Microbial Damage to Iranian Cotton Fibre (Sahel Variety)

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ABSTRACT

Damages resulting by micro-organisms on Iranian cotton (Sahel variety) with 65–70% relative humidity and 25 °C temperature within four months storage period are investigated. A number of tests are currently available to identify and quantify such cottons called cavatomic. These tests include pH and reducing sugar determinations, microscopy techniques, staining methods and determination of physical changes. Some of these tests have been applied to evaluate possible microbial damage to cotton of Gonbad-Ghabous spring crop. The effects of the micro-organisms growth on the whiteness and dyeability of different samples are also determined. Data and observations totally support the slow growth of the micro-organisms in this variety of cottons.

Key Words: Iranian cotton, microbial damage, cavatomic cotton, physical and chemical properties of cotton

INTRODUCTION

The term cavitoma is familiar for the textile industries and it refers to a cotton which has undergone biological damage. Mostly, the deterioration is not sufficient enough to result in a lowering of the grade of the cotton [1]. This type of damage can occur after boll opening, prior to or after harvest and during the storage of cotton in the gins or textile mills in ginned or unginned forms [2].

In the textile industries, inconvenient storage conditions for cotton loose fibres or final products cause damage by the microorganisms [3]. It means that, the alteration of fibre properties continue during warehouse storage. The subjected cotton fibres lose some of their valuable chemical, mechanical and physical properties such as spinability, dyeability and tensile strength.

The micro-organisms responsible for the damages can be either fungi or bacteria and contam-inate cotton from the soil [4]. They are always present and only proper conditions are needed for their growth [4]. It has been reported that the major requirement for growth is the presence of moisture at a minimum level of about 7% [5].

In Iran, cotton products are the major ones in the domestics market and exports. Most of Iranian cotton crops are produced in Gonbad-Ghabous (North-East of the country) and during the recent years, the production has been more than its internal consumption. It means that, some parts of cotton products are stored in the region before they are used by textile mills. In order to evaluate the changes which occur in this cotton, we have simulated the

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climate of that region and the changes on three different grades of cotton, in ginned and unginned forms, caused by micro-organisms are investigated.

EXPERIMENTAL

Materials

All chemicals used were of analytical grades except Congo Red, Chlorantin Fast Green BLL and non-ionic detergent which were commercial. We verified the reflection by Texflash, tensile strength by Pressley Bundle Tester, length by Spinlab 530 (a digital fibrograph). We also used the Ahiba 1000 laboratory dyeing machine for dyeing of cotton samples.

Methods

Preparations of Cotton Samples

Three different types of cotton samples named *strict middling white*, *middling white* and *strict low middling white* were selected in ginned and unginned forms, soon after harvesting. In order to simulate the weathering conditions, they were put in an autoclave which its humidity was controlled to 70–75% by putting four 500 mL bakers of saturated solution of sodium nitrate [6]. The temperature was adjusted within 30–35 °C. The conditions were checked every 8 h and continued for 4 months. Every one month, a series of samples were taken from the autoclave. So, four series of samples which were stored for one, two, three and four months were prepared. All conditioned samples were compared with the respective control samples which kept in dry and normal conditions.

Standard Test Methods

A number of test methods have been suggested for determination of the presence of microbial damage in cotton, including pH determination [7, 8] water soluble reducing substances [2, 5, 9–10], staining by Congo Red [11], microscopy [4], alkali centrifuge value [12], colour measurement [2, 3], tensile strength [3], length measurement [5] and dyeability [2].

Measurement of Reflection and Whiteness Index

By using the cotton selector unit, the fibres were cleaned from the impurities. Then, reflectance values of samples were measured by a Texflash spectrophotometer using CIE D_{65} Illuminant and the CIE 1964 10° observer. The 1982 CIE white indexes were measured for all samples [13].

pH Determination

Wakeham and Skau have developed a method which determines the pH at zero dilution on water extracts from the cotton [14]. However, the pH test is unreliable for cotton held in storage for lengthy periods (over 8–10 months) [2].

The modified zero dilution method of Pons et al. [8], was applied.

A cotton sample of 0.5 g was extracted with 10 mL distilled water and the pH was determined electrometrically. The pH measurements were repeated as 2, 4, 6, 8, and up to 20 mL distilled water was added. The curve to zero dilution was extrapolated to obtain the true fibre pH.

Water Soluble Reducing Sugars

The level of reducing sugars on cotton fibres can be determined with a number of methods [2, 5, 9–10]. The method which has been developed for diabetes and relies on the reaction of the reducing sugars with dinitrosalicylic acid (DNS) has been modified for use with raw cotton and is more popular for detection of micro-organisms on suspected cotton fibres [2].

The method described by Marsh and Simpson [9] was used. The transmission of filtered solutions of samples were measured by Spectronic 70 transmission spectrophotometer at 600 nm.

Alkali-Centrifuge Value

The alkali centrifuge value of the samples were determined in accordance by the method specified by Marsh et al. [12].

Congo Red Staining Test

Cotton fibre of 0.1 g weight was treated in 11% caustic soda solution and then dyed for 10 min in Congo Red solution. After washing with distilled water, samples were dried for 1 h in 50 °C and observed by optical microscopy [2, 11].

Microscopy Test
A 20 mL solution of 15% caustic soda was mixed with 20 mL of carbon disulphide thoroughly. Then, 1 g of cotton sample was put into this solution. After 30 min, the swollen sample was moved and observed by an optical microscope [4].

Measurement of Tensile Strength and Length of Fibres
A fibrogram named Spinlab 530 was used to measure the length of the cotton fibres. A zero gauge Pressley tester was also applied by expertise to measure the tensile strength of the fibres. The strength was determined in the form of Pressley Index.

Adsorption Isotherm for Chlorantin Fast Green BLL
An Ahiba 1000 fully computerized laboratory dyeing machine was used to determine the absorption behaviour of cotton samples. One gram sample of *strict middling white fibre* and 1 g sample of *strict low middling white* with the respective control samples were scoured in 0.1% nonionic detergent at the boil for 10 min. Then, the scoured samples were dyed for 24 h at 80 °C, separately. The applied percentages of dyestuff were 1%, 3%, 5% and 10%. The amount of 0.2% of sodium sulphate was added to all dyeing baths. The amount of exhausted dye was determined by the absorptiometry of remaining dye in the bath.

RESULTS AND DISCUSSION

Measurement of Reflection

The colour of the virgin cotton fibres is subjected to the growth of the micro-organisms [15]. Normally, the whiteness of the infected fibres decreases by the growth of micro-organisms.

The reflectance values of the ginned and unginned samples with different storage periods in 550 nm are shown in Figures 1 and 2. Besides, the 1982 CIE white index for the different ginned and unginned samples are given in Table 1.

As Figures 1 and 2 show, the reflectance values of all samples decrease with the extension of storage periods. These results support by white indexes of samples which decrease by storage periods.

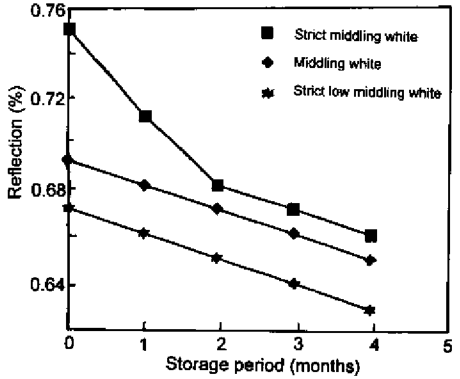

Figure 1. Changes of reflection of different cotton fibres by storage period in 550 nm.

Seventekin and Ucarci have investigated a direct relationship between storage time and change in colour [3]. They concluded to the increase in pigmentation of micro-organisms with time.

pH of the Fibre

Most of the micro-organisms increase the pH of aqueous extracts from the fibres rapidly. This might have been due to the metabolic use of organic acids

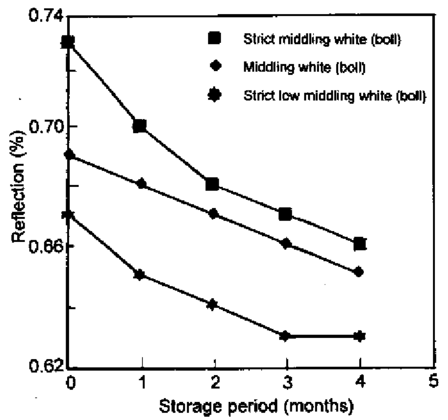

Figure 2. Changes of reflection of different cotton bolls by storage period in 550 nm.

Table 1. 1982 CIE White indexes for control and stored cotton samples, in ginned and unginned forms.

Cotton grades	Storage periods (months)				
	0 (Control)	1	2	3	4
S.M.W (ginned)[a]	28.3	12.9	13.7	11.4	2.3
M.W. (ginned)[b]	25.5	19.6	19.7	15	13.9
S.L.M.W. (ginned)[c]	25.4	18.9	18.7	19.3	12.5
S.M.W. (unginned)[a']	25	14.2	10	9.7	8.6
M.W. (unginned)[b']	27.6	18.9	15.4	15.3	6.2
S.L.M.W. (unginned)[c']	27.2	18.8	20.7	18.3	14.7

(a) ginned strict middling white; (b) ginned middling white; (c) ginned strict low middling white; (a') unginned strict middling white; (b') unginned middling white; (c') ginned strict low middling white

(probably malic acid) by the micro-organisms [2].

Figures 3 and 4 show the changes of pH of cotton samples within the storage periods. The pH values of all cotton samples increase with time which can indicate the growth of micro-organisms in cotton samples.

Water Soluble Reducing Sugar (DNS Indicator)

The growth of microbial damage to cotton has been dealt with the decrease in the level of the reducing substances on the surface of the cotton [5, 10]. These substances are thought to be mainly sugars and the reduction in the sugar content can be considered as the utilization of the sugars during the growth of micro-organisms on the fibres [10]. It is important to consider that, the leaching by rain can also reduce the sugar content of the cotton fibres [2].

DNS values of different cotton samples stored for different lengths of time are shown in Figures 5 and 6 for ginned and unginned fibres, respectively. As these figures show, the DNS values of samples decrease rapidly by increasing in storage periods which show the development of micro-organisms in the fibres.

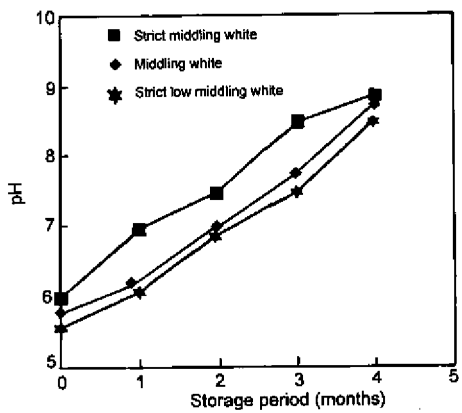

Figure 3. Changes of pH values of different cotton fibres by storage period.

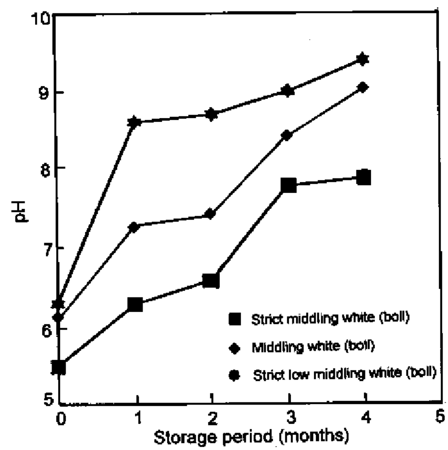

Figure 4. Changes of pH values of different cotton bolls by storage period.

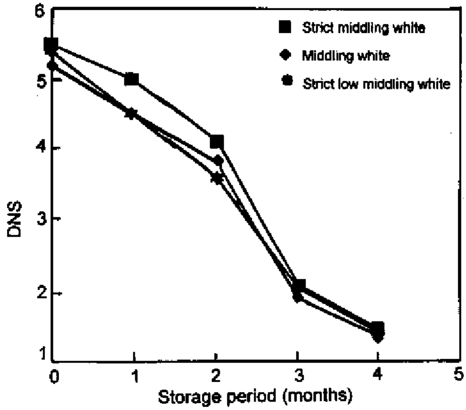

Figure 5. Changes of DNS values of different cotton fibres by storage period.

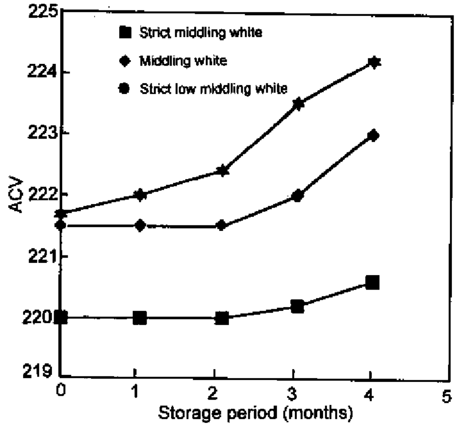

Figure 7. Changes of alkali centrifuge values of different cotton fibres by storage period.

Alkali-Centrifuge Value (ACV Test)

It is thought that during the micro-organisms action, they firstly damage the cuticle and primary wall of the fibre, thus make the secondary cellulose (interior of the fibre) more accessible. So, the alkali-centrifuge value obtained by a gravimetric method and it is based on the differential absorption of sodium hydroxide by fibres, can be employed for determining the level of damages occurred [12].

It should be considered that the results from this test method is a combined measure of the fibre damage and the fibre wall thickness and, therefore, an independent measurement of wall thickness should be done to determine the true damage of the fibre [2].

Figures 7 and 8 show the changes of ACV

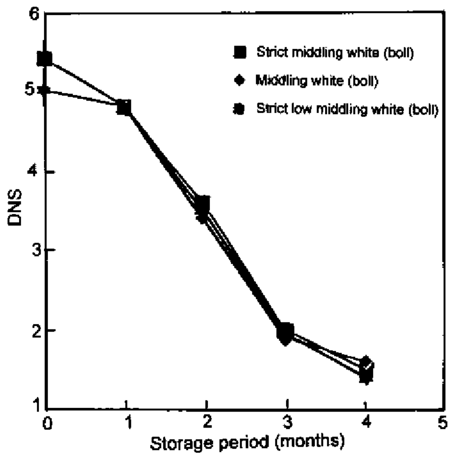

Figure 6. Changes of DNS values of different cotton bolls by storage period.

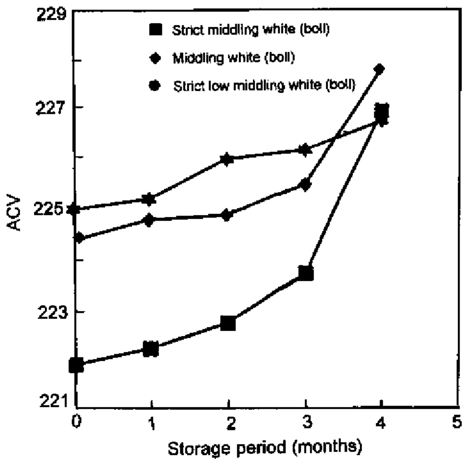

Figure 8. Changes of alkali centrifuge values of different cotton bolls by storage period.

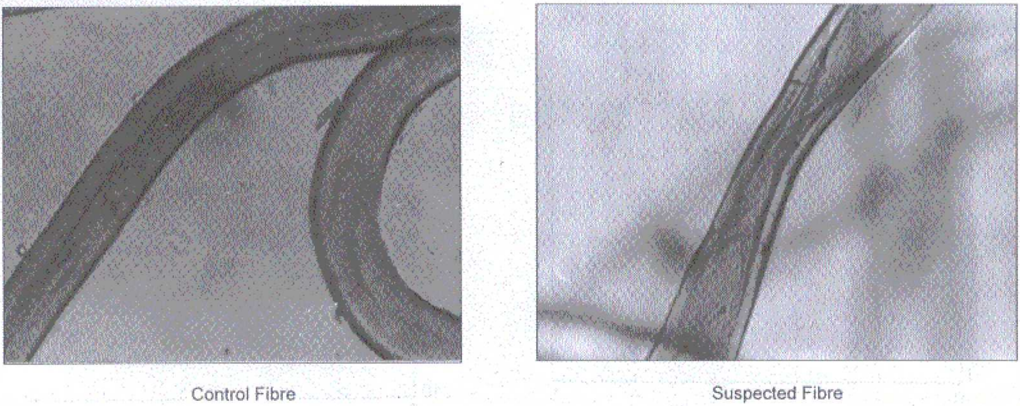

Figure 9. Microscopy images of control and suspected cotton samples stained by Congo Red.

values of different cotton samples during the storage. As these figures show, for the ginned fibres, *strict middling white* cotton has the minimum changes during the storage and the changes is maximum for the *strict low middling white*. Normally, the *strict middling white* has the maximum maturity and minimum impurities. For the unginned samples, the changes of ACV with the storage time is more noticeable due to the existence of more impurities in these samples.

Congo Red Staining Test

This technique is well described in literature [11]. Congo Red does not have any affinity to the cuticle and stains the undamaged cotton to a light pink. On the other hand, the secondary cell wall is more accessible in the damaged cotton fibres, therefore, the Congo Red has a good affinity to the wall and turns it to a bright red. Many of the direct dyes behave similarly but Congo Red possesses the advantages of showing the effect in a well-pronounced manner.

Results from Congo Red staining test are given in Figure 9. The difference in degree of staining, more

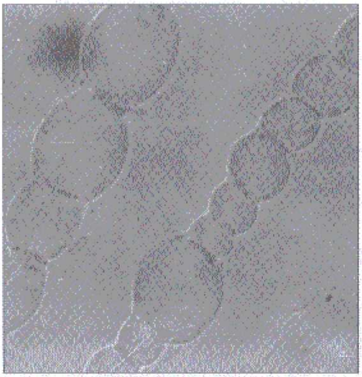

Figure 10. Microscopy image of cotton sample.

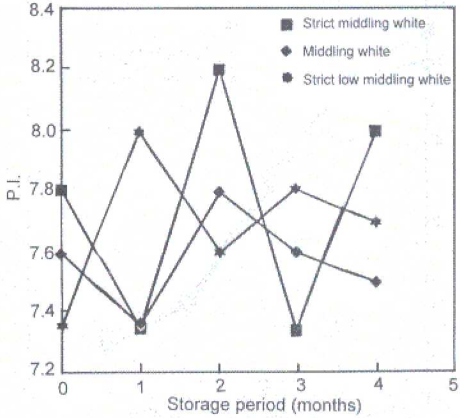

Figure 11. Changes of Pressley Indexes of different cotton fibres by storage period.

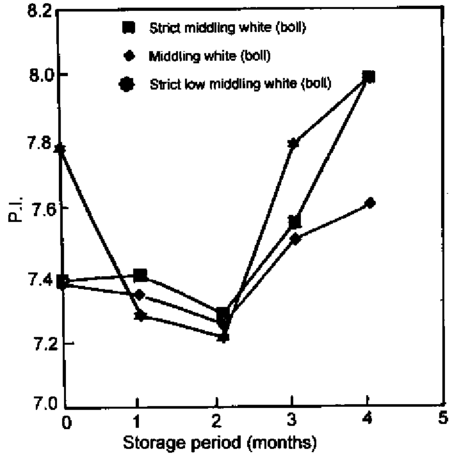

Figure 12. Changes of Pressley Indexes of different cotton bolls by storage period.

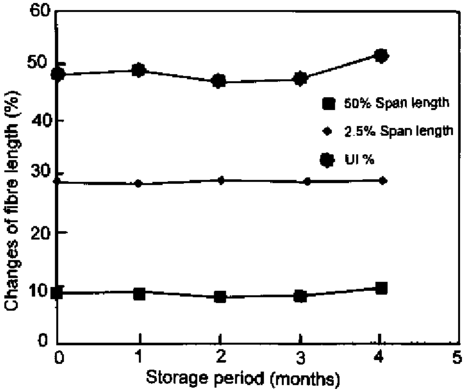

Figure 14. Changes of length of fibres by storage period for *middling white* cotton fibre.

or less, is appeared in the images. The deeper stain around the primary wall indicates to some damages in suspected fibres.

Microscopy

The existence of cuticle in undamaged cotton fibres forms a regular ballooning shapes which were swollen in equal parts of carbon disulphide and 15% sodium hydroxide. On the other hand, microbially damaged cotton fibre exhibits irregular balloons which are distinguishable from undamaged fibres.

These balloons can be observed by optical microscope [4, 16].

Figure 10 shows the images of swelled samples by the optical microscope. The difference between the shape of reference balloons and the suspected samples is not noticeable. These results show that the damage was not as deep as to provide different microscopy

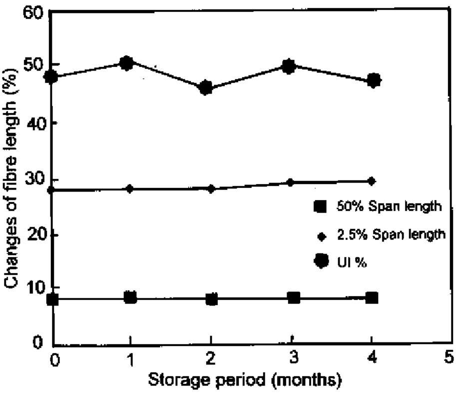

Figure 13. Changes of length of fibres by storage period for *strict middling white* cotton fibre.

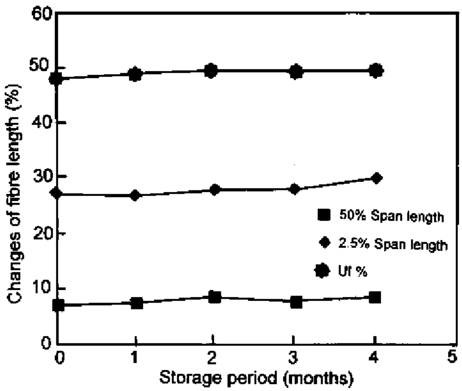

Figure 15. Changes of length of fibres by storage period for *strict low middling white* cotton fibre.

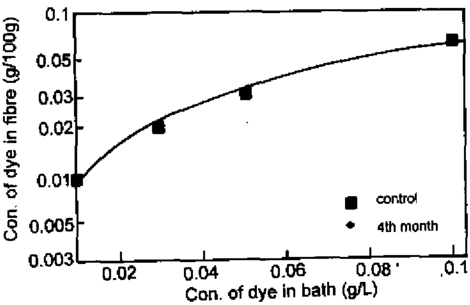

Figure 16. The difference between adsorption isotherms of Chlorantine Fast Green BLL for control and 4 months stored *middling white* cotton fibres.

results for the suspected fibres.

Measurement of Tensile Strength and Length of Fibre

Measurement of tensile and length of the cotton fibre can be an indication of microbial damages [3, 5]. A well description has been published by Hall and Elting [5], which referred to decreases of tensile strength and length of damaged cotton fibres in comparison with undamaged fibres. The changes of tensile strength of different cotton fibres and bolls, stored for different periods, are shown in Figures 11 and 12. The measurements were done by a zero gauge Pressley unit and expressed as Pressley Index (PI)

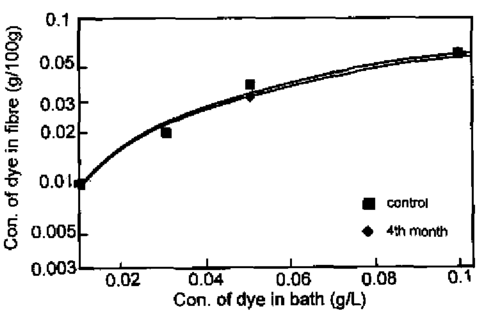

Figure 17. The difference between adsorption isotherms of Chlorantine Fast Green BLL for control and 4 months stored *strict middling white* cotton bolls.

[10]. There is not a significant relation between the changes of the tensile strength (PI) and the storage period [11].

Figures 13–15 show the changes of fibres' length of the unginned cotton samples for different span lengths. The uniformity indexes (UI) of samples are also shown in these figures. The samples were stored in the mentioned conditions and were ginned by a laboratory machine. These results indicate that the storage periods do not have any significant effects on the tensile strength of fibres.

Adsorption Isotherm of Chlorantin Fast Green BLL

Marsh et al. investigated the differential dye absorption of different cotton samples by Chlorantin Fast Green BLL [10]. Figures 16 and 17 show the adsorption isotherm of Chlorantin Fast Green BLL for control and two different grades of cotton samples stored for 4 months. As these figures show, there are not significant differences between the equilibrium distribution of this dyestuff for different samples.

CONCLUSION

In this work, the damages caused by micro-organisms to different grades of Iranian cotton (Sahel variety) in ginned and unginned forms were investigated. Different test methods were employed to detect these types of damages. Some of the characteristics of cotton samples, such as tensile strength and fibre length were not changed with the storage periods systematically. On the other hand, the results of some tests like microscopy and Congo Red staining test did not indicate any severe damage of the samples.

However, results from pH determinations, DNS measurements and alkali centrifuge value as well as reflection measurement proved the growth of micro-organisms on the fibres.

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