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Effect of the blending between upland and combing waste on cotton fiber and yarn quality

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Abstract
Blending of cotton wastes with raw materials to produce different textile products has economically and environmentally beneficial. This study was carried out in Cotton Research Institute, Agricultural Research Center. This investigation aimed to study the impact of blending ratio on fiber, mechanical and physical yarn quality properties to find out the optimum blending ratio that achieves the optimum yarn quality properties. For this purpose, fiber properties, mechanical and physical yarn quality properties of ring spun yarns produced from cotton variety Giza95, Delta pine245 cotton variety (upland cotton) combed cotton waste of Extra Fine Giza93 and six different binary blend ratios were studied. Blended samples were spun into 36s' and 40s' *carded yarns* at constant twist multiplier 4 on ring spinning system. *the results showed that fiber properties, Physical and mechanical properties of yarns produced from Giza95 were better than 100% upland cotton, 100% combed cotton waste and the other blended yarns.65% Giza95-35% combed waste of blended samples recorded higher fiber properties(maturity ratio, fiber length, uniformity index, fiber strength and fiber elongation) than all blended samples.Also,the same blended ratio at* 36s'*yarn count give better lea count product strength, yarn strength, yarn elongation, evenness, imperfections and yarn hairiness compared with all blended yarns followed by 65% combed waste - 35% Giza95.While, the lowest yarn quality properties recorded by The blended yarn of 35% Giza95-65% Delta pine245. Also, it observed that increasing proportion of G95 cotton variety in blended samples led to improve fiber, mechanical and physical yarn properties.*
Key words*: Combed waste, Upland cotton, ring spinning, blending ratios*

I. Introduction

Cotton is one of the best natural fibers in the world. It is one of the most important sources of national income in Egypt. Egyptian cotton has international reputation because it has unique physical and mechanical quality properties such as comfortable soft hand moisture absorbency, good strength, easy to handle and sew, drapes well, prints well and surface characteristics. Besides, it compatibility with other natural and synthetic fibers (Raghavendra et al. 2004; Saha et al. 2020).The textile industry in Egypt faces great challenges for example it providing raw material of cotton at a cheap price to produce medium and coarse yarns for domestic market, competition in textile world and expert fine and extra fine yarns to international market (Mohamed et al. 2005).

The increase in population, the prices of raw materials, the demand for textile products, the decrease in agricultural areas and the lack of natural fibers led to an increase in the production costs in textile industry. The increase in both of textile production and consumption rate of raw materials led to huge amount of textile wastes. Textile industry wastes are generated in the various manufacturing processes of fibers, yarns, fabrics and garments (Wang2010).

Disposing of textile wastes by burning it or dumping in landfills has negative effects on the environment. The best solution to this problem is reuse textile wastes to produce cheap textile products with acceptable quality properties. Recycling textile wastes has economic and environmental benefits. In addition, it reduces the amount of natural raw materials which used in textile industry, and reduces air, water and land pollutions. Also, recycling waste increases profitability (Bhatia et al 2014; Shama and Joel 2017).

There are no fibers have all the desirable properties. However, all fibers are poor in some properties so blending process of different types of fibers is practiced to improve the quality properties of yarn by combining desirable properties of constituent fibres and to reduce the cost (Langenhove2002; Bhardwaj and Juneja2012).

In general, blending process is reduced production costs by blending expensive fibers with a cheaper fibers one. Furthermore, it is improved different yarn quality properties, combining desirable physical properties of both fiber components in the blended yarns, Color and appearance, where novel designs may be carried out by incorporating multi-color effects (Mohamed et al. 2005; Charanker et al.2012).

Mechanical and physical properties of blend yarns depend on quality properties of fiber of each component and their proportions in blended yarns (Rajalakshmi et al. 2012). increasing combed cotton waste and carded cotton waste for Giza90 cotton variety in blended led to decrease in fiber length, fiber strength, fiber and yarn elongation .While, micronaire value, yarn strength, yarn evenness and yarn imperfections increased (Mabrouk and Nour2005).

(Cierpucha et al.2006) the quality properties of cotton and cotton-flax blends yarns were studied .it showed that cotton yarns gave high yarn strength and low evenness compared to blended yarns.

blending cotton fibers and cotton wastes from ginning process with three blending ratios led to reduce production costs and improved most physical properties of blended yarns (Marinus 2007).

(Khan et al. 2015) reported that single yarn strength increased with increasing the proportion of pure cotton in the blended. (Rizk et al. 2016) imported upland cottons are lower fiber quality properties than Egyptian cotton .therefore, blending upland cottons with Egyptian cottons improves mechanical and physical quality properties of blended yarns compared to upland cotton yarns and it reduces production costs.

Fiber properties, mechanical and physical properties of blended yarns cotton-modal with four blending ratios including 100% cotton were studied. It observed that 100% cotton yarn gave better yarn quality properties such as yarn evenness, yarn imperfections and yarn hairiness than cotton –modal blended yarns (Saha et al. 2020)

Yarn quality properties produced from cotton, tencel and modal fibers and their blends were studied. The blend yarns of 33% tencel - 67% Giza94 cotton variety and 33% modal - 67% Giza94 cotton variety recorded the highest yarn strength followed by 50/50 and 67/33 %.whereas, The blend yarns of 67% tencel - 33% Giza94 cotton variety and 67% modal - 33% Giza 94 cotton variety recorded the highest yarn evenness. Also, yarn strength (cN/Tex) and yarn evenness were decreased with increasing proportion of regenerated fibers in blended samples (El-Banna 2019).

(Abd-Elkawe and Aly2019) studied Mechanical and physical properties of open end spun yarns produced from cotton, flex, polyester fibers and their blends. It observed that the cotton- flax blended yarn gave the lowest functional performance due to its high unevenness and yarn hairiness.

This investigation aimed to study the influence of blending ratio on fiber properties .In addition, study the effect of blending ratio and yarn counts on mechanical and physical yarn quality properties to find out the optimum blending ratio that achieves the optimum yarn quality properties.

II. Materials And Methods

This study was carried out in the experimental cotton spinning mill, Cotton Research Institute. Egyptian commercial cotton variety Giza95 and upland cotton (Delta pine cotton variety) were selected and blended with combed waste of Giza93extra-long staple to produce six different binary blend ratios of yarns beside prepared 100% pure Giza95 Egyptian cotton, 100% pure upland cotton and 100% combed waste. Blended samples were spun into36s' and 40s' carded yarns spun at constant twist multiplier 4 on a ring spinning system. The ring spun yarn samples are presented in Table1.

Table 1. Ring spun yarns specifications

Blending code	Materials	Blending ratio
A	Giza 95 Egyptian cotton variety	100%
B	Upland cotton (Delta pine 245 cotton variety)	100%
C	Combed cotton waste of Giza93	100%
D	Giza95/ Delta pine245	65% - 35%
E	Giza95 /Delta pine245	35% - 65%
F	Giza95 / Combed cotton waste	65% - 35%
G	Giza95/ Combed cotton waste	35% - 65%
H	Delta pine 245 /Combed cotton waste	65% - 35%
I	Delta pine245 /Combed cotton waste	35% - 65%

Fiber and yarn tests were conducted in the laboratories of Cotton Technology Research Division, Cotton Research Institute, Agricultural Research Centre, Egypt. Fiber properties i.e. micronaire value, maturity ratio, fiber length (UHM), uniformity index, short fiber index, fiber strength, fiber elongation, fiber reflectance and fiber yellowness were measured on HVI according to (ASTM, D-5867-05) .lea count strength product (LCSP) was performed on good brand (ASTM,D1578-93) .Physical properties i.e. yarn evenness, yarn hairiness and yarn imperfection were examined on Uster Tester 3 at 400m/min test speed according to (ASTM, 1425-96) with testing speed of 400mm/min. Mechanical yarn properties i.e. yarn strength and yarn elongation were measured in the laboratories of Textile Consolidation Fund on Uster Tensorapid4(according to ASTM., D2256-02) at 5000mm/min test speed and test length of 50cm used for the testing of tensile properties. All samples were opened and left for 24 hours at least under the standard humidity and temperature conditions (65% ± 2% relative humidity and 21 ± 1°C temperature) before tested.

Statistical procedures

The experimental design was conducted as completely randomized design with three replications and analyzed as factorial experiment according to the method described by Gomez and Gomez (1984). Analysis of variance was carried out using SPSS 20.0 as a statistical program. The L.S.D. at 5% level of probability was used to calculate the significant differences between the mean values of treatments according to Snedecor and Cochran (1981).

III. Results And Discussion

1-Fiber quality properties:

Data in Table 2 and Fig 1 and 2 showed that significant differences between mean values of all fiber quality properties, i.e. upper half mean length, uniformity ratio, short fiber index, fiber strength, fiber elongation %, micronaire value, maturity ratio, color attributes (reflectance degree and yellowness) of Giza 95, Delta pine 245 cotton variety (*Gossypium hirsutum* L.), 100% combed waste and their blends.100% Giza 95 cotton variety recorded higher mean values of upper half mean length (31.17 mm), uniformity ratio (86.77), fiber strength (36.97 g/tex), fiber elongation (8.23%) and maturity ratio (0.92 %) compared with 100% Delta pine 245 cotton variety, 100% combed waste and all blends. on the other hand , 100% Delta pine 245 cotton variety gave the lowest mean values of maturity ratio (0.84%) and yellowness (8.53) upper half mean length (27.03 mm) , uniformity ratio (81.43) and fiber strength (27.27g/tex). While the same variety recorded the highest mean value of micronaire value (4.97). Regarding the different blends, 65% Giza95-35% combed waste gave better mean values of upper half mean length (29.97 mm), uniformity ratio (84.90), fiber strength (35.23 g/tex), maturity ratio (0.91 %) and yellowness (11.67) as compared to 100% Delta pine cotton variety, 100% combed waste and all different blends. These results are in harmony with those reported by (Mabrouk and Nour 2005 ;Arafa 2019) who reported that increasing the portion of Giza90 fibers in the blend led to increase in fiber length, uniformity index ,fiber strength and decrease short fiber index.

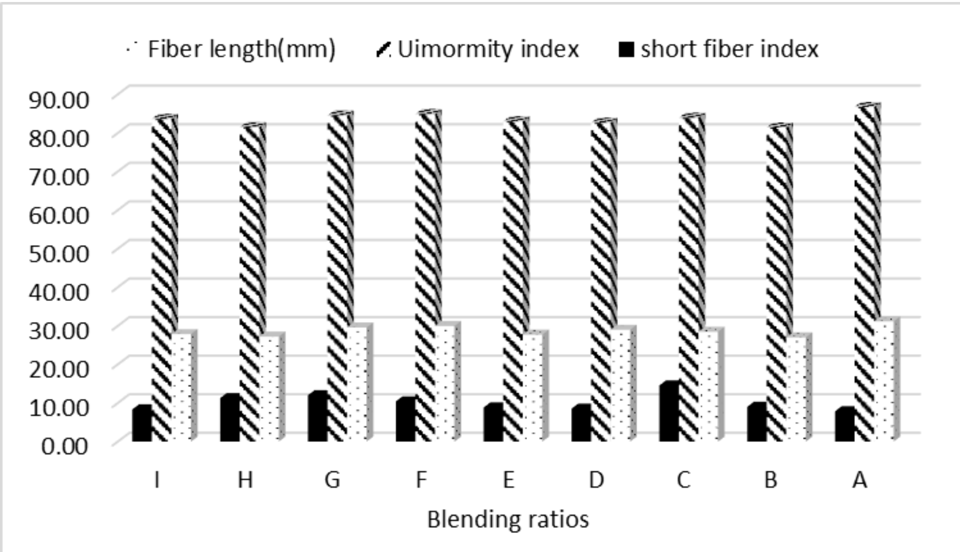

Fig.1. Fiber length, uniformity index and short fiber index for Giza95, Delta pine 245, combed waste fibers and their blends

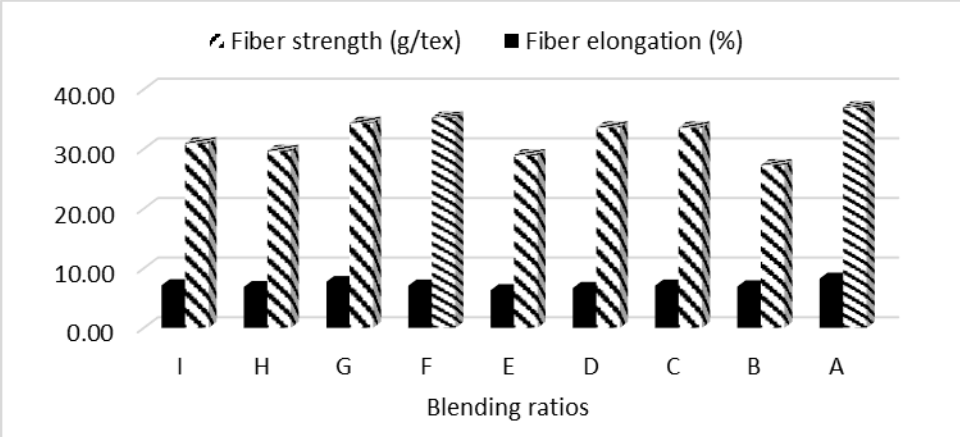

Fig.2. Fiber strength (g/tex) and fiber elongation (%) for Giza95, Delta pine 245, combed waste fibers and their blends

Table 1. Effect of blending cotton materials on fiber quality properties and color attribute as estimated by (HVI).

Materials	UHML (mm)	Uniformity (%)	SFI%	Fiber strength g/tex	Fiber elongation%	Micronaire value	Maturity ratio	Color attributes	
								RD%	(b+)
100% Pure Egyptian cotton Giza 95	31.17	86.77	7.87	36.97	8.23	4.73	0.92	68.33	11.57
100% Pure Upland cotton (Delta pine245)	27.03	81.43	9.03	27.27	6.93	4.97	0.84	68.50	8.53
100% Combed waste	28.47	83.97	14.57	33.57	7.07	3.7	0.89	73.67	11.63
65 % Giza 95 - 35% Delta pine245	28.99	82.67	8.53	33.60	6.67	4.6	0.88	69.67	11.53
35%G 95 - 65% Delta pine245	27.73	83.03	8.87	28.93	6.30	4.9	0.87	68.27	9.67
65%Giza 95 -35% Combed waste	29.97	84.90	10.43	35.23	7.07	4.5	0.91	68.23	11.67
35%G95- 65% Combed waste	29.60	84.53	12.03	34.37	7.67	4.1	0.90	71.43	11.60
65% Delta pine 245-35% Combed waste	27.23	81.50	11.30	29.67	6.83	4.37	0.85	74.40	10.07
35% Delta pine 245- 65% Combed waste	27.87	83.67	8.37	30.93	7.13	4.17	0.88	73.50	9.53
LSD at 5%	**0.60**	**0.36**	**4.16**	**0.56**	**0.34**	**0.23**	**0.05**	**0.51**	**0.57**

High Volume Instrument (HVI), Upper half means length (UHML), Short fiber index (SFI %), reflectance degree (RD %), Fiber yellowness degree (b+)

2. Yarn quality properties

2.1. Mechanical yarn properties

Mechanical yarn properties of ring spun cotton blended yarns are given in Table 3. And Fig 3 and 4 .The effect of blending ratio and its components were highly significant on lea count strength product (LCSP) 2365, yarn strength (19.36cN/Tex) and yarn elongation (5.79 %) of ring spun cotton blended yarns. Lea count strength product, yarn strength and yarn elongation of 100% Giza95 cotton yarn were more than 100% Delta pine 245 cotton variety, 100% combed cotton waste and the other blended yarns.65% Giza95-35% combed waste of blended yarns give better lea count product strength (2285), yarn strength (18.91 cN/Tex) and yarn elongation (5.47%) compared with all blended yarns and 100% Delta pine 245 cotton variety and 100% combed cotton waste. Followed by 65% combed waste - 35% Giza95.While, 35% Giza95-65% Delta pine 245 cotton blended yarn gave lower lea count product strength, yarn strength and yarn elongation than all blended yarns. It noticed that mechanical yarn properties increased as the proportion of Giza95 cotton variety increased in blended yarns.

T**able 2.** Mechanical yarn properties for ring blended yarns

Blending code	**Materials**	**Lea count strength product**	**Yarn strength (cN/Tex)**	**Yarn elongation (%)**
A	100% G95	2365	19.36	5.79
B	100% Delta pine 245	1555	14.31	3.56
C	100% Combed waste	1815	16.66	4.18
D	65% G95-35% Delta pine245	1800	16.75	4.71
E	35% G95-65% Delta pine 245	1695	15.34	4.07
F	65% G95-35% Combed waste	2285	18.91	5.47
G	35% G95-65% Combed waste	2020	17.81	4.39
H	65% Delta pine 245 -35% Combed waste	1690	15.31	3.95
I	35% Delta pine 245 -65% Combed waste	1780	16.42	4.13
LSD at 5%		57.69	0.09	0.09

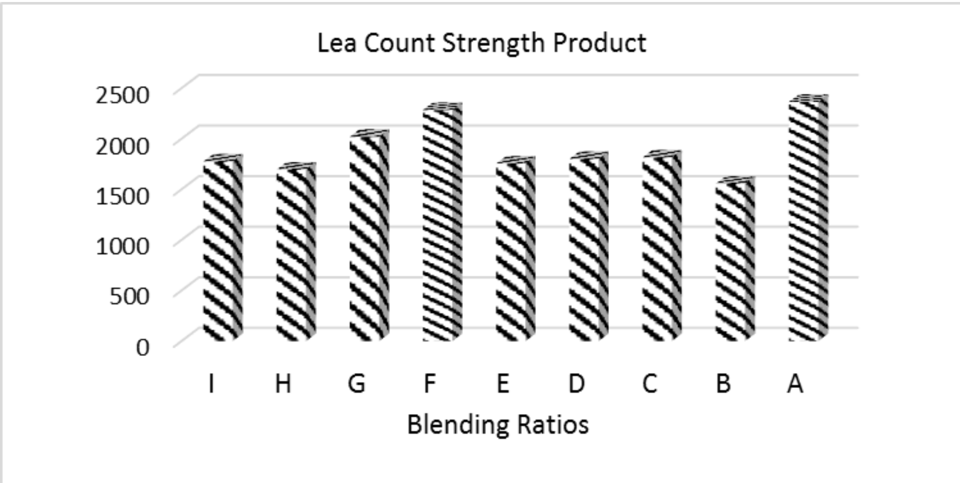

Fig.3. Lea count product strength of ring spun cotton blended yarns

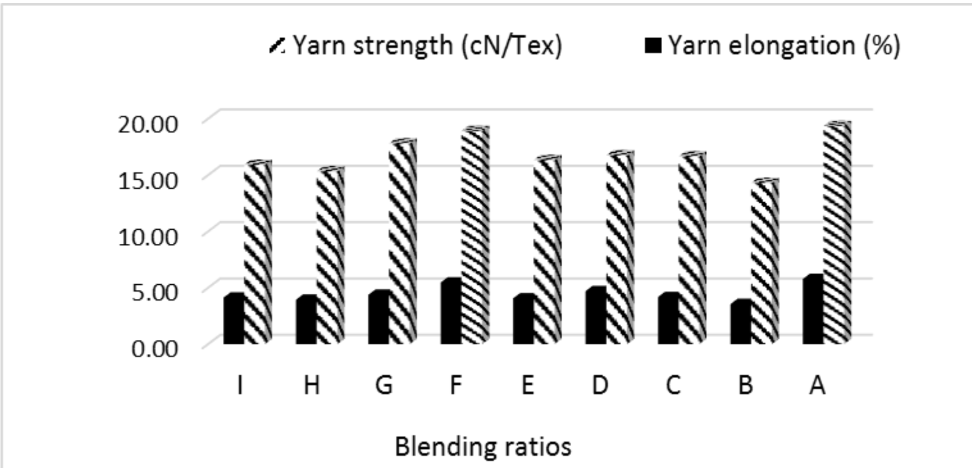

Fig.4.Yarn strength (cN/tex) and yarn elongation % of ring spun cotton blended yarns

As shown in Table 3 and Fig 5 and 6 yarn count had significant effect on all mechanical yarn properties. Also, it found that yarn count 36s, gave higher lea count strength product (1921) and yarn strength (17.04 cN/Tex) than yarn count 40. It noticed that increasing yarn count form 36s to 40s led to decrease lea count strength from 1921 to 1875, yarn strength from 17.04 to 16.61 cN/tex and yarn elongation from 4.58 to 4.37%. These results are a gree with (Sanad et al. 2011; Abd-Elkawe and El-Sayed 2021) yarn strength (cN/Tex) was decreased with increasing yarn count that may be due to the lower number of fibers in cross section of fine yarns.

Table 3. Effect of yarn count on mechanical yarn properties

Mechanical yarn properties	Yarn count		LSD at 5%
	36s'	40s'	
lea count strength product	1921	1875	**
Yarn strength (cN/Tex)	17.04	16.61	**
Yarn elongation (%)	4.58	4.37	*

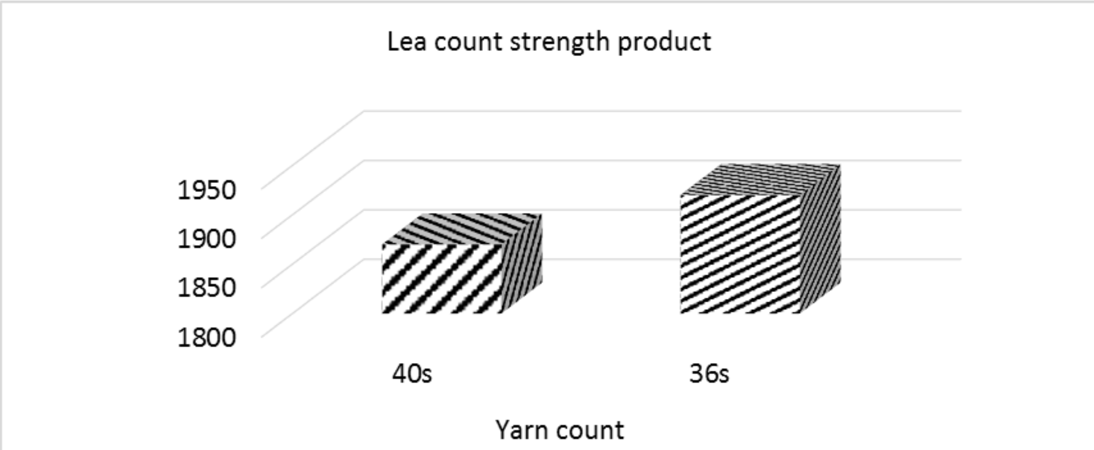

Fig.5.Lea count strength product for ring spun blended yarns at 36s and 40s yarn counts

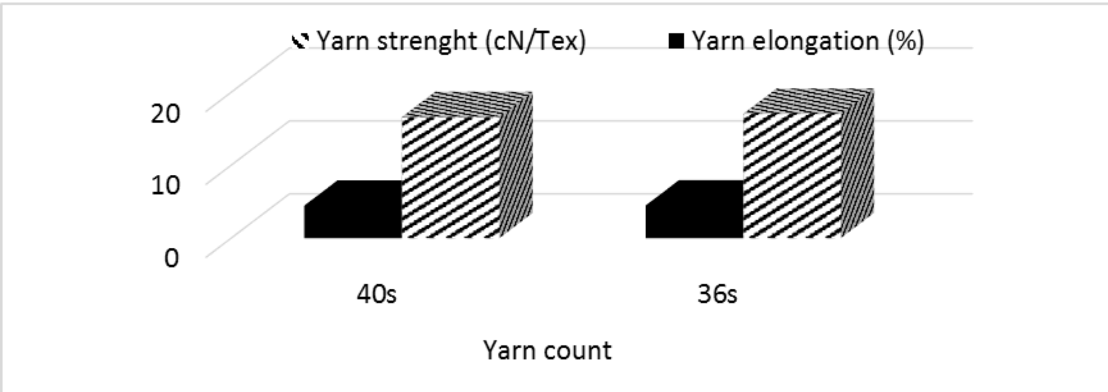

Fig.6.Yarn strength and yarn elongation for ring spun blended yarns at 36s and 40s yarn counts

Regarding data in Table 4 and Fig 7 showed that the interaction between blending ratio and yarn count had significant effect on all mechanical yarn properties except lea count strength product.65% Giza95-35% Combed waste blended yarn spun into 36s yarn count give better yarn strength (19.12 cN/Tex) and yarn elongation (5.58%) as compared with all blended yarns at both yarn counts. Whereas, 65% Delta pine 245– 35% combed waste blended yarn at 36s and 40s yarn counts gave the lowest yarn strength (15.47 and 15.21 cN/tex) and yarn elongation (3.97 and 3.92 %) respectively.

Table 4. Lea count strength product, yarn strength and yarn elongation for ring spun yarns as affected by the interaction between blending ratio and yarn count

Blending code	Materials	Yarn count	Lea count strength	Yarn strength (cN/Tex)	Yarn elongation (%)
A	100%Giza95	36s	2385	19.44	5.8
		40s	2347	19.29	5.78
B	100% Delta pine 245	36s	1567	14.33	3.67
		40s	1542	14.29	3.46

C	100% Combed waste	36s	1847	16.86	4.22
		40s	1782	16.45	4.14
D	65%Giza95-35% Delta pine	36s	1855	17.23	5.13
		40s	1773	16.71	4.29
E	35% Giza95-65% Delta pine 245	36s	1767	16.45	4.15
		40s	1745	16.23	3.99
F	65% Giza95-35% Combed waste	36s	2312	19.12	5.58
		40s	2257	18.71	5.37
G	35% Giza95-65%Combed waste	36s	2053	17.9	4.46
		40s	1990	17.73	4.32
H	65% Delta pine 245-35% Combed waste	36s	1707	15.47	3.97
		40s	1687	15.21	3.92
I	35%Delta pine-65% Combed waste	36s	1798	16.56	4.2
		40s	1752	15.27	4.07
	LSD at 5%		NS	0.139	0.128

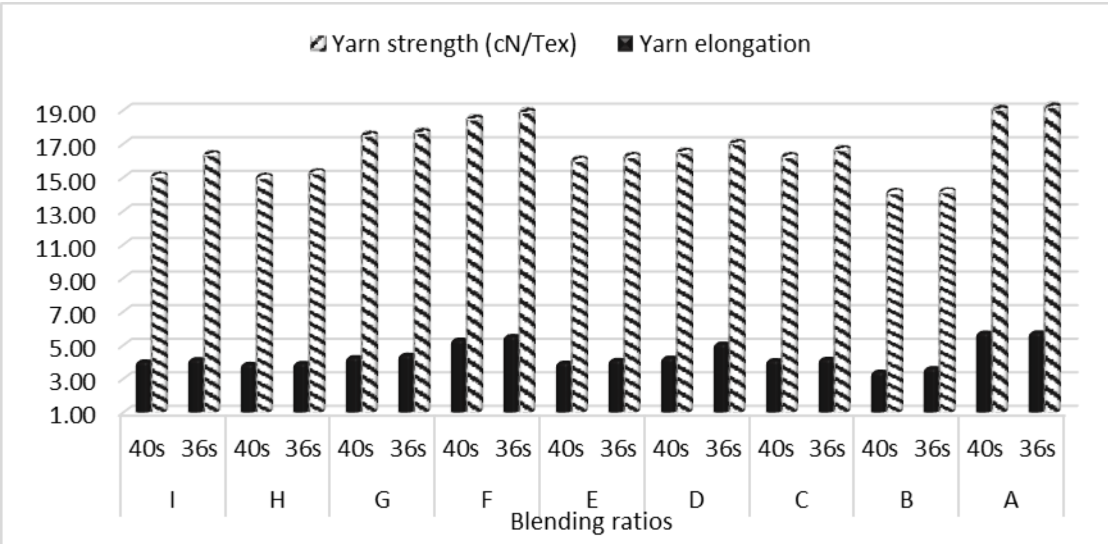

Fig.7. Yarn strength (cN/tex) and yarn elongation (%) for ring spun blended yarns at different yarn counts

2.2 Physical yarn properties

Data in Table 5 showed the effect of blending ratios on Physical yarn properties of ring spun cotton blended yarns. Results indicated that blending ratio had significant effect on thin places, thick places, neps, unevenness (%) and yarn hairiness of ring spun cotton blended yarns. Thin places (119), thick places (215) , neps (114), unevenness (19.76) and yarn hairiness (3.92) of 100% Giza95 cotton yarn were lower than 100% Delta pine 245 variety, 100% combed waste and the other blended yarns. 65% Giza95-35% combed waste of blended yarns give better thin places(139), thick places (250), neps(171), unevenness (20.29) and yarn hairiness (4.30) compared with all blended yarns and 100% upland cotton Delta pine 245 variety and 100% combed waste followed by 65% combed waste - 35% Giza95. On the other hand, the highest thin places (400), thick places (514), neps (390), unevenness (22.44) and yarn hairiness (5.40) recorded by 35% Giza95-65% Delta pine245 blended yarn .It observed that yarn imperfections and yarn hairiness increased with increasing proportion of Delta pine 245 cotton variety in blended yarns. Yarn evenness increased with increasing fiber length and decreasing short fiber content (Wali 2003).

Table 5. Physical yarn properties for ring blended yarns.

Materials	Thin (50-)	Thick (+50)	Neps (+200)	Unevenness (CV %)	Hairiness
100 % Giza95	119	215	114	19.76	3.92
100 % Delta pine	444	573	421	23.50	5.75
100 % Combed waste	328	440	326	21.65	4.97
65% Giza95-35% Delta pine	283	414	275	21.02	4.72

35% Giza 95- 65% Delta pine	399	506	381	22.28	5.31
65% Giza95-35% Combed waste	139	250	171	20.29	4.30
35% Giza95-65% Combed waste	236	370	220	20.68	4.35
65% Delta pine -35% Combed waste	400	514	390	22.44	5.40
35% Delta pine – 65% Combed waste	361	471	344	21.93	5.14
LSD at 5%	21.79	15.66	14.60	0.189	0.123

Data presented in Table 6 and Fig 8 and 9 showed that yarn count had significant effect on yarn imperfections and yarn hairiness. Yarn count 40s recorded higher thin places (315), thick places (429), yarn unevenness (21.73), number of neps (306) and yarn hairiness (4.98) than 36s yarn count. It observed that yarn unevenness (CV%, the number of thin and thick places were increased with increasing yarn count.

Table 6. Effect of yarn count on physical yarn properties

Physical yarn properties	Yarn count		LSD at 5%
	36s	40s	
Thin places (-50%)	290	315	**
Thick places (+50%)	404	429	**
Neps (+200%)	281	306	**
Unevenness (CV %)	21.28	21.73	*
Hairiness	4.76	4.98	*

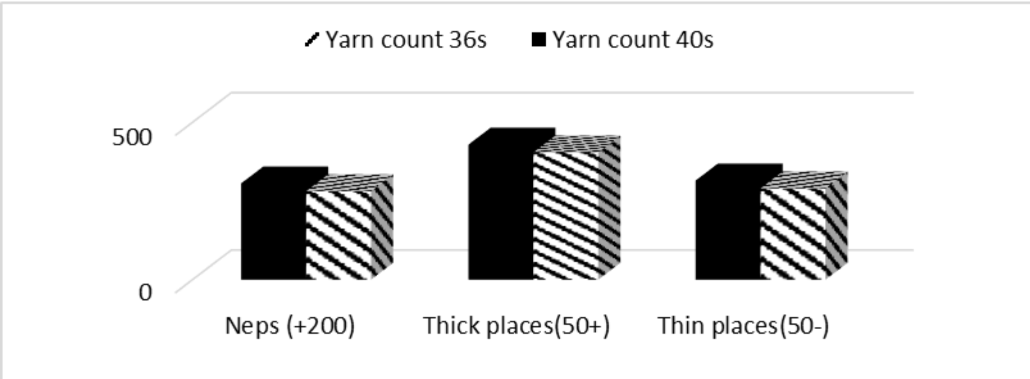

Fig.8 **N**umber of neps, thin and thick places at different yarn count**s**

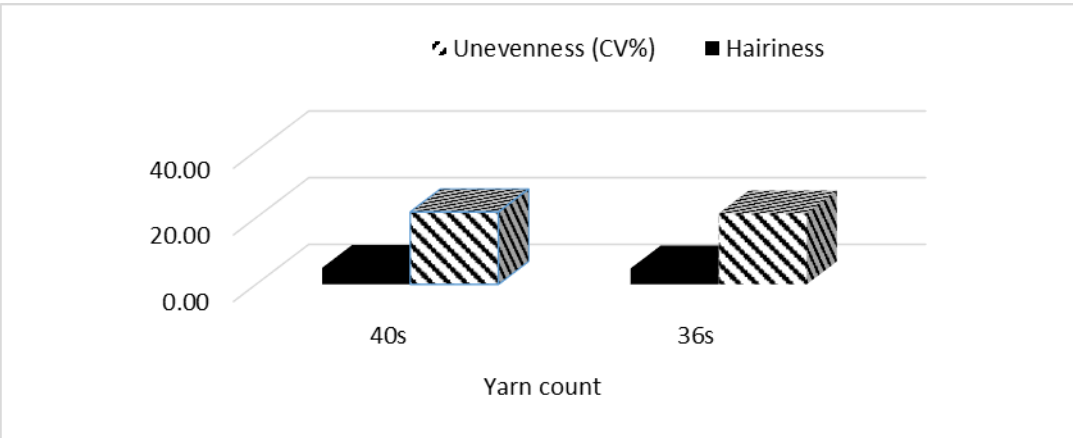

Fig.9. Yarn unevenness (CV %) and yarn hairiness at different yarn counts

As shown in Table 7 and Fig.10 showed that the interaction between blending ratio and yarn count had significant effect on all physical properties except thin and thick places. Giza95 cotton variety at 36s yarn count give the best imperfections and yarn hairiness than 100% Delta pine 245 cotton yarn, 100% combed waste and all blended yarns. 65% Giza95-35% combed waste of ring yarn spun into 36s yarn count give better unevenness

(20.09), number of neps (164) and yarn hairiness (4.08). These results are in agreement with those obtained by (Arafa2009; Abd-Elkawe and El-Sayed 2021) who stated that yarn count had significant effect on yarn strength, unevenness and yarn imperfections. It cleared that 65% Giza95-35% combed waste was the optimum blending ratio that achieves the optimum yarn quality properties.

Table7. Effect of the interaction between blending ratio and yarn count on yarn imperfections and hairiness yarn

Materials	Yarn count	Thin (50-)	Thick (50+)	Neps (200+)	CV %	Hairiness
100% Giza95	36s	92	195	94	19.11	3.84
	40s	145	235	134	20.40	4.00
100% Delta pine 245	36s	434	555	412	23.23	5.58
	40s	454	590	431	23.77	5.92
100% Combed waste	36s	320	424	298	21.44	4.85
	40s	336	456	354	21.86	5.08
65% Giza95 - 35% Delta pine	36s	262	395	264	20.84	4.48
	40s	304	433	287	21.19	4.96
35% Giza95 -65% Delta pine	36s	393	493	374	22.13	5.31
	40s	404	518	389	22.44	5.31
65% Giza95- 35% waste	36s	131	236	164	20.09	4.08
	40s	146	263	178	20.49	4.51
35% Giza95- 65% waste	36s	226	366	211	20.51	4.30
	40s	246	374	229	20.84	4.41
65% Delta pine -35% waste	36s	408	508	388	22.35	5.36
	40s	427	520	392	22.53	5.44
35% Delta pine -65% waste	36s	346	467	329	21.77	5.07
	40s	375	474	360	22.08	5.20
LSD at 5%		NS	NS	20.66	0.27	0.17

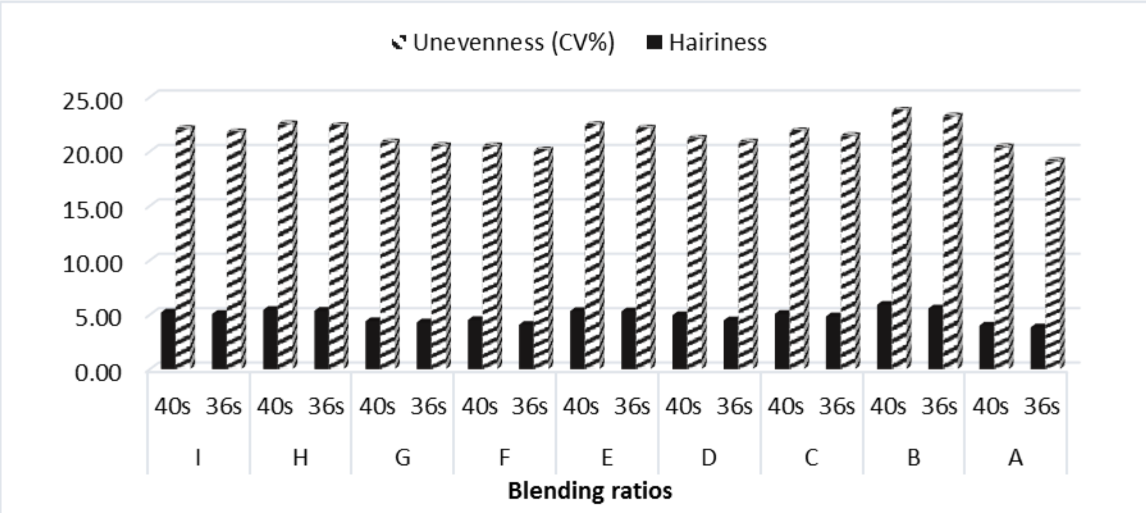

Fig.10. Yarn Unevenness and yarn hairiness for blended yarns at two yarn counts

IV. Conclusion

Recycling waste materials is very important and necessary process because it reduces the production costs, decreases the harmful impacts on environment, produces new textile products. The purpose of this investigation was to study the influence of blending ratios and its components and yarn count on fiber and yarn quality properties. Yarn count and blending ratios had significant effect on the most yarn properties. Yarn hairiness, yarn unevenness and yarn imperfection increased with increasing yarn count from 36s to 40s. While, lea count strength product, yarn strength and yarn elongation decreased with increasing yarn count. Also, increasing the proportion of upland fibers in blended yarns led to decrease yarn strength ,lea count strength and yarn elongation and increase unevenness and hairiness due to increase the amount of short fiber in blended yarn.65% Giza95-35% combed waste was the optimum blending ratio that achieves the optimum yarn quality properties. Increasing proportion of G95 cotton variety in blended samples led to improve fiber, mechanical and physical yarn properties.

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