The effect of twist multiplier on the tear strength of woven fabrics

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Abstract:

Tearing strength is one of the important quality items of finished woven fabrics. It refers to the rupture of a fabric progressively along a line thread by thread. Tearing strength mainly depends on fibre, yarn and fabric characteristics along with mechanical and chemical finishing treatments given to the fabric. From an industry point of view, studying this fabric characteristic is an essential and urgent step because it reflects the endurance extent of the end textile structure. The main objective of this investigation is to examine the effect of twist multiplier (4.1, 4.4 and 4.7) on weft/warp tear strengths for fabric samples of cotton/polyester blend (50:50) using carded and combed spun yarns. In addition, three weft densities being 18, 22 and 25 were also applied. Results exhibited that the weft/warp tearing strengths are negatively responded to the increase of twist multiplier and weft density for the two spinning systems. In some cases, the weft-way and warp-way warp tearing strengths may be decreased with increasing twist multiplier to a certain extent and then slightly decreased or constant. On the other hand, it is observed that weft/warp tearing strength values for the fabrics made of combed spun yarns were very close to their corresponding values for carded spun yarns under most tested treatments.

Keywords:

Fabric Structure, Tearing Strength, Twist Multiplier, Weft Density

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INTRODUCTION

Tear strength is the resistance of the fabric against tearing or force required to propagate the tear once it is initiated. The tear strength is required in high performance applications as well as in the conventional textiles *i.e.* in the industrial applications; bullet proof jackets "army and police fabrics", tents, worker jeans, sacks, aesthetic apparel and other applications. This is also important in the industrial textiles where heavy duty work is performed. High tear strength of textiles makes sure that the puncture in the fabrics doesn't propagate easily. Accordingly, it is essential to make more effort to measure fabric tearing resistance. The tearing strength is influenced by many factors such as yarn geometry, relaxation of the fibres, fabric geometry, interyarn spacing in the fabric and their frictional characteristics.

Dhamijaa and Chopra (2007) defined the tearing strength as one of the important aspects of a finished fabric. It refers to the rupture of a fabric progressively along a line, thread by thread. With the development of garment industry, the measurement of tearing strength is gaining a fairly wide importance these days as it is directly involved in the assessment of serviceability of the fabric in use. They stated that tearing strength of a fabric mainly depends on fibre, yarn and fabric characteristics along with mechanical and chemical finishing treatments given to the fabric.

Scelzo *et al*, (1994 a and b) investigated the influences of physical parameters such as weave density and yarn spinning system on the tearing behaviour of fabrics. They showed that less dense weaves had higher tear strengths for both ring and rotor spun cotton fabrics. They added that it can anticipate a fully predictive model of tear resistance based solely on yam properties and fabric geometry.

Nawaz *et al*, (2002) explained that the tear strength of the fabrics produced by yarns of the same spinning and folding twist, would increase up to a certain level and then decrease with increasing twist multipliers. While for the fabrics made from yarns of the same spinning but opposite folding twist, it increases with the increase of the twist multiplier.

Eltahan (2018) stated that the higher tearing strength is achieved by providing a degree of mobility for the fibers and yams within the structure. When a coating is applied over the fabric, the degree of mobility possible within the structure is almost invariably reduced. As a result, the coating decreases the tear strength of the fabrics regardless of the type of coating**.**

Abou-Nassif (2014) revealed that woven fabrics produced from compact spun yarns are superior to those produced from ring spun yarns with respect to breaking strength, breaking elongation, abrasion resistance, tearing strength, and air permeability.

Kotb *et al*, (2009) found that the tearing strength is affected to a great extent by type and count of weft yarns, weft density, ground structure, and tension on ground yarns.

The main goal of this study was to investigate the effect of twist multiplier on weft and warp tear strengths for fabric samples of cotton/polyester blend (50:50) made by different weft density using carded and combed spun yarns.

MATERIALS AND METHODS

The experimental fabric samples were weaved from blended yarn 50% cotton - 50% polyester using static combed warp yarns of No. 30/2 N and wefts from No. 1/16 N carded and combed yarn of 3 different densities (18, 22 and 25) according to three twist multipliers being 4.1, 4.4 and 4.7 which represents, respectively, three levels of the number of twist per meter (650, 690 and 740), and the ribstop structure fabric was used 16 widthitudinal end, and 11 longitudinal picks, using Rapier Loom "super excel".

Fabric Specification: (EPI x PPI) / (Warp count x Weft count) x Fabric Width: (35cm x 18cm, 22cm and 25cm) / (30/2 x 16/1) x 160 cm.

Methodology:

After preparation of test specimen, all the fabric is tested in the standard testing atmosphere 65 % relative humidity and temperature 20 ± 2ºC and following test are done to assess the tearing properties.

Tear strength: The tear strength of fabric was tested according to ASTM Standard – D1424 by using Falling Pendulum (Elmendorf's) Apparatus. In this study, the tear strength of the grey fabric Warp and weft direction of the tested fabrics was identified. Two strips were cut from the fabric in both directions having dimensions of 100 x 63.5 mm. The sample was fixed in the jaws of the shredding tester, was determined slit is centrally precut in a test specimen held between two clamps and the specimen is torn through a fixed distance. The resistance to tearing is in part factored into the scale reading of the instrument and is computed from this reading and the pendulum capacity. Then it is determined in grams in both directions of the warp and weft directly through reading the scale indicated by the pointer fixed to the pendulum.

The experimental data were automated as one way analysis of variance (ANOVA) according to the procedure outlined by **Steel *et al*, (1997)**. Duncan's test was used at 5 % probability level to compare the treatment means for weft and warp tear strengths as affected by twist multiplier. According to Duncan's test, treatment means with different letters are significantly differ while those had at least one similar letter are not significantly differ. The results were graphically plotted in line with marker points graph which is an easy and quick tool to understand the results. All statistical analyses were automated using Minitab version 16 (Minitab, 2010) statistical package.

RESULTS AND DISCUSSION

The tear strength of a woven fabric is necessary and indispensable property, since it is one of the main determinants of the fabric serviceability in use. Tearing can be described as the sequential breakage of yarns or groups of yarns along a line through a fabric. It is one of the most common types of failure in textile materials and in many cases, serves to terminate their useful life. The tearing strength is often used to give a reasonably direct assessment of serviceability than the tensile strength and a fabric with low tearing strength is generally an inferior product **(Eryuruk1 and Kalaoğlu1, 2015).**

A- The effect of twist multiplier on weft and warp tearing strengths overall two studied factors (spinning system and weft density)

For the fabric samples of cotton/polyester blend (50:50), the behaviors of weft and warp tearing strengths as affected by twist multiplier overall the tested factors are graphically plotted in line with marker points as depicted in Fig. (1).The statistical analysis revealed that both of weft and warp tearing strength are significantly influenced by twist multiplier. The tearing strength of the two weave types significantly reduced as the twist multiplier increases from 4.1 up to 4.7 indicating negative association between twist multiplier and tearing strength. Overall the studied factors, it is clear that weft tearing resistance values were found to be slightly greater than their corresponding warp tearing strength values with 5.5, 2.94 and 2.72 % at twist multiplier equal 4.1, 4.4 and 4.7, respectively. These results are parallel to the findings obtained by **Eryuruk and Kalaoğlu (2015)** who found that for all studied samples, the weft tear strength is significantly higher than warp tear strength. This results may be ascribed to that the fabric density in weft direction is lower than warp direction, so it was expected that the weft yarns absorbed more amount of treating materials than warp yarns which are more in number, so the tear strength after treatment will expected to be lower than pre-treatment **(Eltahan, 2018)**.

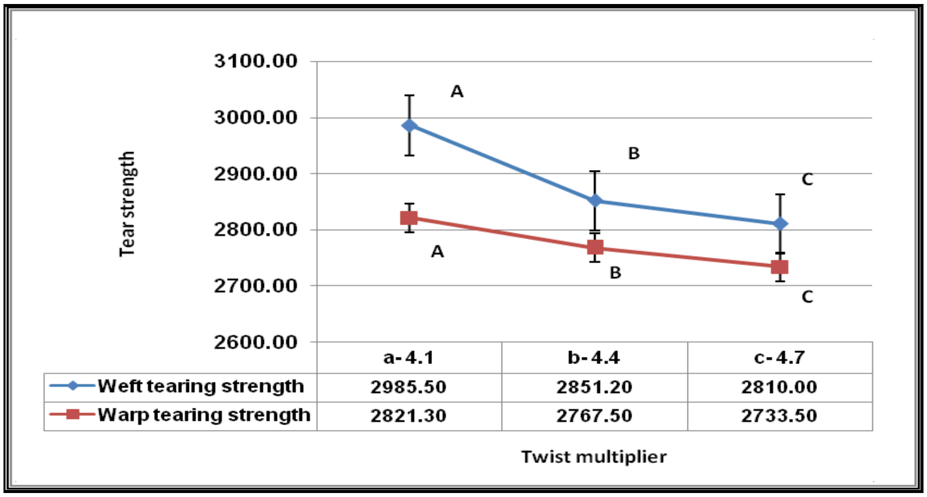


Fig. (1): The effect of twist multiplier on weft and warp tearing strengths overall studied factors.

B- The effect of twist multiplier on weft tearing strength under different spinning system and weft density.

B-1- The effect of twist multiplier on weft tearing strength for two spinning systems (carded and combed) under each weft density.

The mean values of weft tearing strength as affected by twist multiplier for two carded and combed spun yarns under two weft densities of 18 and 22 were graphically presented in Figures (2 and 3) using line with marker points graph.

The general trend of results for the two weft densities of 18 and 22 was similar, so they were simultaneously discussed. For the two weft densities of 18 and 22, there was reverse relationship between the twist multiplier and weft tearing strength for the fabrics made by carded and combed spun yarns. As the twist multiplier increased, the weft tearing strength values of the woven fabrics were significantly decreased. It is noted that weft tearing strength values for combed spun yarns was somewhat lower than their corresponding values for carded spun yarns. For the two spun systems (carded or combed), the textured fabrics had the highest tearing strength values at twist multiplier equal 4.1 under the two weft densities of 18 and 22. However, the weft tearing strength for weft density (18) were more resistant than their corresponding values for weft density (22).

Considering the tested fabrics of cotton/polyester blend (50:50), the statistical analysis cleared that there was significant difference only between the weft tearing strength for twist multiplier 4.1 and 4.7 while the mean values of weft tearing strength for twist multiplier 4.4 were intermediate between other two levels (4.1 and 4.7) and did not differ significantly from them. **Teli *et al*, (2008)** found pronounced effect of the spinning system on the weft tearing strength. They mentioned that the fabrics made by ring spun yarn in the weft had a higher strength value in weft-way and warp-way directions compared to fabrics spun with rotor yarns in the weft.

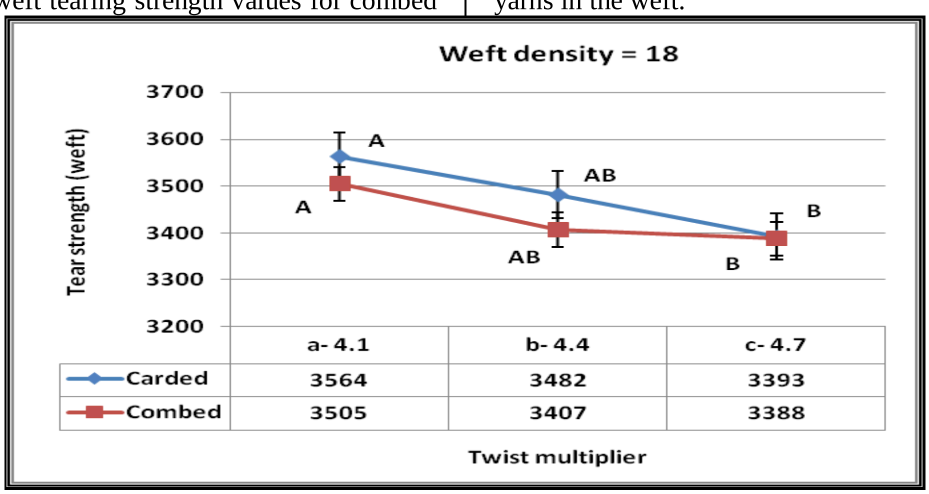


Fig. (2): The effect of twist multiplier on weft tearing strength for two spinning systems (carded and combed) under weft density (18).

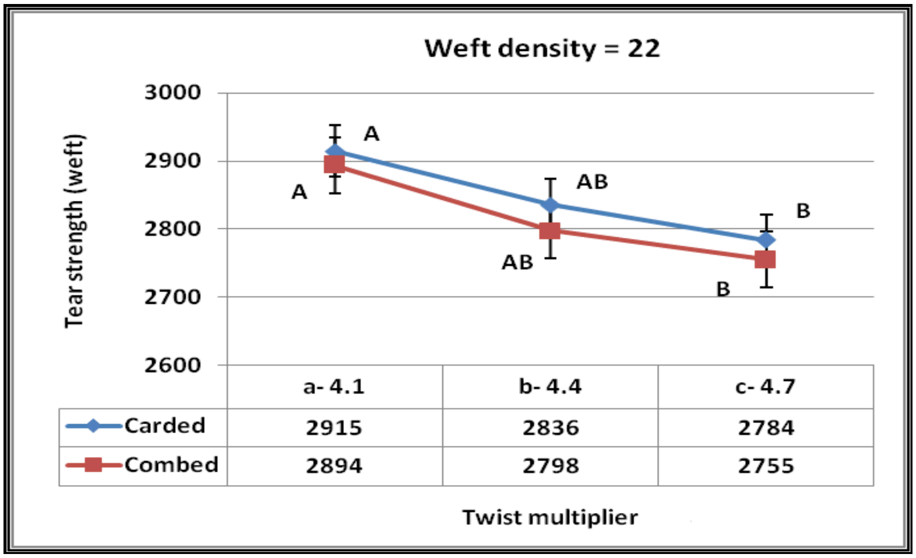


Fig. (3): The effect of twist multiplier on fabric weft tearing strength for two spinning systems (carded and combed) under weft density (22).

Figure (4) explained the weft tearing strength values as affected by twist multiplier for two spun yarns (carded and combed) under weft density (25). Results appeared that the weft tearing strength was negatively responded to the increasing of twist multiplier. Increasing twist multiplier from 4.1 up to 4.4 leads to a significant decrease of weft tearing strength for the two spinning systems. On the other hand, no significant differences were detected between the weft tearing strength for the two spinning systems when the twist multiplier increased from 4.4 up to 4.7. These results indicated that the weft tearing strength may be decreased with increasing twist multiplier to a certain extent and then slightly decreased or constant. As shown in Fig. (4), the weft tearing strength values of woven fabrics using combed spun yarns were very close to their corresponding values under carded spun yarns.

Teli *et al*, (2008) stated that the influence of the yarn count and twist multiplier on the tearing strength varies with the different forms of spinning. Using an open end, conventional ring and rotor spun yarns with a similar yarn count and twist multiplier did not reflect a similar strength profile, due to the difference in the fibre orientation and fibre cohesion in the different spinning systems. **Dhamija and Chopra (2007)** explained that tearing strength is a function of some factors being yarn strength, number of load-bearing elements, distribution of load and ease of slippage among the yarns at the point of tear. Accordingly, the spinning system affects the tearing strength via its single thread strength, smoothness/roughness (which affects ease of slippage and fabric deformation), uniformity and extensibility. A greater smoothness permits greater fabric distortion and allows more yarns to carry the load as they tend to group together with greater freedom of movement or ease of slippage, leading to higher tearing strength.

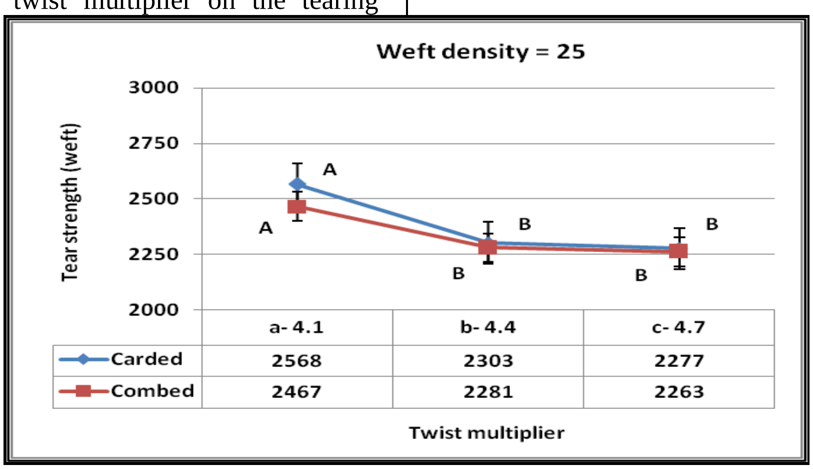


Fig. (4): The effect of twist multiplier on fabric weft tearing strength for two spinning systems (carded and combed) under weft density (25).

B-2- The effect of twist multiplier on fabric weft tearing strength for three weft densities (18, 22 and 25) under two spinning systems (carded and combed).

Concerning the current fabrics of cotton/polyester blend (50:50), results presented in Fig. (5 and 6) showed the behavior of weft tearing strength as affected by three weft densities (18, 22 and 25) under two spinning systems (carded and combed). For the two spinning systems (carded and combed), it is obvious that the weft tearing strengths for the three weft densities (18, 22 and 25) were significantly decreased when the twist multiplier increased from 4.1 up to 4.7. It is easy to investigate that there was significant difference between using twist multiplier 4.1 and 4.7 in reducing fabric weft tearing strength while no significant differences were detected between twist multiplier 4.4 and 4.7 under the three weft density points. Also, there was negative association between the weft density and weft tearing strength for the two spinning systems. As the weft density increased, the weft tearing strength values were gradually decreased through the three twist multiplier points. **Wang *et al*, (2007)** showed that weft density did not significantly influence the tearing strength of woven fabrics. This is mainly because the weft yarns are in the non-direct loading system, and the evolution of the delta zone is mainly determined by other factors. On the contrary, **Dhamija and Chopra (2007)** stated that increasing the weft yarn linear density restricts the freedom of threads movement as a result of increase in yarn diameter which reducing the grouping tendency of the threads.

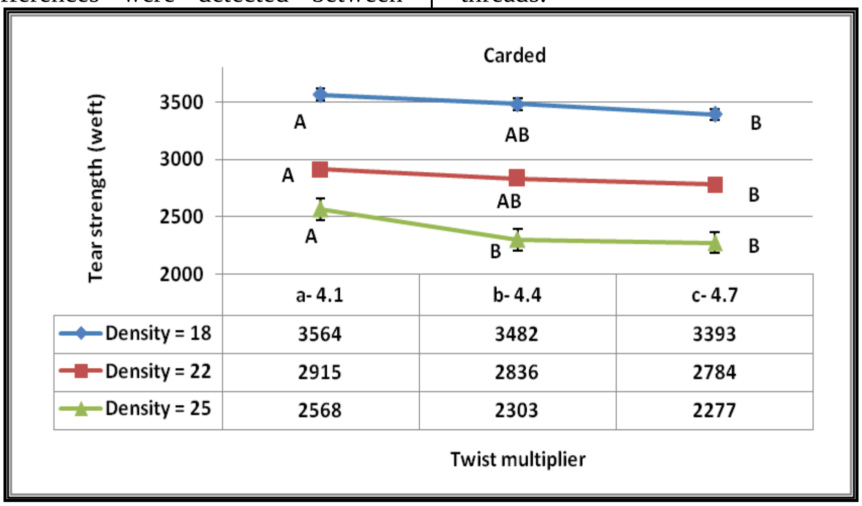


Fig. (5): The effect of twist multiplier on weft tearing strength for three weft densities (18, 22 and 25) using carded spun yarns.

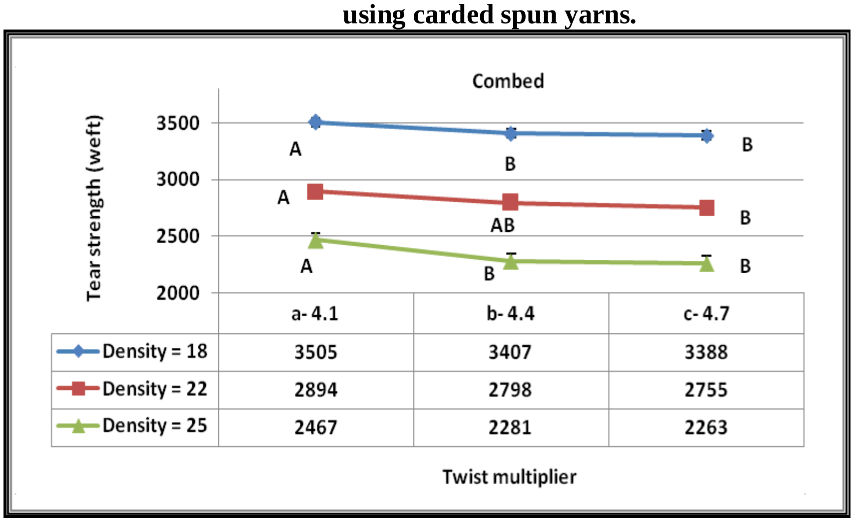


Fig. (6): The effect of twist multiplier on weft tearing strength for three weft densities (18, 22 and 25) using carded spun yarns.

C- The effect of twist multiplier on warp tearing strength under different spinning system and weft density.

C-1- The effect of twist multiplier on warp tearing strength for two spinning systems (carded and combed) under each weft

density.

For the experimental fabric samples of cotton/polyester blend (50:50), the effect of twist multiplier on fabric warp tearing strength for two spinning systems (carded and combed) under weft density of 18 was graphically plotted in Figure (7) using line with marker points graph. Results presented that there was no significant differences among the three twist multipliers either using carded or combed yarns. Regardless the insignificant effect of twist multiplier, but the warp tearing strength was slowly decreased with increasing twist multiplier. However, the warp tearing strength values for carded spun yarns was slightly higher than their opposite values for combed spun yarns. Accordingly, there was limited effect of twist multiplier on fabric warp tearing strength for the two spinning systems (carded and combed) using the lowest weft density of 18. **Dhamijaa and Chopra (2007)** concluded that the use of compact-spun yarns as weft results in higher tearing resistance of cotton fabrics as compared to that of ring-spun yarn weft fabrics. Also, they added that the increase in weft yarn linear density increases weft-wise but decreases warp-wise tearing resistance of cotton fabrics.

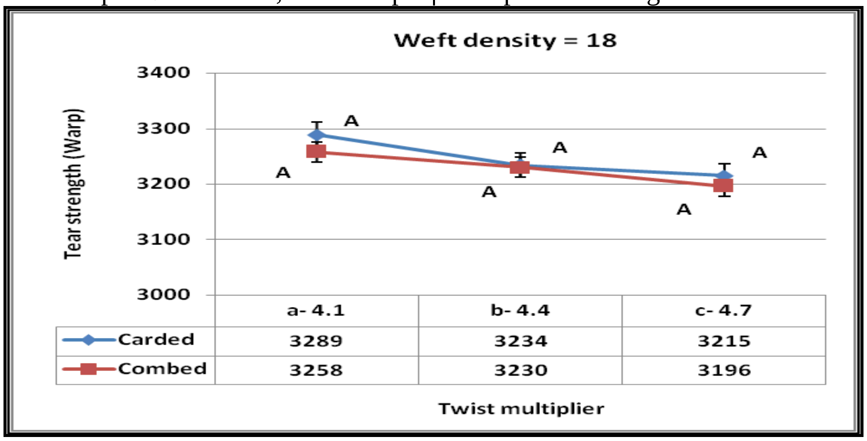


Fig. (7): The effect of twist multiplier on warp tearing strength for two spinning systems (carded and combed) under weft density (18).

Fig. (8) showed the behavior of warp tearing strength as affected by twist multiplier using carded and combed spun yarns under weft density (22). Results indicated that the warp tearing strength reversely reacted with the increasing of twist multiplier. When twist multiplier increased from 4.1 up to 4.4, the warp tearing strength values were significantly decreased for the two spinning systems (carded and combed). Unlike the aforementioned case, no significant effect were detected between the weft tearing strength values for the two spinning systems when the twist multiplier further increased from 4.4 up to 4.7. These results are in harmony with those obtained by **Almetwally and Salem (2010)** who indicated that the effect of twist factor was no significant on fabric tear resistance. Also, they found that the differences between tear resistance values for compact and ring fabrics were insignificant, but in most cases fabrics woven with compact spun yarns were more tear resistible than those woven with ring spun yarns.

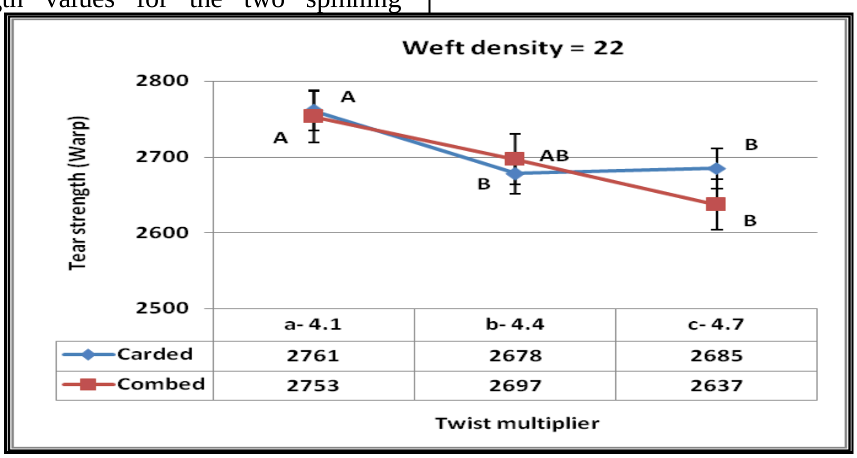


Fig. (8): The effect of twist multiplier on warp tearing strength for two spinning systems (carded and combed) under weft density (22).

Results in and Fig. (9) presented the mean values of warp tearing strength as affected by twist multiplier for carded and combed fabrics under weft density (25). It is revealed that the weft tearing strength was negatively responded to the increasing of twist multiplier. There was a significant decrease of warp tearing strength values with increasing twist multiplier from 4.1 up to 4.4 for the two spinning systems (carded and combed) while no significant differences were obtained when the twist multiplier increased from 4.4 up to 4.7. Subsequently, in some cases, the warp tearing resistance may decrease to a specific limit, and then slightly decreased or stabilized. As shown in the previous results, the fabrics woven with spun combed yarns were slightly lower tearing resistance than fabrics woven with carded spun yarns. **Eltayib *et al*, (2016)** showed that the fabric tear strength was not affected by the weft density at the weft and warp directions.

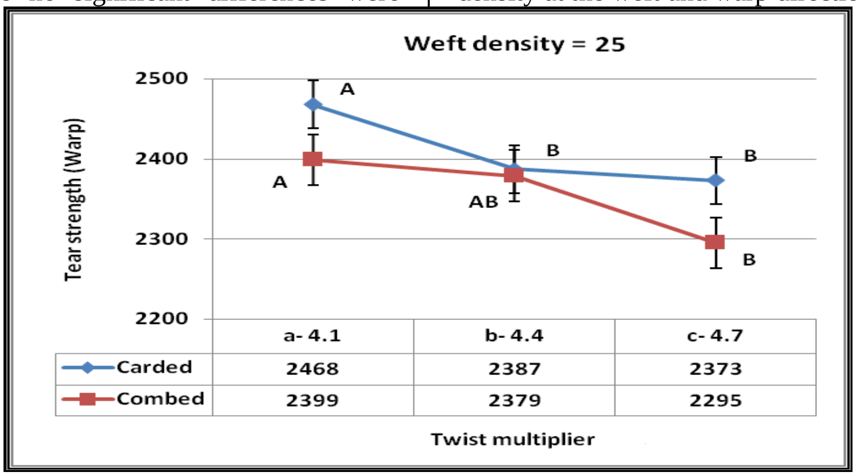


Fig. (9): The effect of twist multiplier on warp tearing strength for two spinning systems (carded and combed) under weft density (25).

C-2- The effect of twist multiplier on warp tearing strength for three weft densities (18, 22 and 25) under two spinning systems (carded and combed).

Testing the fabric samples of cotton/polyester blend (50:50), the behavior of fabric warp tearing resistance as affected by three weft densities (18, 22 and 25) under two spinning systems (carded and combed) are showed in Fig. (10 and 11). Overall carded and combed fabrics, it is cleared that the warp tearing resistance for the three weft densities (18, 22 and 25) was significantly decreased when the twist multiplier increased from 4.1 up to 4.7 except in the case that has been used combed spun yarns with weft density (18) which was insignificant. Also, there was significant difference only between twist multiplier 4.1 and 4.7 in reducing warp tearing strength while no significant differences were detected between twist multiplier 4.4 and 4.7 under the three weft density points. As well as, since the weft density increased, the warp tearing strength values were gradually decreased through the three twist multiplier points. **Abou-Nassif (2012 and 2014)** revealed that increasing weft density leads to decreased air permeability, and tearing strength.

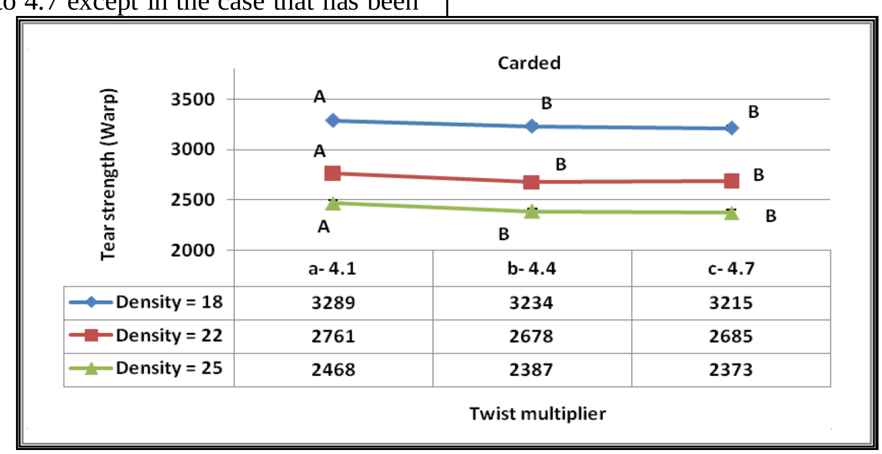
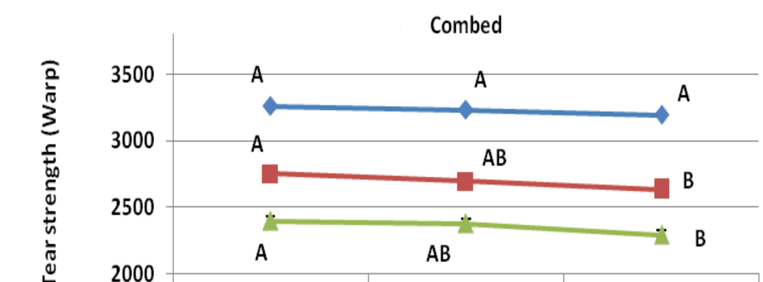


Fig. (10): The effect of twist multiplier on warp tearing strength for three weft densities (18, 22 and 25) using carded spun yarns



	a- 4.1	b- 4.4	c- 4.7
Density = 18	3258	3230	3196
Density = 22	2753	2697	2637
Density = 25	2399	2379	2295

Fig. (11): The effect of twist multiplier on warp tearing strength for three weft densities (18, 22 and 25) using combed spun yarns.

CONCLUSION

The present work aimed to explain the optimum treatments of yarn factors and fabric structure that give high weft and warp tearing strength for the fabrics woven of cotton/polyester blend (50:50). Overall the studied factors, it can be summarized the following conclusions:

(1) The tearing strength of the two weave types significantly reduced as the twist multiplier increases regardless the weft density indicating the existence of negative association between twist multiplier and tearing strength.

(2) In some cases, the weft/warp tearing strengths may be decreased with increasing twist multiplier to a certain extent and then slightly decreased or stabilized.

(3) Also, there was reverse relationship between the weft density and weft/warp tearing strength. As the weft density increased, the weft/warp tearing strength values were gradually decreased through the three twist multiplier points.

(4) It is found that the fabric weft/warp tearing strength values of fabrics woven using combed spun yarns were very close to their corresponding values under carded spun yarns.

(5) It is clear that weft tearing resistance values were found to be greater than their corresponding warp tearing resistance values.

REFERENCES

1. **Abou-Nassif, G.A. (2012)**. Effect of weave structure and weft density on the physical and mechanical properties of micropolyester woven fabrics, Journal of American Science, 9(3): 1326-1331.
2. **Abou-Nassif, G.A. (2014)**. Comparative study between physical properties of compact and ring yarn fabrics produced from medium and coarser yarn counts. Journal of Textiles, 1-6.
3. **Almetwally, A. A. and Mona. M. Salem (2010).** Comparison between mechanical properties of fabrics woven from compact and ring spun yarns**.** AUTEX Research Journal, Vol. 10 (1): 35-40.
4. **Dhamijaa, S. and M. Chopra (2007)**. Tearing strength of cotton fabrics in relation to certain process and loom parameters. Indian Journal of Fibre & Textile Research Vol. (32) : 439-445.
5. **Eltayib, H.E.; A.H.M. Ali and I.A. Ishag (2016).** The Prediction of Tear Strength of plain weave fabric Using Linear Regression Models. International Journal of Advanced Engineering Research and Science (IJAERS). Vol. 3 (11): 151-154.
6. **Eman Eltahan (2018)**. Structural parameters affecting tear strength of the fabrics tents. Alexandria Engineering Journal, 57: 97–105.
7. **Eryuruk, Selin H. and Fatma Kalaoğlu (2015).** The effect of weave construction on tear strength of woven fabrics. AUTEX Research Journal, Vol. 15 (3): 207-214.
8. **Kotb N.; A. El Geiheini; A. Salman and A. Abdel –Samad (2009)**. Engineering of Tearing Strength for Pile Fabrics. Journal of Textile and Apparel Technology and Management, Vol. 6 (1): 1-8.
9. **Minitab IN. Minitab 16 statistical software. State College: Minitab, Inc.; 2010.**
10. **Scelzo, W. A.; Backer, S. & Boyce, C., (1994 a).** Mechanistic role of yarn and fabric structure in determining tear resistance of woven cloth - Part I: Understanding tongue tear. Textile Research Journal, Vol. 64, No. 5:

291-304.

11. **Scelzo, W. A.; Backer, S. & Boyce, C., (1994 b).** Mechanistic role of yarn and fabric structure in determining tear resistance of woven cloth. Part II: Modelling tongue tear.Textile Research Journal, Vol. 64, No. 6: 321-329.
12. **Snedecor, G.W. and W.G. Cochron (1989).** Statistical Methods. 8th Ed., Iowa State Univ. Press, Ames Iowa, USA.
13. **Steel, R.; J. Torrie and D. Dicky (1997)**. Principles and Procedures of Statistics; A Biometrical Approach. 3rd
14. **Teli, M.D.; A.R. Khare and R. Chakrabarti (2008).** Dependence of yarn and fabric strength on the structural parameters. AUTEX Research Journal, Vol. 8, No. 3: 63-67.
15. **Wang, P.; M. Qian; S. Baozhong; H. Hong and G. Bohong (2007)**. Finite element modeling of woven fabric tearing damage. Textile Research Journal, 81(12): 1273–1286.