6th International Fibre Recycling Symposium
7-8 June 2017 Manchester UK

EFFECTS OF COTTON TEXTILE WASTE PROPERTIES ON RECYCLED FIBRE QUALITY AFTER SHREDDING

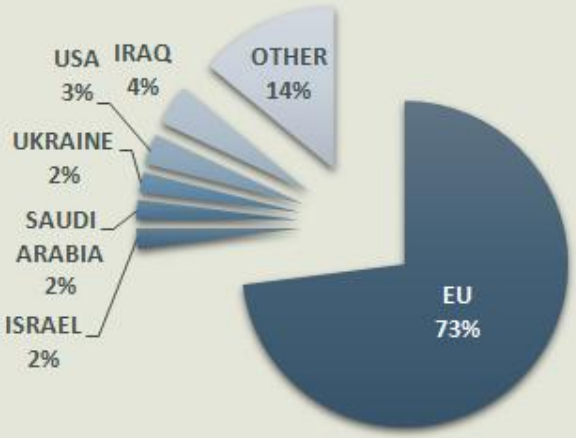
Burçin Eser[1], Pınar Çelik[2], Ahmet Çay[2]

[1]Uniteks Textile R&D Centre, İzmir, Turkey
[2]Ege University, Department of Textile Engineering, İzmir, Turkey

TURKISH TEXTILE INDUSTRY

- Textile and clothing industry is among the largest sectors of the Turkish economy
- Nearly 60,000 textile and clothing companies and employs around 2 million people (10%)
- Turkish clothing industry is the 3rd largest exporter to the European Union and 7th largest globally

TURKISH APPAREL EXPORTS



WORLD APPAREL TRADE* (2015)

Source: www.ithib.com.tr

*Billion US dollars

TURKISH TEXTILE INDUSTRY
A COTTON COUNTRY

- 7th in the world cotton production
- Although Turkey is among main cotton growers in the world, domestic cotton does not meet the production demand, thus 4th largest cotton importer

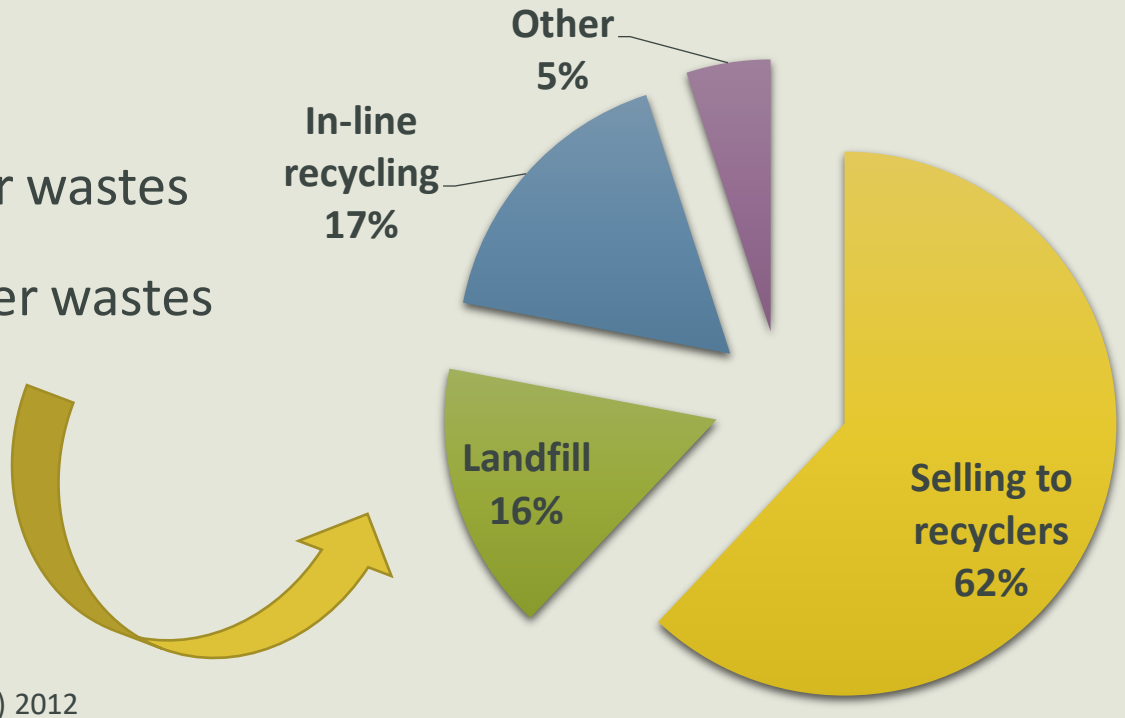
Source: Cotton Incorporated , 2016/17 May

TEXTILE RECYCLING

- **EUROPE**: 10% of the clothing waste is recycled and 8% is reused, the rest are landfilled (57%) or incinerated (25%)
- **U.S.**: 15-16% recovery rate for textiles
- **TURKEY**:

500,000 tonnes pre-consumer wastes

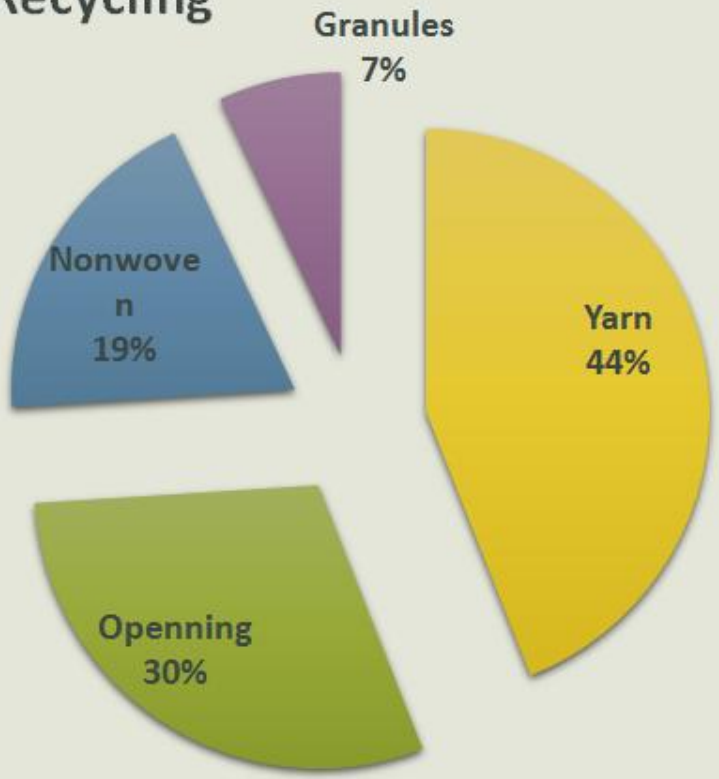
500,000 tonnes post-consumer wastes



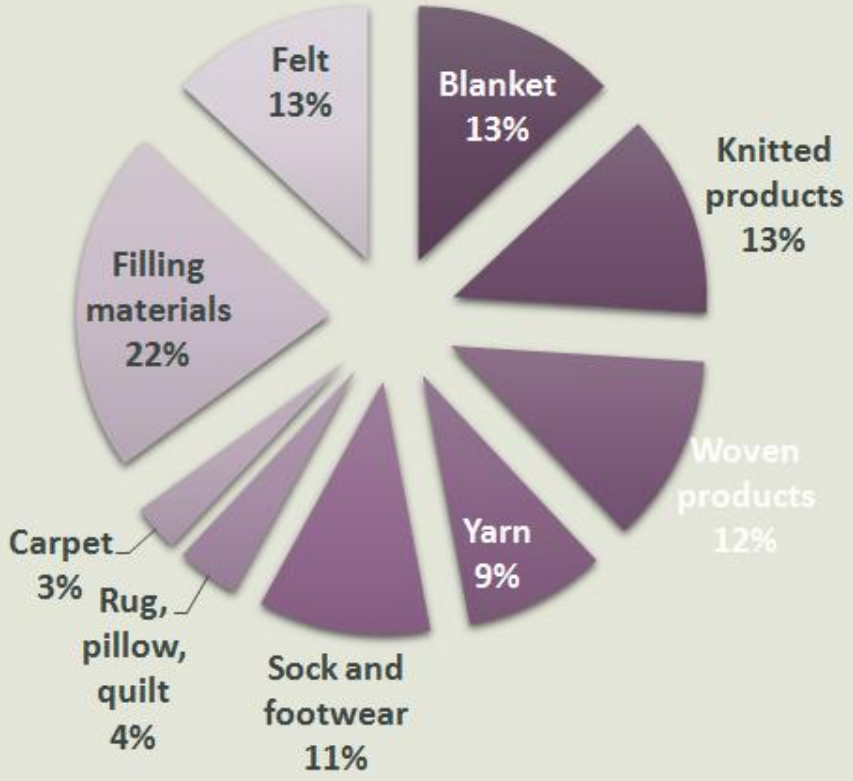
Sources: Altun S, Fibres & Textiles in Eastern Europe, 94(5) 2012
http://usaktso.org/dosya/Kurumsal/Trk_Teks_Ger_Don.pdf

TEXTILE RECYCLING IN TURKEY
Low added value products

Recycling

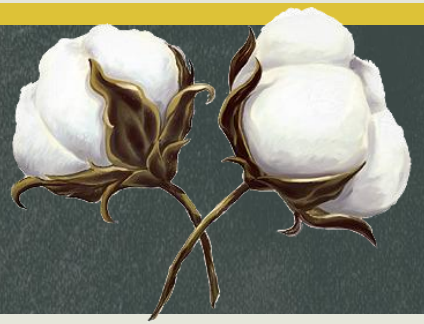


Application



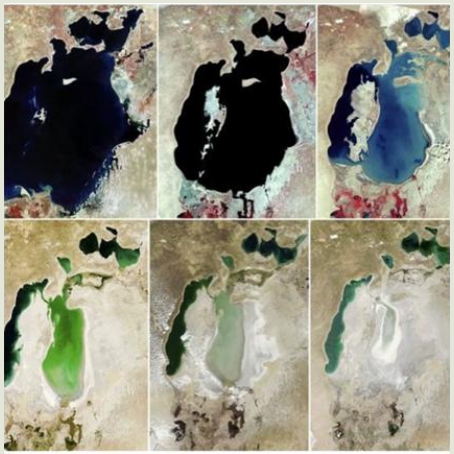
Sources: Altun S, Fibres & Textiles in Eastern Europe, 94(5) 2012
http://usaktso.org/dosya/Kurumsal/Trk_Teks_Ger_Don.pdf

COTTON – AN UNSUSTAINABLE FIBRE



- Cotton production has severe environmental impacts in terms of water consumption, land occupation, emissions and the use of pesticides.

Consumption per 1 tonnes of cotton *	
Land occupation	8×10^3- 18×10^3 km^2
Pesticides	8.3 – 13.8 kg (11% of global use)
Water	5700 m^3 – 29000 m^3
Energy	36-55 GJ



ARAL SEA
AN ENVIRONMENTAL TRADEGY

RECYCLING OF COTTON IS A MUST

ECONOMICAL SCOPE
A CALL TO ACTION

GLOBAL *FASHION* AGENDA

- Worlds most recognizable brands have began taking action and have initiated several recycling programmes
- Marketing potential

Global Fashion Agenda has identified four immediate actions points:

- Implementing design strategies for cyclability
- Increasing the volume of used garments collected
- Increasing the volume of used garments resold
- Increasing the share of garments made from recycled textile fibres

Brands or retailers committed the use of recycled textile fibres in collection range by 2020

https://www.copenhagenfashionsummit.com/global-fashion-agenda/

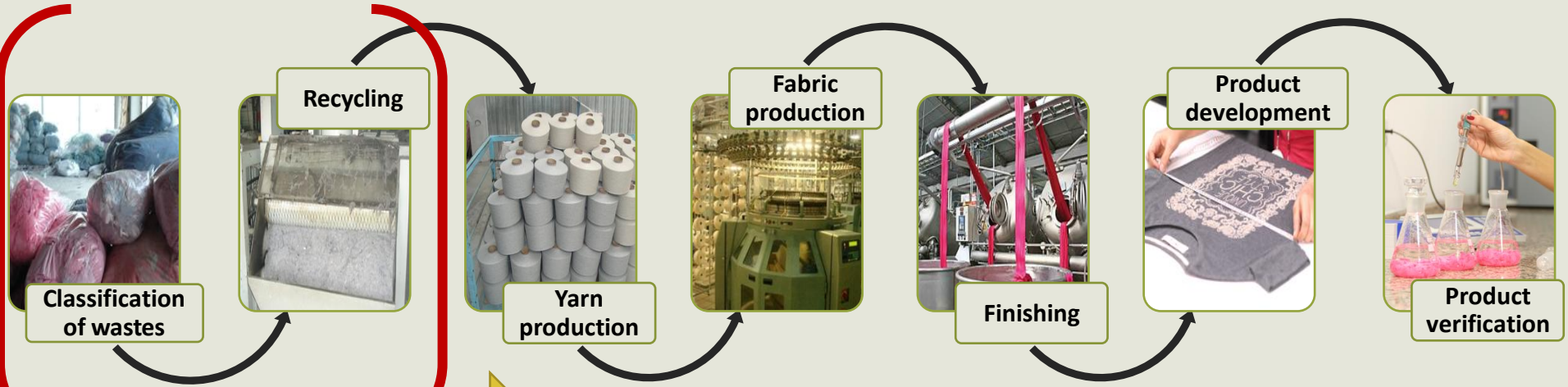
SIGNATORIES

[PAPER.], ADIDAS, AIAYU, ASOS, BESTSELLER, BETTER WORLD FASHION, BYT, DESIGNERS REMIX, DHANA INC., DK COMPANY, EILEEN FISHER, ELSK APS, FILIPPA K, GANNI , H&M, INDITEX, KAPPAHL, KERING, LACOSTE, MADS NORGAARD, MARKS & SPENCER, MUD JEANS, NORRONA SPORT , OVS SPA, SALVATION ARMY REDESIGN CPH, SKUNKFUNK, SOULLAND, STUDY 34, SUITSUPPLY, SUSANNE GULDAGER, TARGET, VAGABOND, VF CORPORATION

E! 9153 RECYCLING FIBROUS WASTE INTO ADDED VALUE PRODUCTS

- Üniteks Textile R&D Centre
- University of Bolton
- Ege University

- To assess the limitations
- To build an ecoline to develop recycled textile garments
- To create a new product platform for the top clothing retailers



EFFECTS OF WASTE PROPERTIES ?

EXPERIMENTAL

Pre-consumer 100% cotton textile wastes were collected and classified according to :

- fabric tightness (loose/single-jersey and tight/interlock)
- post-treatments (untreated raw cotton fabrics and dyed-finished cotton fabrics).

Before shredding, the fabric pieces are normally cut into a proper size.

In practice, for disintegration of textile wastes, up to 6-7 shredding passages are used continuously

- Sample size
- Shredding passage number

Samples were shredded by a pilot type shredder (Balkan Makine)

EXPERIMENTAL

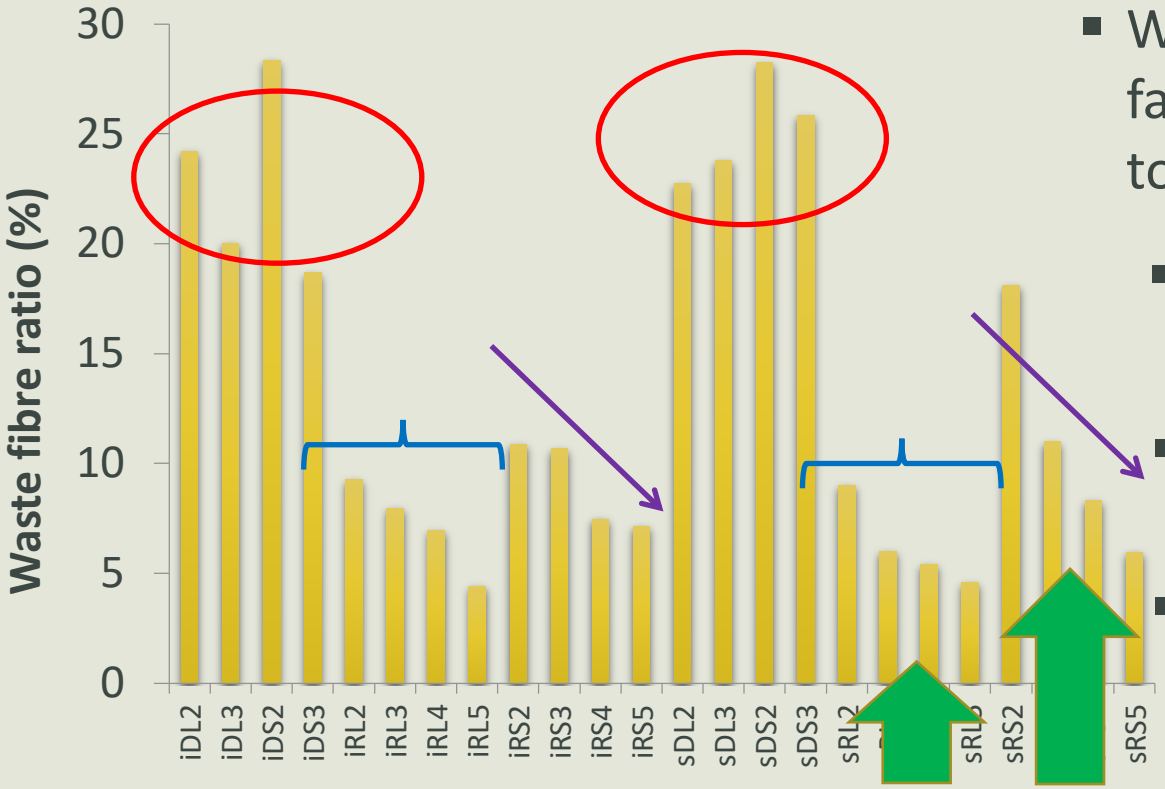
Fabric structure	Post-treatment	Feeding size	Number of passes	Notation*
Interlock	Dyed-finished cotton fabrics	Large	2	iDL2
		Large	3	iDL3
		Small	2	iDS2
		Small	3	iDS3
	Untreated raw cotton fabrics	Large	2	iRL2
		Large	3	iRL3
		Large	4	iRL4
		Large	5	iRL5
		Small	2	iRS2
		Small	3	iRS3
		Small	4	iRS4
		Small	5	iRS5
Single-jersey	Dyed-finished cotton fabrics	Large	2	sDL2
		Large	3	sDL3
		Small	2	sDS2
		Small	3	sDS3
	Untreated raw cotton fabrics	Large	2	sRL2
		Large	3	sRL3
		Large	4	sRL4
		Large	5	sRL5
		Small	2	sRS2
		Small	3	sRS3
		Small	4	sRS4
		Small	5	sRS5

*i-interlock, s-single-jersey, D-dyed, R-raw, L-large, S-small, 2,3,4,5-number of passes

EXPERIMENTAL

- The short fibre ratio of the recycled fibres was tested by SDL Atlas MDTA 3 (Micro dust and trash analyser).
- Fibre length was measured by LCT (Length Control Tester, Textechno) by using the slivers obtained from MTDA machine. LCT can process only raw cotton, therefore the fibre length of recycled cotton fabrics from untreated cotton fabrics were tested in this stage.
- In order to investigate the spinnability of the recycled fibres, slivers including 50% recycled cotton, 30% regular cotton and 20% poliester fibres were fed to Rieter M1 manual open-end spinning machine (rotor diameter 46 mm, 56000 rpm). Ne20/1 open-end yarns with an αe of 4.0 were produced.
- In the second trial, the recycled cotton ratio was increased and Ne10 open-end yarns with 80% recycled cotton and 20% polyester fibres were produced by Rieter R40 open-end spinning machine

RESULTS AND DISCUSSION
WASTE FIBRE RATIO – MDTA results



- Waste ratio of dyed-finished fabrics were higher compared to untreated raw cotton fabrics
  - Fabric tightness had no effect
  - Shredding passage number decreased waste ratio
  - Smaller sized fabrics increased waste ratio

Larger sized untreated raw cotton fabrics with 3 or more passages led to recycled cotton fibres with lower short fibre content

RESULTS AND DISCUSSION
MEAN FIBRE LENGTH – LCT results

	2.5% span length (mm)	50% span length (mm)	Mean fibre length (mm)	Short fibre ratio
iRL2	23.56	8.67	14.1	43.9
iRL3	23.84	9.34	15.67	32.4
iRL4	24.43	8.41	12.01	53.9
iRL5	23.43	8.8	14.39	42.5
iRS2	23.32	8.72	14.15	43.6
iRS3	23.07	8.72	14.13	43.7
iRS4	24.09	8.52	12.79	52.4
iRS5	23.75	9.19	16	32.2
sRL2	23.32	9.29	15.52	33.4
sRL3	23.76	9.53	16.14	29.5
sRL4	22.6	8.81	14.56	41.4
sRL5	22.64	8.46	13.36	47.6
sRS2	23.35	9.31	15.6	31.5
sRS3	23.27	9.07	15.09	37
sRS4	22.23	8.96	14.87	40.7
sRS5	23.58	9.19	15.4	35
cotton	27.67	12.5	20.59	17.4

Mean fibre length of recycled cotton fibres were approximately 25-35% shorter than standard cotton fibre

RESULTS AND DISCUSSION
MEAN FIBRE LENGTH – LCT results

	2.5% span length (mm)	50% span length (mm)	Mean fibre length (mm)	Short fibre ratio
iRL2	23.56	8.67	14.1	43.9
iRL3	23.84	9.34	15.67	32.4
iRL4	24.43	8.41	12.01	53.9
iRL5	23.43	8.8	14.39	42.5
iRS2	23.32	8.72	14.15	43.6
iRS3	23.07	8.72	14.13	43.7
iRS4	24.09	8.52	12.79	52.4
iRS5	23.75	9.19	16	32.2
sRL2	23.32	9.29	15.52	33.4
sRL3	23.76	9.53	16.14	29.5
sRL4	22.6	8.81	14.56	41.4
sRL5	22.64	8.46	13.36	47.6
sRS2	23.35	9.31	15.6	31.5
sRS3	23.27	9.07	15.09	37
sRS4	22.23	8.96	14.87	40.7
sRS5	23.58	9.19	15.4	35
cotton	27.67	12.5	20.59	17.4

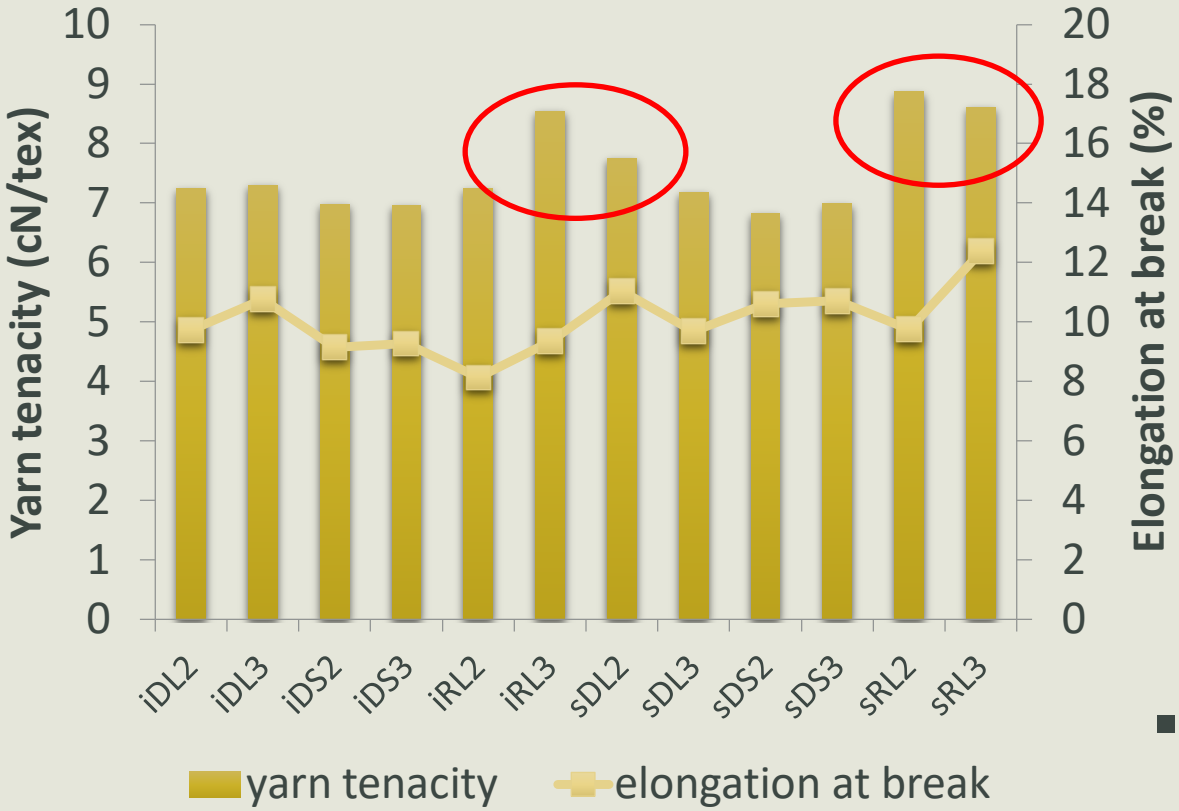
The effects of material size and shredding passage number on fibre length are ambiguous

Recycled cotton fibres obtained from loose (single-jersey) samples had higher 50% span length, mean fibre length and uniformity values and lower short fibre ratio, in general

RESULTS AND DISCUSSION

YARN TENACITY – Rieter M1 results

50% r-cotton
30% cotton
20% polyester
Ne 20



- Tenacity of untreated-raw fabric based yarns were higher compared to dyed-finished fabric based ones

- Effects of fabric structure, sample size and shredding passage number are insignificant

RESULTS AND DISCUSSION
USTER TEST – Rieter M1 results

50% r-cotton
30% cotton
20% polyester
Ne 20

	Uster Cv%	Thin places/1000m (-50%)	Thick places/1000m (+50%)	Neps/1000m (+28%)	Uster hairiness (H)
iDL2	19.74	90	1490	2020	5.65
iDL3	20.68	60	1860	2070	5.7
iDS2	22.36	130	1750	2170	5.78
iDS3	21.91	160	2170	3310	5.76
iRL2	22.64	200	2370	2460	5.69
iRL3	20.8	30	1330	1570	5.4
sDL2	23.13	150	2330	3510	6.16
sDL3	23.2	220	2770	4230	5.81
sDS2	23.43	290	2320	3210	6.19
sDS3	22.86	240	2230	3680	5.91
sRL2	21.95	270	1700	1930	5.19
sRL3	22.73	230	1810	2420	5.29

Fabric structure affects yarn evenness

Evenness of yarns produced from interlock based recycled fibres were lower compared to yarns produced from single-jersey based ones

	Fabric structure	Post treatments	Shredding size	Number of shredding passages
Uster Cv%	**0.013***	0.860	0.291	0.803
Thin places	0.923	0.552	0.719	0.208
Thick places	0.138	0.241	0.559	0.893
Neps	0.059	0.066	0.291	0.522
Hairiness	0.616	**0.004***	0.115	0.484

*statistically significant

RESULTS AND DISCUSSION
USTER TEST – Rieter M1 results

50% r-cotton
30% cotton
20% polyester
Ne 20

	Uster Cv%	Thin places/1000m (-50%)	Thick places/1000m (+50%)	Neps/1000m (+28%)	Uster hairiness (H)
iDL2	19.74	90	1490	2020	5.65
iDL3	20.68	60	1860	2070	5.7
iDS2	22.36	130	1750	2170	5.78
iDS3	21.91	160	2170	3310	5.76
iRL2	22.64	200	2370	2460	5.69
iRL3	20.8	30	1330	1570	5.4
sDL2	23.13	150	2330	3510	6.16
sDL3	23.2	220	2770	4230	5.81
sDS2	23.43	290	2320	3210	6.19
sDS3	22.86	240	2230	3680	5.91
sRL2	21.95	270	1700	1930	5.19
sRL3	22.73	230	1810	2420	5.29

Post treatments affects yarn hairiness

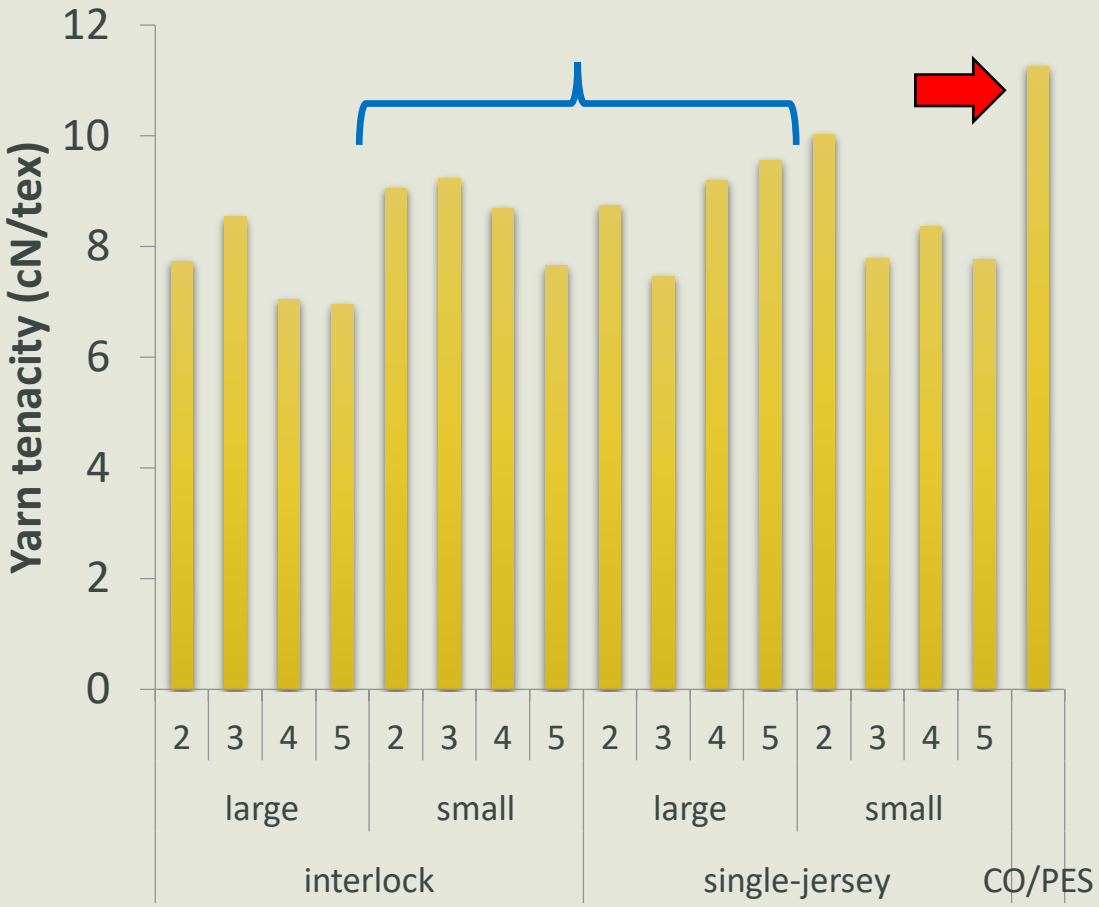
Hairiness of the yarns produced from raw fabric based recycled fibres were lower compared to those of dyed-finished fabric based ones

	Fabric structure	Post treatments	Shredding size	Number of shredding passages
Uster Cv%	**0.013***	0.860	0.291	0.803
Thin places	0.923	0.552	0.719	0.208
Thick places	0.138	0.241	0.559	0.893
Neps	0.059	0.066	0.291	0.522
Hairiness	0.616	**0.004***	0.115	0.484

*statistically significant

RESULTS AND DISCUSSION
YARN TENACITY – Rieter R40 results

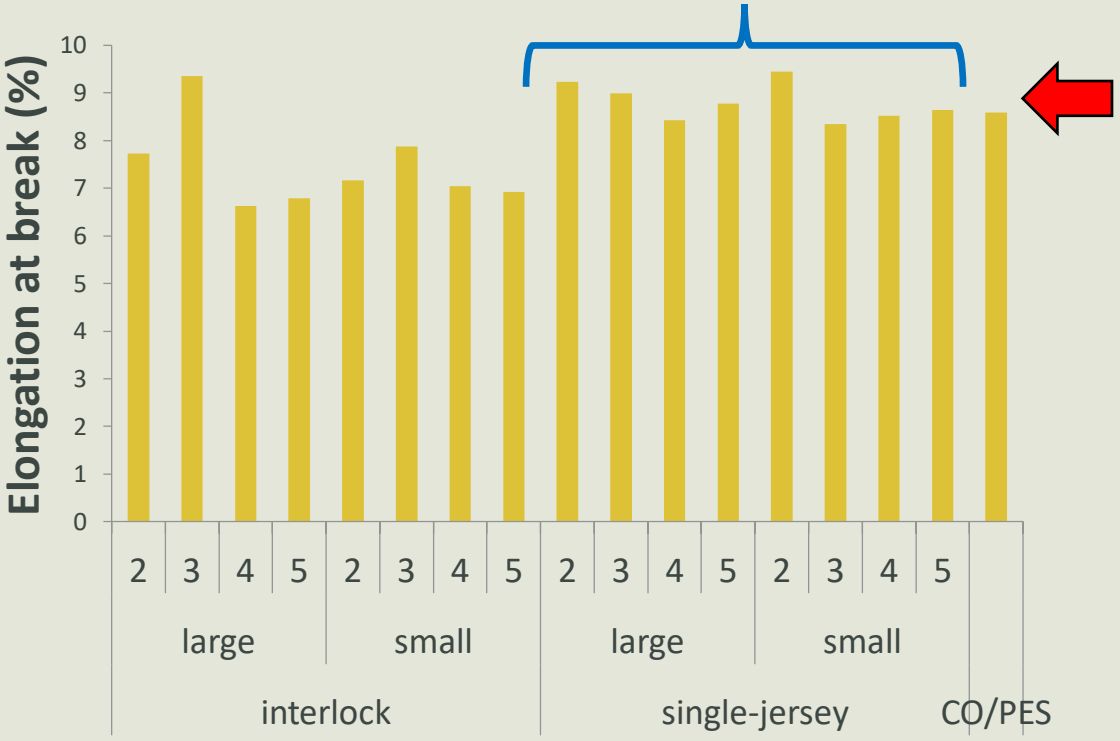
80% r-cotton
20% polyester
Ne 10



- Tenacity of rCO/PES yarns were 11%-38% lower compared to standard CO/PES yarn
- In general small piece interlock based and large piece single-jersey based yarns had higher tenacity

RESULTS AND DISCUSSION
ELONGATION AT BREAK– Rieter R40 results

80% r-cotton
20% polyester
Ne 10



- rCO/PES yarns had comparable elongation compared to standard CO/PES yarn
- In general single-jersey based yarns had higher elongation at break values

RESULTS AND DISCUSSION
USTER TEST – Rieter R40 results

80% r-cotton
20% polyester
Ne 10

	Uster Cv%	Thin places/1000m (-50%)	Thick places/1000m (+50%)	Neps/1000m (+28%)	Uster hairiness (H)
iRL2	17.27	190	270	150	6.83
iRL3	18.99	40	310	150	6.66
iRL4	18.13	30	610	420	6.73
iRL5	19.07	40	530	480	6.88
iRS2	17.53	20	570	530	6.65
iRS3	17.69	50	500	320	6.77
iRS4	16.44	0	490	260	6.65
iRS5	19.25	40	520	430	6.66
sRL2	14.2	0	250	120	6.47
sRL3	17.05	10	170	140	6.5
sRL4	17.26	20	370	240	6.49
sRL5	18.59	70	540	320	6.73
sRS2	14.36	0	250	230	6.32
sRS3	14.94	0	350	240	6.41
sRS4	16.84	10	410	360	6.32
sRS5	18.13	60	540	380	6.53
CO/PES	14.5	0	0	0	6.16

- Single-jersey based rCO/PES yarns had lower yarn hairiness

CONCLUSION

- **Use of untreated-raw cotton wastes**

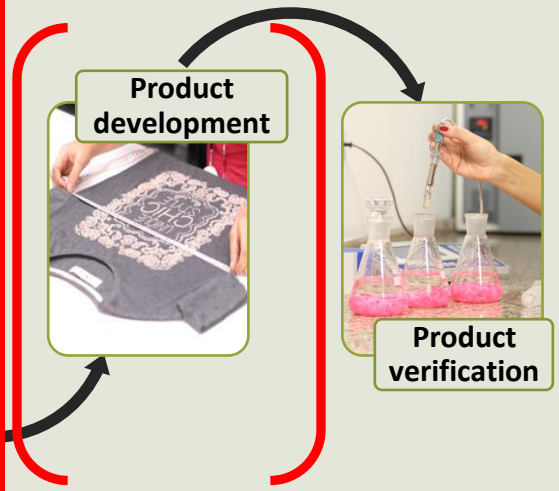
- Lower short fibre ratio
- Higher yarn tenacity
- Lower hairiness

- **Use of loose (single-jersey) wastes**

- Higher mean fibre length
- Lower hairiness

- Higher quality recycled cotton fibres can be achieved by the selection of loosely knitted raw cotton fabrics preferably from pre-consumer textile wastes

PRODUCT DEVELOPMENT



- Next:
  - Washings
  - Printing
  - Verification

THANK YOU

ahmet.cay@ege.edu.tr

For detailed information on yarn and fabric production, please contact

Prof. Dr. Pınar Çelik

pinar.celik@ege.edu.tr

Financial support from The Scientific and Technical Research Council of Turkey (TUBITAK) – TEYDEB (No:9140051) for EUREKA E!9153 project is gratefully acknowledged.

*Sources:

Lena Youhanan. (2013), “Environmental Assessment of Textile Material Recovery Techniques”, Examining Textile Flows in Sweden, MSc Thesis, Industrial Ecology, Royal Institute of Technology, Stockholm.

Bartl, A., (2011), “Textile Waste”, In: T. M. Letcher & D. A. Vallero, eds. Waste - Handbook for Management. Oxford: Elsevier Inc., 167-179.