 and 300 nm; micro-silicone has clear and transparent, its particle size is below 40 nm (11,14,15,1).

As the literature reviewed, it can be stated that many textile scientists have made valuable contributions to objective assessments of fabric pilling. However, there is not a comprehensive research, which includes, such as cationic, non-ionic, anionic and silicone softeners on the bamboo fabrics especially the effect of softeners on pilling problem of bamboo knitted fabrics (13,15,16,17,18,19,20,21). Therefore, the importance of this study is to investigate systematically the effect of different softeners on fuzzing and pilling problems of bamboo knitted fabrics. Furthermore, the washing durability of the used softeners after 5, 10 and 20 washing cycles has been also examined.

2. MATERIAL and METHOD

In this study, 100% bamboo yarns in Ne 30 yarn count and in α_e= 4 twist coefficient were used. They were knitted in interlock structure in the same density (27 wpc and 15 cpc) by using the FOUQUET 18E gauge knitting machine in Textile Engineering Department of Ege University.

After the bamboo fabrics were pre-wash and reactive dyed, seven different softeners were applied to these fabrics by padding method. For impregnation, Rapid Model PA-1 marked laboratory padder was used and for drying, Ataç GK4 marked laboratory stenter was used. Table 1 indicates the codes and chemical structures of used softeners and the application recipes.

After the applications, the untreated and treated samples were washed at the Wascator machine according to ISO 6330 standard (5A program) and dried by lying. The washing cycles were selected as 5, 10 and 20.

Before the tests, the fabric samples were conditioned under standard atmosphere conditions (20°C±2°C temperature, 65%±4%RH). Afterwards, the parameters of pilling were measured.

Pilling Test

Pilling test was conducted according to EN ISO 12945-2 (2.000 cycles) standard by Martindale instrument (Figure 1).

The Martindale Pilling and Abrasion Tester is primarily designed to determine the abrasion resistance of textile fabrics. Fabrics of all types may be tested by this method, including woven, non-woven, and knitted fabrics, household fabrics, industrial fabrics, and floor coverings. Abrasion resistance is measured by subjecting the specimen to rubbing motion in the form of a geometric figure. Resistance to abrasion is evaluated by various means, including comparison to visual aids in the form of photographs or actual samples (22).

In this work, after the fabrics were pilled by using Martindale instrument, the fabric surfaces were evaluated by using PillGrade system.

PillGrade System

The PillGrade system is an automated pilling grading system developed to provide objective and repeatable pilling assessment in compliance with both ASTM and ISO test methods. It detects, measures, and grades pills by scanning the specimen's horizon as the specimen is rolled over a rotating drive rod. By scanning the horizon of the fabric, the height of each pill can be measured, fuzzing can be measured, and fabric patterns and weave/knitted structure is disregarded. Figure 2 shows the fabric specimen rolling over the drive rod while the video camera captures the video images.

The fabric specimen runs through the rollers at a speed of about 1"/second (25 mm/sec). While the specimen runs through the rollers, the camera takes video of the fabric at a rate of 30 frames per second. So if the specimen is 4" (25 mm) in length, the camera will capture a total of 120 video frames of the specimen as it runs through the rollers.

Figure 1. Martindale Pilling and Abrasion Tester (22)

Table 1. The codes and application recipes

Code	Softener type	Recipes
UT	Untreated fabric (only pre-treated and dyed fabric)	-
S1	Micro-dispersed poly-amino siloxane	30 g/l, pH: 5.5-6 (Acetic acid)
S2	Macro-emulsion of elastomeric poly-amino siloxane	30 g/l, pH: 4.5-5.5 (Acetic acid)
S3	Nano-emulsion of elastomeric polyaminosiloxane	30 g/l, pH: 4.5-5 (Acetic acid)
S4	Cationic softener, Carbamide derivative	30 g/l, pH: 4-5 (Acetic acid)
S5	Nonionic softener, Polyethylene emulsion	30 g/l, pH: 6-7 (Acetic acid)
S6	Mixture of carbamino derivative and micro silicone	30 g/l, pH: 4.5-5 (Acetic acid)
S7	Mixture of carbamino derivative and macro silicone	30 g/l, pH: 4.5-5 (Acetic acid)
Impregnation conditions: Pick up value: 75% Drying: 130ºC for 3 min.		

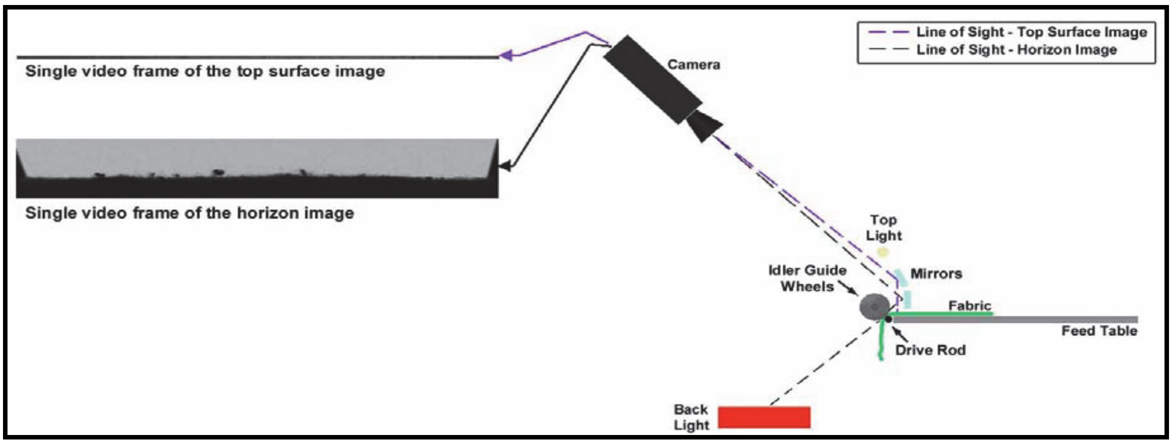

Figure 2. Schematic view of the measuring principle of PillGrade system (23)

Every 1/30th of a second, the camera takes a single video frame. As shown above, two mirrors at different angles allow the camera to capture simultaneous images of both the horizon image and a slice of the fabric's top surface within each single video frame. By stitching together all of the video frames that are captured while the specimen runs through the rollers, a complete 3D topological map of the specimen is scanned into the PillGrade system.

After scanning the entire specimen, PillGrade analyzes each of the horizon images to detect and measure the pills, and then plots each pill's XY location on the graph display using semi-circular markers color-coded by pill size, as shown in the figure below. Also, by stitching together each of the top surface images (as explained above), PillGrade also displays the surface scan of the specimen (Figure 3).

After scanning the specimen and detecting and measuring each and every pill in the center area of the specimen, PillGrade uses the PillGrade Grading system from 1.0 to 5.0 (1.0 means excessive pilling, 5.0 means no pilling).

The definitions of the results are given below:

Pill Density: Total number of pills in inspection area / total size of inspection area.

Pill Count, Total number of pills in inspection area.

Pill Count, Weighted: Using a logarithmic scale, each pill is mathematically weighted according to its size, where the largest pills (>Ø3.9mm) are multiplied by a factor of 5.0 and the smallest pills (<Ø0.3mm) are multiplied by a factor of 0.6.

Fuzz Loft: The height of the dense layer of fabric fuzz, disregarding the single strands of fuzz sticking up out of the denser layer of fuzz.

Weighted Pill Density: Total number of weighted pills in inspection area/total size of inspection area.

Avg. Pill HC Diam: (Average Pill Height-Compensated Diameter.) The average "size" of all the pills is in the inspection area. Because a pill is much more apparent if it rests higher up on a layer of fuzz, PillGrade uses a height-compensated pill diameter to measure the size of each pill (23).

All fabrics were assessed after Martindale pilling test. However, in order to determine the effect of washing and softeners, fabrics not tested in Martindale, were also assessed by using PillGrade instrument for their fuzz loft properties.

3. RESULTS AND DISCUSSION

Evaluation of Pilling Degree

Figure 4 illustrates the pilling degrees of untreated and treated bamboo fabrics.

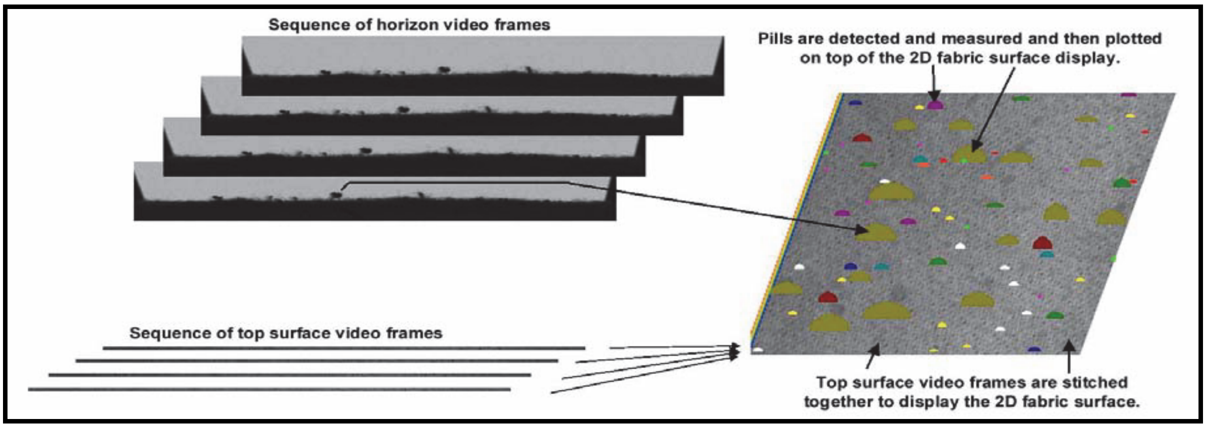

Figure 3. The view of surface scanning on PillGrade system (23)

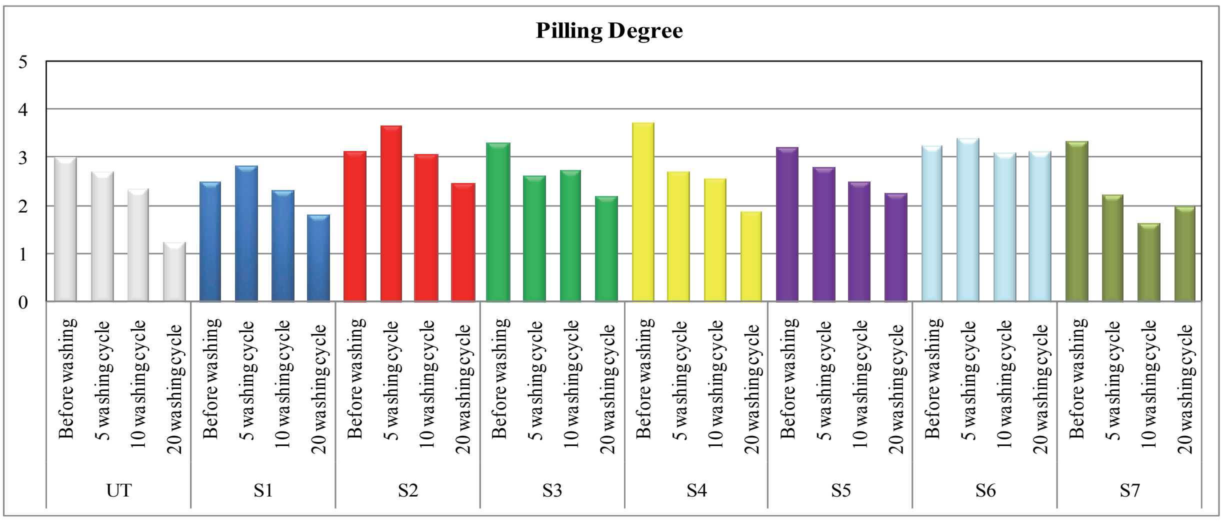

Figure 4. Pilling degrees of the fabrics

Before washing, compared to the pilling degrees of all fabrics, the softened fabrics exhibited lower pilling tendency. Most of softeners gave high pilling values. It means that the effect of softeners is positive and they can prevent the pilling formation. As the softener type was evaluated on the unwashed fabrics, it can be said that softeners generally decreased the pilling formation. Especially, the pilling degree of fabric treated with softener S4 (cationic softener) was higher (lower pilling tendency) than that of other softeners. The reason of this result could be the changing of the fabric surface thanks to the cationic softener. The cationic softener gave to the fabric surface more slippery and softness.

The pilling degree did not decreased so much on the treated fabrics with softener S6 after washings. It means that softener S6 (Mixture of carbamino derivative and micro silicone) was durable to washing and prevented the pilling formation. It is thought that this is due to the synergistic effect of micro silicone and carbamino derivative.

While the number of washing cycles increased, the pilling formation except S6 rose as well. After 20 washings, the pilling formation was the maximum. It is thought that multiple washings caused increases in pilling formation due to the intensive mechanical effect on bamboo knitted fabrics.

Evaluation of Average Pill Height

Figure 5 shows the average pill heights of untreated and treated bamboo fabrics.

Figure 5 shows that there are no significant differences between untreated and softened fabrics. The average pill height values (mm) of the fabrics were between 0.8 and 1.3 mm. After washing processes, average pill height values did not change significantly for all fabrics. As the softener type was evaluated, there are no important differences between softeners. While the number of washing cycles changed, there was no stable tendency on average pill height value.

Evaluation of Weighted Pill Density

Figure 6 demonstrates the weighted pill densities of untreated and treated bamboo fabrics.

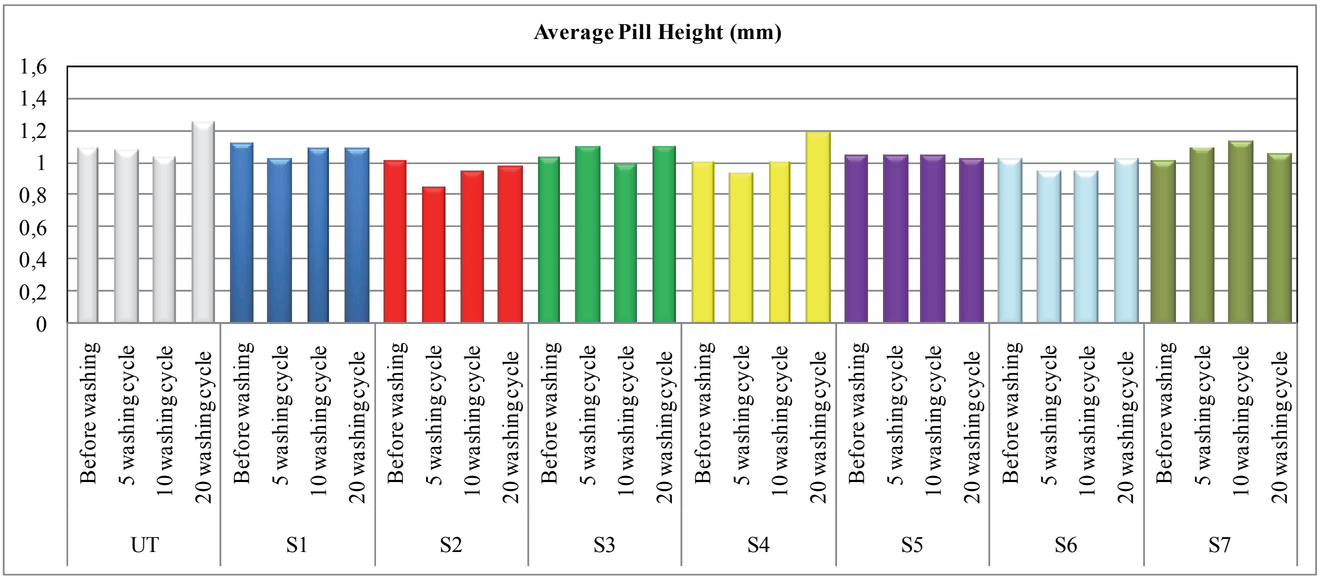

Figure 5. Average pill height values (mm) of the fabrics

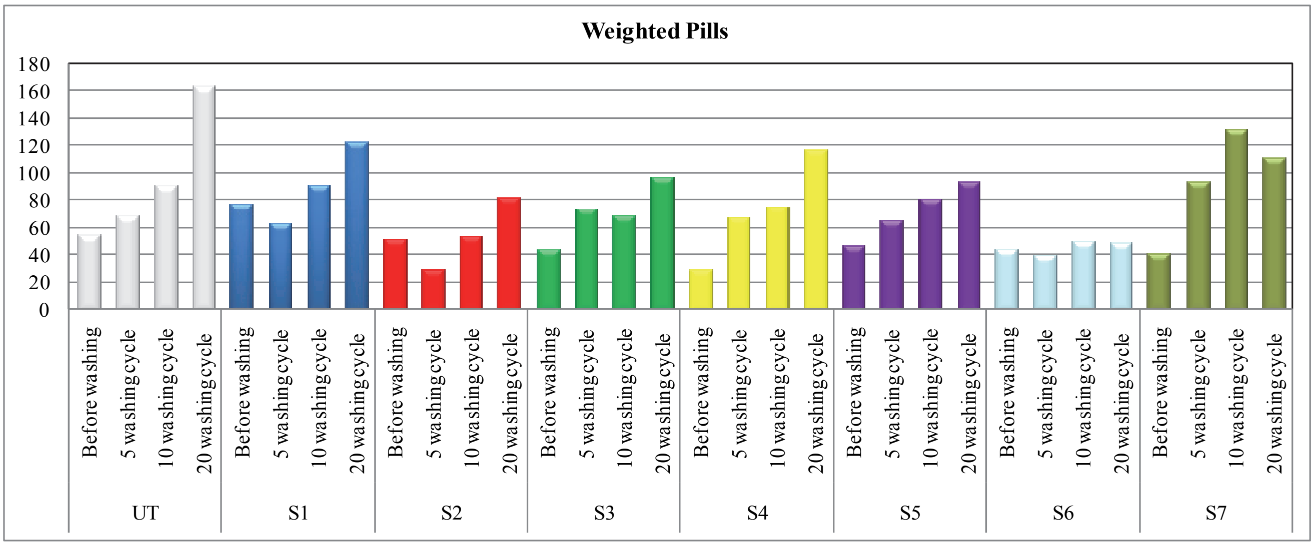

Figure 6. The weighted pill densities of the fabrics

As evaluated Figure 6, the positive effect of softeners can be seen obviously. The numbers of weighted pills of untreated fabrics were higher than that of softened fabrics. Particularly, the numbers of weighted pills of softened fabrics with softener S6 were lowest. While the number of washing cycles rose, weighted pill density increased greatly as well. As washing cycles were 20, weighted pill density was highest for all fabrics.

Evaluation of Fuzz Loft

Figure 7 shows the fuzz lofts of untreated and treated bamboo fabrics.

The fuzz loft values of untreated fabrics were higher than that of softened fabrics. The softeners had positive effect. After 20 washings, softener S6 had the lowest fuzz loft values. There was some fuzz on surface of the fabrics before washing. After washings, this fuzz was moved away from the fabric and the surface of the fabrics became smoother.

4. CONCLUSION

In this study, it was aimed to investigate systematically the effect of different softeners on pilling properties and durability to laundering of bamboo knitted fabrics.

According to the results, the following consequences were obtained;

It was found that the softeners generally decreased the pilling formation on bamboo knitted fabrics and the effect of softeners was positive. Commonly, the multiple washings caused increases in pilling formation due to the intensive mechanical effect during laundering on bamboo knitted fabrics.

Among the softeners, before washing Softener S4 (cationic softener) and Softener S6 (mixture of carbamino derivative and micro silicone) were the best. Compared to the other softeners, Softener S4 and Softener S6 caused in reduce notably fiber-fiber frictions and provided to the yarn surface more slippery and softness. Therefore, these softeners prevented the pilling formation.

Only Softener S6 was more durable to washing. It is thought that this is because of the synergistic effect of micro silicone and carbamino derivative. Moreover, micro silicone penetrates easily into the fibers due to the low molecule size and this softener cannot remove from the fibers during washing.

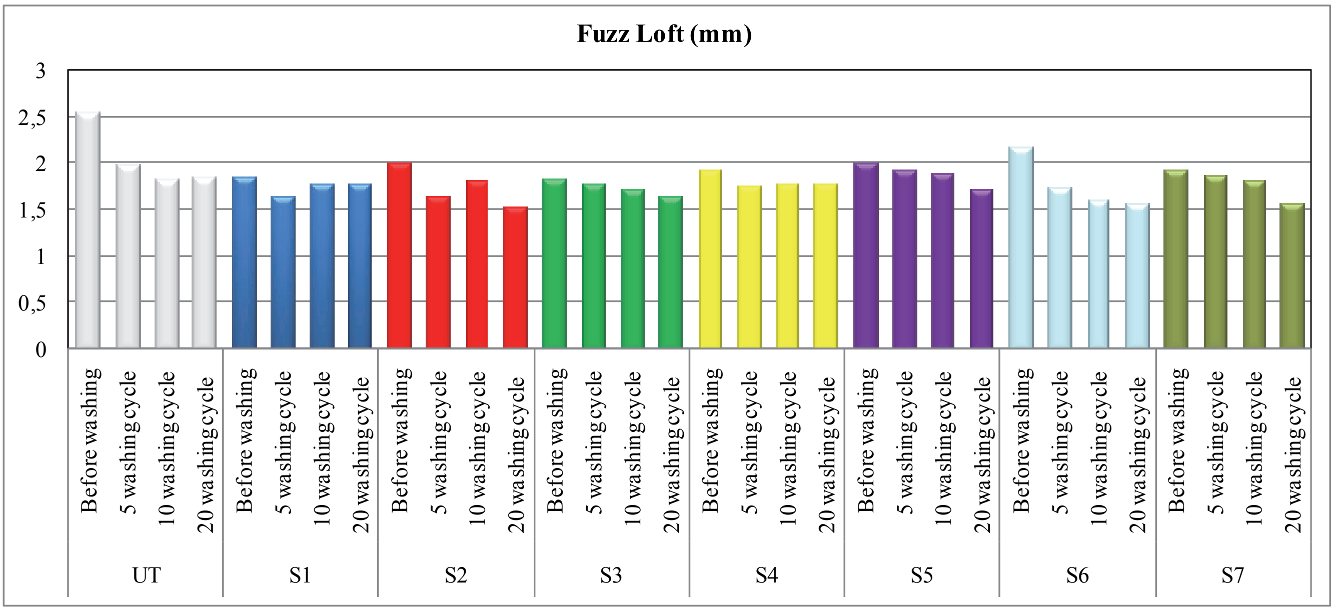

Figure 7. Fuzz lofts (mm) of the fabrics

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