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Mechanical properties of ultrasonic washed organic and traditional cotton yarns

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Properties

ABSTRACT

Purpose: The demand of natural and eco-friendly products have undergone tremendous growth after the awareness and realization of global ecological concerns. In this study we have used a novel product (organic cotton) and a novel system (ultrasonic), both having critical importance to environmental pollution. Cotton is one of the oldest and most abundant natural, biodegradable and renewable fibres. Although numerous synthetic fibres have been produced, cotton is still the most important fibre because of its unique physical properties like durability, strength and absorbency, furthermore, only 10% of the raw weight is lost during processing. Organic farming does not have any negative impact due to its natural growing abilities, in which the seeds genetic are not modified and no chemicals such as disinfect or fertilizer are used. Ultrasonic washing has many advantages such as the extra cleanliness of textile materials, reducing process time, energy and chemicals which are used in the washing process. In addition ultrasonic agitation brings less fibre migrations than conventional washing.
Design/methodology/approach: The experimental section reports on the characterization of the organic and conventional cotton that were washed by using an ultrasonic process. Both of the cotton types that used in this study were Turkish cottons and manufactured by ring spinning system. The yarn samples were applied with two different washing temperatures (30°C and 40°C) and three different washing times (10, 20 and 30 minutes). The following stage of ultrasonic and conventional washing physical properties (yarn count, twist, tensile strength, elongation etc) was investigated and comparisons were made.
Findings: The investigation presented in this study indicates benefits of employing ultrasonic washing and organic cotton farming.
Research limitations/implications: The properties of yarn washed with ultrasonic energy shows better properties than those of yarns washed with conventional washing technique. The results confirms that ultrasonic washing has some advantages such as less processing time, less chemical and water consumptions compared to conventional washing methods.
Originality/value: Organic cotton has a potential to substitute traditional cotton providing crop harvesting cost is significantly reduced.
Keywords: Ultrasonic washing; Organic cotton; Eco-friendly product; Ring spinning

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1. Introduction

Cotton is one of the oldest and most abundant natural, biodegradable and renewable fibres. Although numerous synthetic fibres have been produced, cotton is still the most important fibre because of its unique physical properties like durability, strength and absorbency; furthermore, only 10% of the raw weight is lost during processing. Recently, importance of organic farming has been widely recognised and investment in organic crop farming have increased many folds. It is accepted that more than 10% of the world's pesticides (including herbicides, insecticides and defoliants) are used for the cotton crops [1,2], which must be reduced to a tolerant level.. Whereas organic farming does not have any negative impact due to its natural growing abilities, in which the seeds genetic are not modified and no chemicals such as disinfect or fertilizer are used [3,4].

Both natural and synthetic textile products are subjected to a variety of finishing processes, and as a result, large amount of chemicals and water is consumed, resulting in placing even greater burden on depleting earths resources. Ultrasonic washing has many advantages including superior cleaning properties, reduction in process time, energy and chemical used for washing process. In addition ultrasonic agitation brings less fibre migrations than conventional washing. Ultrasonic energy generates millions of bubbles or cavities into the liquid with very high frequency which constantly strikes the target material surface and as a result, removes the dirt off the fibres. One of the most important parameter for ultrasound mechanism is the power of ultrasonic cavitations in liquids [5,6,7,8].

The aim of this study is to investigate ultrasonic washing method and its effectiveness on the cotton yarn and to directly compare the organic and traditional cottons physical properties such as elongation, tenacity, yarn twist etc. within the remit of eco-friendly environment.

2. Experimental

2.1. Materials

The organic and traditional cotton fibres and yarn (Ne40) were manufactured and supplied by Topkapi Iplik Ltd (Istanbul, Turkey). The yarns were fabricated with ring spinning system.

Both cotton fibres and yarns physical properties were the same for comparison purposes. The basic properties of organic and traditional fibres are given in Table 1. The yarn properties of unwashed and washed were investigated and shown in Table 2. A standard commercial detergent was employed with 1 g/L ratio, the main ingredient of the detergents are:

- 5-15% anionic surfactants which oxygen-based bleaching agents,
- <5% non-ionic surfactants, phoshonates, polycarboxylates, zeolites,
- Optical brighteners, enzymes, perfumes, butylphenyl methylpropional, hexyl cinnamal.

2.2. Ultrasonic and conventional washing processes

For the ultrasonic washing technique, ultrasonic bath (Branson 2200, 220 Volt and 205 Watt) was employed using 20kHz frequency. The conventional washing was performed using Roaches model-MB lab type HT dyeing machine and 1 g of detergent and 1 L of deionised water was pre prepared as a mixture and poured into the ultrasonic bath for each sample. The weight of the cotton fibres and yarns were 10 g each and treated at two different temperatures, (30°C and 40°C) and three different times (20 min, 30 min and 40 min). The sample washing were repeated 5 times and after the washing process, the samples were rinsed three times in deionised water. Finally, the samples were left to dry at room temperature for 24 hours. The conventional washing was performed by Roaches model-MB lab type HT dyeing machine.

2.3. Mechanical characterisation of cotton fibres and yarns

Initially, the raw, organic and traditional cotton fibres were conditioned for 48 hours using the standard procedure of 65% relative humidity at temperatures of 20°C. After which the cotton fibre properties were measured by HVI™ 900 according to ASTM standards [9] (Table 1).

Table 1.
Summary of HVI™ results from raw organic and traditional cottons

Cotton	Fineness [μ]	Strength [g/tex]	Elongation [%]	Uniformity [%]	Reflection [%]	UHML [mm]	Short Fibre Index [%]
Organic	4.63	35.8	8.5	77.2	81.5	28.6	7.3
Traditional	4.12	32.5	9.3	85.2	74.1	31.1	8.9

Table 2.
Summary of yarn properties

Cotton type	Organic Cotton			Traditional Cotton		
Parameters/Washing	Raw	UW	CW	Raw	UW	CW
Count [Ne]	39.4	39.8	40.9	38.7	39.3	39.5
Twist [T/m]	817	831	798	786	803	810
Strength [gf]	269.3	246.7	235.46	257.0	224.96	199.33
Elongation [%]	4.86	4.87	4.87	4.82	4.40	4.55

Table 3.
Organic and traditional cotton results after washing process*

Temperatures [°C]			30			40	
Times [min]		10	20	30	10	20	30
Organic Cotton							
OUW	Strength [gf]	241.21	248.92	231.96	257.58	268.87	231.7
OUW	Elongation [%]	3.89	4.49	4.69	4.61	4.99	4.61
OCW	Strength [gf]	234.87	233.79	210.6	261.54	235.21	236.75
OCW	Elongation [%]	4.78	4.75	4.68	5.1	5.05	4.86
Traditional Cotton							
TUW	Strength [gf]	227	247.12	253.47	209.27	207.8	205.1
TUW	Elongation [%]	5.06	4.64	4.62	3.84	4.34	3.92
TCW	Strength [gf]	207	205.08	212.25	216.93	186.1	168.6
TCW	Elongation [%]	4.82	4.66	4.6	4.91	4.23	4.05

*Abbreviations: Organic ultrasonic washing (OUW) and organic conventional washing (OCW), traditional ultrasonic washing (TUW) and traditional conventional washing (TCW)

The properties of yarns were tested as follows; count (TS 244), twist (TS 247, by James H. Heal), strength and elongation (TS 245-ISO 2062). The strength and elongation properties of both yarns were determined using Instron 4411 with test parameters of 500 mm gauge length, load cell 5 kg and test speed 500 mm/min. The summary of the results are given in Fig. 1.

Where:
Raw
UW is Ultrasonic Washing,
CW Conventional Washing.

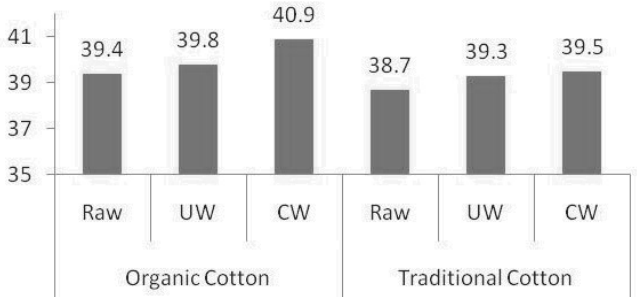

Fig. 1. Raw, ultrasonic and conventional washed yarns counts [Ne]

3. Results and discussion

After the relevant experiment, maximum strength and percentage elongation were evaluated and tabulated in Table 3 below and graphically shown from Fig. 2 to Fig. 4.

Where:
OUW is Organic Conventional Washing,
OCW is Organic Conventional Washing,
TUW is Traditional Ultrasonic Washing,
TCW is Traditional Conventional Washing.

The yarn count decreased with conventional washing, in the Ne counting system; if the number is lower that means the yarn is thicker. In Fig. 1 organic and traditional raw cotton counts are slightly less than washed yarns with both techniques. The reason is the getting thinner related with washing effect of cotton yarns. It is suggested that, after the both washing technique yarn lost some short fibres and get thinner.

Fig. 2 it can be seen that organic cotton based yarns shows discrepancy count of twists ultrasonic washed yarns have more twists than raw and conventional washed yarns. Traditional cotton based yarn twists increase slightly with raw and the washing techniques, but changing is not significant. The count of twist on cotton yarn are related with fibre length and fineness, in this case both organic and traditional fibre properties are nearly same therefore the count of twists do not change considerable.

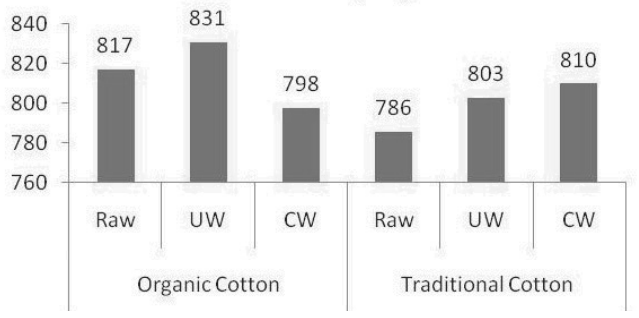

Fig. 2. Raw, ultrasonic and conventional washed yarns twists [T/m]

In Fig. 3 tensile strength properties of yarns decline after washing process. The tensile strength for traditional cotton yarns drop sharply by washing effect. Between unwashed and washed yarns tensile strength properties have 60 gf differences. Organic cotton yarns tensile strength also decrease but it is a slight reduction. For all tensile strength properties, organic yarns have better properties than traditional yarns. Tensile strength correlates with fibre fineness and fibre count on the yarn cross section.

In Fig. 4 organic cotton yarn's elongations remain constant for all because cotton elongation changing related with twist and the

count of twists do not change considerable. Traditional cotton yarns are affected by washing process and the elongations decrease significantly.

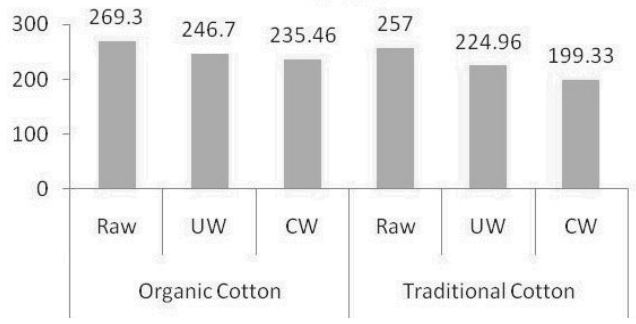

Fig. 3. Raw, ultrasonic and conventional washed yarns tensile strength properties [gf]

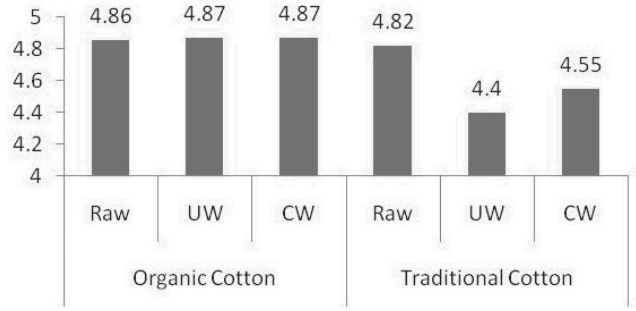

Fig. 4. Raw, ultrasonic and conventional washed yarns elongation properties [%]

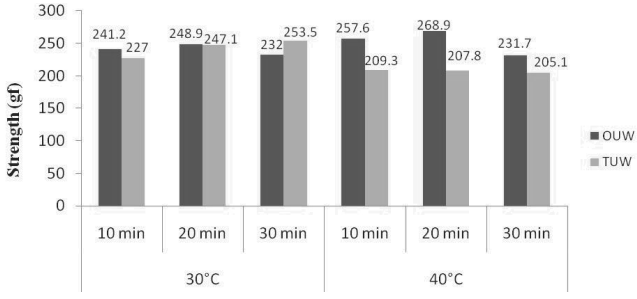

Fig. 5. Shows strength values for Ultrasonically Washed Organic and Traditional Cotton [gf]

The Fig. 5 below shows a maximum strength endured by the cotton yarn when subjected to tensile test after ultrasonically washing the organic and traditional cotton materials under 30°C and 40°C temperatures for 10 minutes, 20 minutes and 30 minutes. The OUW seems to indicate improved strength properties when washed for 20 minutes at both temperatures, whereas with the TUW technique, the maximum strength prior to breakage increases with washing time under 30°C temperature conditions but displays no significant change when subjected to temperatures of 40°C are used. OUW typical feature of strength is better than TUW owing to organic cotton yarn's count [Ne] and twist [T/m] are higher than traditional cotton yarn equivalent.

Fig. 6 shows that the strength of the OCW techniques is gradually declining as the washing time is increased from 10 minutes to 30 minutes for both temperature parameters. The highest strength measured was 261.5 gf at 10 minutes of washing in 40°C temperatures. The strength of TCW technique showed marginal improvement from 207 gf to 212.3 gf when the time was increased from 10 minutes to 30 minutes, respectively under 30°C conditions. Furthermore, the TCW faced greater reduction in strength output when washing was subjected to 40°C. It is clearly showed that ultrasonic washed both cotton yarns have improved tensile strength and the results showed us it is noticeable difference.

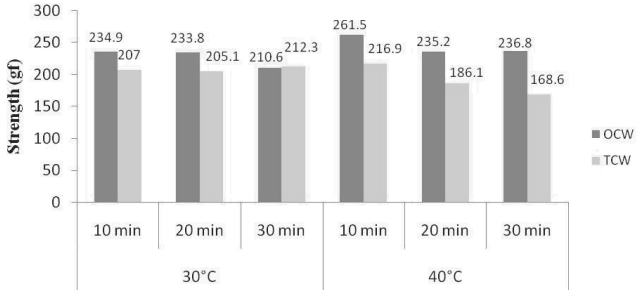

Fig. 6. Shows strength values for Conventionally Washed Organic and Traditional Cotton [gf]

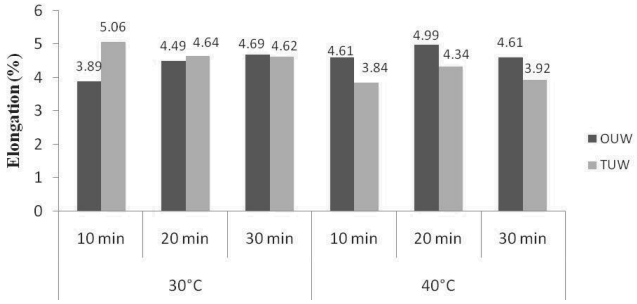

Fig. 7. Shows elongation values of Ultrasonically Washed Organic and Tradidional Cotton [%]

Fig. 7 indicates the maximum elongation recorded for Ultrasonically washed organic and traditional cottons. The percentage of elongation sustained through OUW technique resulted in minimal percentage elongation of 3.89% at 10 minutes of washing under 30°C and highest percentage elongation of 4.99 at 20 minutes of washing at 40°C conditions. However, the largest percentage elongation of 5.06% was noted for TUW technique at 10 minutes of washing using temperatures of 30°C and minimal percentage elongation of 3.84% at 10 minutes of washing at 40°C conditions. Elongation is one of the key properties which belong to yarn twist. In Table 2, it has been shown that organic cotton yarn has more twist than traditional cotton yarn, as a result

organic cotton elongation properties is better than conventional cotton yarn.

Fig. 8 below indicates relatively similar percentage elongation results for both OCW and TCW techniques under 30°C temperature conditions, at the same time, both technique seems to be declining gradually as the washing time is increased from 10 minutes to 30 minutes. However, washing under 40°C temperatures indicates that OCW technique shows 5.1% elongation at 10 minutes of washing and the lowest percentage elongation is associated with TCW at 30 minutes.

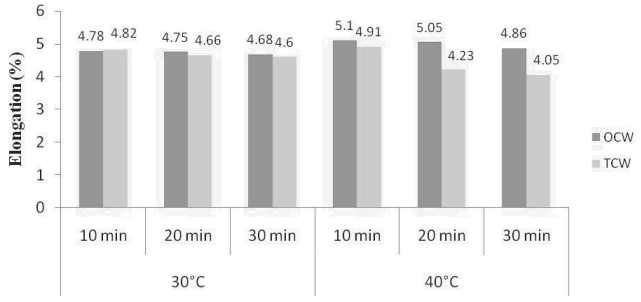

Fig. 8. Shows elongation values of Conventionally Washed Organic and Tradional Cotton

4. Conclusions

The investigation presented in this study indicates benefits of employing ultrasonic washing and organic cotton farming. The results confirms that ultrasonic washing has some advantages such as less processing time, less chemical and water consumptions compared to conventional washing methods.

Furthermore, organic cotton has a potential to substitute traditional cotton providing crop harvesting cost is significantly reduced. Some of the key findings are as follows:

- We compared a conventional and ultrasonic washing technique and the results clearly found that ultrasonic can be employed as a washing technique textile product.
- It has seen that ultrasonic washed cotton yarns are better tensile strength properties than conventional washed cotton yarns because cotton yarns were manhandled by the conventional washing technique.
- A traditional and organic cotton yarns have approximately some properties even organic cotton produce without any extra chemicals.
- Increasing washing temperatures decrease the tensile strength for the all yarns because cotton fibres can lose strength by high temperature.
- Yarn elongations have different behaviour each an every yarns, there is no constant direction.
- Increasing the process time effect the yarn properties in the negative way.

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