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Development of High Count Repurposed Yarns from Pre Consumer Textile Waste

Ananya Mitra Pramanik[1], Anjali Agrawal[2]

[1]*Assistant Professor, Textile Design Department, National Institute of Fashion Technology, New Delhi-110016, India.*

[2]*Assistant Professor, School of Fashion and Design, GD Goenka University, Gurugram, Haryana, 122001, India.*

Abstract

Currently, pre consumer wastes are used to create low count repurposed yarns (RY) which has a limited usage in the floor covering industry. A previous research paper had established that there was a need to reduce the thickness of the existing repurposed yarns (RY) to increase its usage. Therefore, the objective of this present study was to undertake design intervention on the existing RY to change its count. Wider usage of RY can divert maximum pre-consumer textile waste from reaching the landfills. The count of the existing RY procured from Bhadohi was 0.23Ne which was made finer by using the manual spinning method. The methodology used in this study was of practice based research through which solutions were designed in the existing repurposed yarns to create higher count yarns and hence, make it suitable for generic end use. Two different counts of yarns were created in this research study, which were then characterized for their tensile strength, wash, and rub and perspiration fastness. The results of the characterization were compared to the existing RY. The modified repurposed yarns (MRY) were found to be 0.44Ne and 0.98Ne count which was much higher than the existing yarns. The tenacity of the yarns was mostly found to be improved in comparison to the existing RY yarns. Fastness properties of the yarns were also found improved in comparison to the existing yarns.

Keywords: Design intervention • Pre Consumer • Repurposing • Sustainability • Textile Waste • Yarn Industry

Introduction

Waste is a by-product of almost all modern industries and currently, earth is struggling with growing waste. Textile industry is one of the major contributors to waste. Pre-consumer waste makes up to 10% - 20% of the entire amount of discarded textiles and primarily includes unused and discarded textiles before it is ready for consumer usage such as virgin yarns, factory dead stock, factory off cuts, textile pieces etc . This waste not only occupies the landfill but it also leads to the destruction of the environment by radiating toxic gases which seeps inside the earth and pollutes the ground water. This creates hazard for the survival of plants and animals . Therefore, it was considered essential to develop techniques to minimise textile waste and achieve sustainable development.

Various techniques have been reported by researchers for waste minimisation e.g. recycling, reusing, repurposing, reclaiming etc. Amongst these, this study investigates the method of repurposing as a waste minimisation technique. Repurposing can be defined as a technique of utilising textile waste which is different from its original intended use. There are a number of methods which are categorised underneath repurposing techniques such as quilting, felting, patchwork, kantha etc. Manufacturing of yarns from pre-consumer textile waste is one of the methods of repurposing . Although, repurposed yarns (RY) are available in the form of rugs in the market but not much information is available on the RY made from pre-consumer textile waste. A semi structured interview conducted by the researchers to gain knowledge about these yarns exhibited various aspects (characteristics and limitations) of RY. Colourful look, strength, and diverse textures were determined as the strength of RY. Apart from this, RY have a number of limitations also such as thickness, colour matching, and utilisation of extensive hand labour in its making. Amongst these, thickness of RY was found to be the major area of concern. Unsorted RYs are made in low count (thick) yarns and are therefore coarse and suitable only for the making of carpets and rugs in the floor covering industry. Although, repurposing techniques have been used through the ages, it is imperative that more traditional waste minimising techniques are documented and understood in order to improvise upon them, which can result in reduced waste and effectuate sustainable development.

Hence, this current research study was undertaken to overcome the drawbacks of thickness of RY and making it suitable for generic usage. To achieve this objective, RY was spun into higher count yarns using hand spinning method and characterized for its strength and fastness using standard methods.

Materials and Materials

Materials- Pre consumer waste (Figure 1), existing mixed coloured RY1 (Figure 2) and colour sorted RY2 (Figure 3) were procured from Mahalaxmi Yarns Private Limited, Bhadohi. The RY are called cho-cho in local usage (in

U.P and Haryana regions of India) Methods

The study employs practice based research methodology (Figure-4), which was first developed in UK and is useful for conducting research in the field of design and creative arts. The word “practice” means empirical use of a method, idea, or belief . Artists and designers conduct “research” as an essential segment of their everyday practice through their search for new improvisations in methods and techniques for creating a new or increasing the usability of existing objects It may be noted that creative practices on its own may not constitute research but creative practices in a methodical way might constitute the basis of research study . In this particular study, practice based research methods were implemented through design intervention on the existing repurposed yarns. Two experiments were conducted using practiced based research methods as given in section 2.2.1. After the creation of the yarns using the yarn experiments-I and yarn experiment-II, the yarn count was determined using test method IS: 1315-1977. An average of 30 readings was reported. The breaking strength was determined using test method IS: 1670-91and Tenacity of the yarns was assessed using test method IS: 1670-91. Elongation at break was determined using test method 1670-91. Wash colour fastness was determined using test method IS/ ISO105-C10:2010(A1) and perspiration fastness was evaluated using test method IS: 766:1988

***Address for Correspondence:** Ananya Mitra Pramanik, Assistant Professor, Textile Design Department, National Institute of Fashion Technology, New Delhi-110016, India, Tel: +91-11-9811232907; E-mail: ananya.pramanik@nift.ac.in*

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Figure 1. Pre consumer waste.

Figure 2. A close up view of the hank of the mixed coloured RY1 procured from Bhadohi.

Figure 3. A close up view of the hank of the colour sorted RY2 procured from Bhadohi.

Figure 4. The Research Methodology followed for this study.

(reaffirmed 2009). Finally rubbing fastness was determined using test method IS: 971:1983 (reaffirmed 2009).

Yarn Design Experiment-1:

The main objective of this experiment was to spin higher counts RY. The existing RY which was bulky and used as weft insertions in rugs and durries. The modified repurposed yarns (MRY) were created at Mahalaxmi Yarns Private Limited (MYPL), Bhadohi, and Uttar Pradesh which is the hub of production of the unsorted RY made from pre consumer industry waste in India. The researcher made a sample of high count RY and submitted to MYPL. The waste was held on the left hand of the spinner and twisted to form a yarn with the right hand. Simultaneously, the wooden spindle was rotated to help in twisting the yarns and also to wind it up. Figure 5 shows a young hand spinner working on the pre-consumer textile waste to draw a finer count yarn by rotating a wooden spindle. The wooden spindle wound up the yarns simultaneously as they were formed. Figure 6 shows the newly spun RY being wound on the wooden spindle. The yarns formed were then converted into a hank and was ready to be used. Figure 7 shows the high count yarns being made into hanks ready for use. The hanks needed to be wound on a bobbin and then on a shuttle before being used for weaving. Figure 8 shows the close up view of the MRY developed through Yarn Design Experiment-1

Yarn Design Experiment-2:

This experiment focussed onto spin RY with a count higher than MRY1. The researcher wanted to create a yarn finer than the one developed through

Figure 5. A young hand spinner working on the pre consumer textile waste to draw a finer count yarn (MRY1) by rotating a wooden spindle.

Figure 6. The MRY1 yarns being wound on the wooden spindle.

Figure 7. The high count yarns being made into hanks ready for use.

Figure 8. The close up view of the 0.44N^{e} count (MRY1) repurposed yarns developed through Yarn Design Experiment-1.

Yarn Design Experiment-I. However, the manual spinner at MYPL was unable to create a yarn which was finer than the one created as a result of Yarn Experiment-I. Therefore, the researcher undertook to self spin a finer RY yarn count so that a finer fabric can be generated from it. For Yarn Design Experiment-2, the researcher opened up the existing RY1 procured yarns from MYPL. Figure 9 shows the constituents of the opened up RY. The constituents of the RY were multi coloured yarn pieces, fabric pieces and fibres. The RY were opened and straightened so that its constituents lay parallel to each other. Figure-10 shows the pulling and straightening of the yarn pieces so that they lie parallel to each other. The more parallel the waste pieces lay to each other, the finer the yarns can be twisted. A paper straw was used as a spindle to hold the yarns. Figure 11 shows the yarns formed being twisting together onto a paper straw (used here as a spindle) core. Figure 12 shows the close up view of the finer repurposed yarns developed through yarn experiment-2

Characterization of yarns

The RYs and the MRYs were tested for the parameters of count, tenacity and fastness so as to compare their characteristics. Table 1 shows the details of the characterisation of the existing RYs and Table 2 shows the list of the characterisation of MRYs.

Figure 9. The opened up existing RY yarns consisting of waste yarns, fibres and cloth pieces.

Figure 10. The pulling and straightening of the yarn pieces so that they lie parallel to each other. The more parallel the waste pieces lie to each other, the finer the yarns can be twisted.

Figure 11. The yarns are formed by twisting the waste pieces together onto a paper straw (used here as a spindle) core.

Figure 12. The close up view of the fine repurposed yarns (MRY2) with count 0.98N^{e} developed through Yarn Experiment-2 of this research.

Results and Discussion

Through Yarn Design Experiment-1 and Yarn Design Experiment-2, two varieties of finer yarn counts were created using the pre-consumer textile waste. The first sample of modified repurposed yarns hand spun at MYPL was named MRY1. The second sample of modified repurposed yarns which was sun by the researcher was named MRY2.

Comparative characteristics of RY1, RY2, MRY1 and MRY2

Yarn count

The yarn counts created as the result of design intervention was found much finer than the existing yarns. While comparing the four reports it was found that although the MRY1 and MRY2 were the finest yarns and had increased breaking strength, in comparisons to RY1 and RY2, however MRY1 and MRY2 lacked tenacity in comparison to the existing RY1 and RY2. These factors are explained in details in this section

Figure. 13 show the bar graph of comparative characteristic study of yarn count between RY1, RY2, MRY1 and MRY2**.** It was found that the MRY2 was the finest yarn with size 0.98N^{e} count. MRY1 which was developed at MYPL Bhadohi was the second finest yarn with size 0.44N^{e} count. The third finest yarn was the existing colour sorted sample RY2 which was of count 0.28N^{e} size. RYI was found the coarsest yarn with size of 0.23N^{e} count.

Fastness assessment

The objective of conducting this assessment was to determine the fastness properties of the MRY Colour fastness to washing which included the parameters of change in colour, staining on wool, staining on acrylic, staining on polyester, staining on nylon, staining on cotton and staining on acetate were measured using test method IS/ ISO 105-C10:2010 (A1). Figure. 14 show the bar graph of the comparative study of yarn colour fastness to washing. RY2 reported the lowest colour fastness to washing properties with staining on wool reported Grade 3-4 while staining on acrylic were also reported as Grade 3-4. In comparison RY1, MRY1 and MRY2 reported the grades of 4-5 under the wash fastness parameters of staining on wool and staining on acrylic. For RY2, MRY1 and MRY2 the parameter of staining on nylon reported a low Grade-3. RY1 reported the highest resistance to

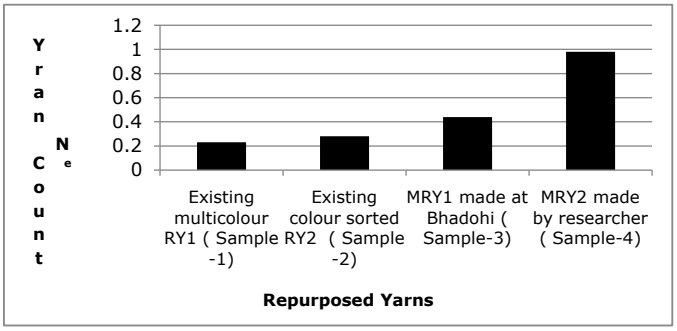

Figure 13. Bar graph of the comparative study of yarn counts.

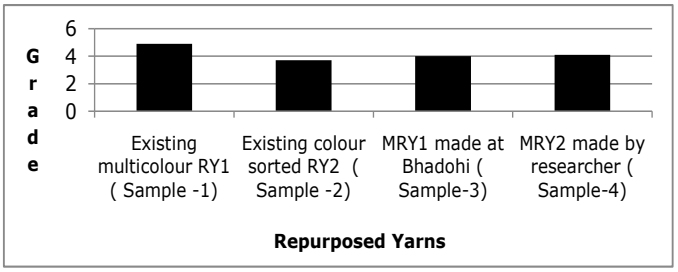

Figure 14. Bar graph of the comparative study of yarn colour fastness to washing.

staining on nylon with a high Grade 4-5. For the samples of RY2, MRY1 and MRY2 the parameter of staining on cotton reported low at Grade-2-3, whereas RY1 reported the highest resistance to staining on cotton and reported a high Grade 4-5.

Colour fastness to rubbing which included the parameters of dry rubbing fastness and wet rubbing fastness were measured using test method IS: 766:1988 (reaffirmed 2009). All the samples of RY1, RY2, MRY1 and MRY2 reported a high parameter of dry rubbing fastness of Grade 4-5. However all the samples of RY1, RY2, MRY1 and MRY2 reported a medium parameter of wet rubbing fastness of Grade 3-4? Figure. 15 show the bar graph of the comparative study of yarn colour fastness to rubbing

Colour fastness to perspiration which included the parameters of change in colour, staining on wool, staining on acrylic, staining on polyester, staining on nylon, staining on cotton and staining on acetate were measured using test method IS:971:1983 (reaffirmed 2009). The samples of RY1, RY2, MRY1 and MRY2 reported high parameters in change in colour, staining on wool, staining on acrylic and staining on polyester at Grade 4-5. The samples of RY1 and RY2 reported high parameters of perspiration staining on nylon and staining on cotton of Grade 4-5. The samples of MRY1 and MRY2 reported medium parameters of perspiration staining on nylon and staining on cotton of Grade 3-4. Figure 16. Shows the bar graph of the comparative study of yarn colour fastness to perspiration.

Thus the comparative characterisation report indicated that the MRY properties strengthened in some parameters whereas it was found feeble in few other parameters. Colour fastness to washing, rubbing and perspiration was strong for the MRYs; however certain parameters of wash fastness staining on nylon and wash fastness staining on cotton fell in the medium

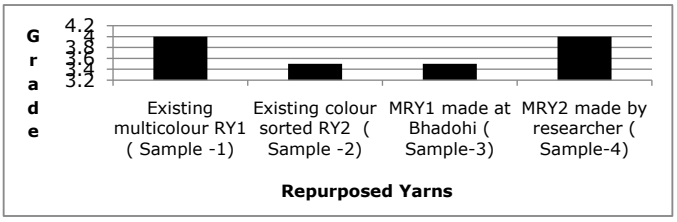

Figure 15. Bar graph of the comparative study of yarn colour fastness to rubbing.

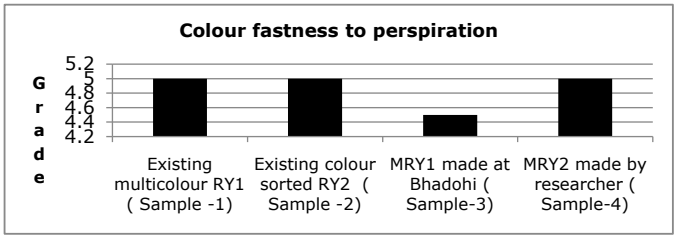

Figure 16. Bar graph of the comparative study of yarn colour fastness to perspiration.

range. Also wet rubbing fastness, perspiration staining on nylon and perspiration staining on cotton remained in the medium range for the MRYs. Tenacity and CV% elongation at break tended to be feeble in both MRY1 and MRY2. This may be caused by the lower twist per inch of these yarns in comparison to RY1 and RY2 . Conversely, this character of the MRY can be altered if mechanized spinning is conducted or more twist is added to the yarn by hand during the hand spinning process. It was also noted in that the breaking strength increased considerably in the MRYs in comparison to the RYs. This is attributed to parallelization of MRY during the process of refinement and re spinning from RY.

Tensile strength

The breaking strength and CV% of strength was determined using test method IS: 1670-91 with 30 readings. In this report it was noted that the breaking strength increased considerably in the MRYs. The MRY2 reported breaking strength of 48.88 kgf, whereas the MRY1 reported the breaking strength of 27.04 kgf. RY2 reported the breaking strength of 13.48 kgf which was lower than the breaking strength of the RY1, which reported a breaking strength of 16.56. The breaking strength of the MRY was improved, as the MRY yarns were made more parallel during the process of refinement and re spinning from RY. Figure 17 shows the bar graph of comparative characterisation study of the breaking strength indicating that RY2 is the weakest yarn or has the lowest breaking strength between all the four samples of RY1, RY2, MRY1 and MRY2**.** This report also indicated that MRY2 is the yarn which is the strongest or has the highest breaking point. In RY2 the CV% of strength was recorded as 28.8%. This value was the lowest amongst all the 4 samples and this indicated the highest elongation strength. The second highest elongation strength was noted in the MRY2 with CV% of strength recorded as 29.2%. The RY1 reported a CV% of strength recorded as 29.9%. MRY1 recorded the highest CV% of strength at 40.3% which indicated that MRY1 has the lowest elongation strength. The CV% of strength was lacking in MRY1 and MRY2 due to the low twist per inch of these yarns in comparison to RY1 and RY2.

The tenacity (RKM) was measured using test method IS: 1670-91. Figure 18 shows the bar graph of comparative characterisation study of tenacity. RY1 reported the highest tenacity of 6.45 g/Tex whereas RY2 reported the second highest tenacity of 6.39 g/Tex. MRY1 recorded the third highest tenacity of 2.01 g/Tex, while MRY2 displayed the least tenacity of 6.45 g/Tex. Therefore it can be concluded that the MRYs lacked tenacity in comparison to the existing RYs

Elongation at break and CV% of elongation was measured using test method IS: 1670-91. Figure 19 shows the bar graph of comparative characterisation study of yarn elongation at break. RY1 reported the highest elongation at break of 14.56%. RY2 reported the second highest elongation at break of 8.98%. MRY1 recorded the third highest elongation at break of 5.88% while MRY2 displayed the least tenacity of elongation at break at 5.46%. Therefore it can be concluded that the MRYs lacked the property of elongation at break in comparison to the existing RYs. Tenacity of elongation at break was lacking in MRY1 and MRY2 due to the low twist per inch of these yarns in comparison to RY1 and RY2

In RY2 the CV% of elongation was recorded as 24.2%. This value was the lowest amongst all the 4 samples and this indicated the highest ratio between the increased length and the initial length at the point of yield. RY2 reported

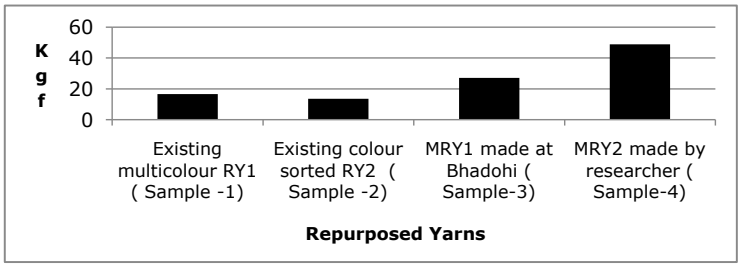

Figure 17. Bar graph of the comparative study of breaking strength.

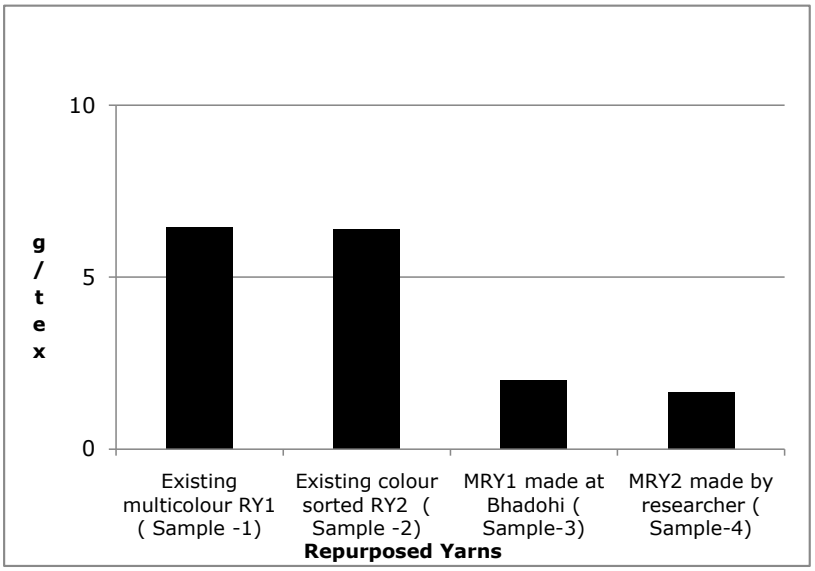

Figure 18. Bar graph of the comparative study of yarn tenacity.

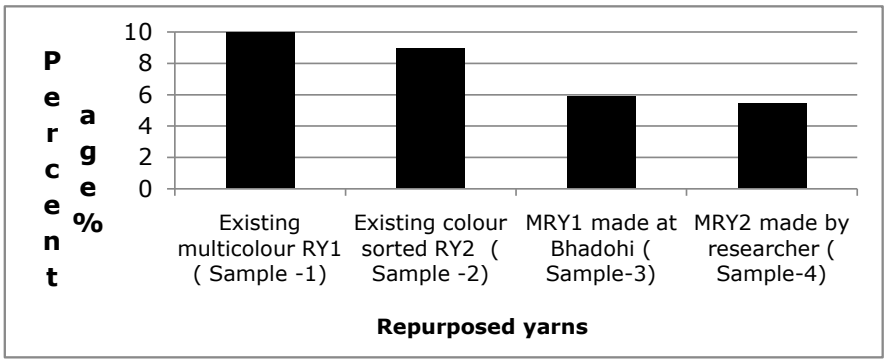

Figure 19. Bar graph of the comparative study of yarn elongation at break.

a CV% of strength recorded as 31.5%. Therefore RY1 recorded the second highest elongation strength. The second lowest elongation strength was noted in MRY2 with CV% of elongation recorded as 34.3%. MRY1 recorded the highest CV% of elongation at 45.5% which indicated that MRY1 has the lowest elongation strength. Elongation strength was lacking in MRY1 and MRY2 due to the low twist per inch of these yarns in comparison to RY1 and RY2.

Conclusion

This research focuses on the repurposing of textile pre-consumer waste.into repurposed yarns. Currently low count (thick) repurposed yarns are made from this waste which is suitable for making carpets and rugs in the floor covering industry. The yarn size currently available is between 0.23N^e to 0.44N^e Through the primary research of interacting with prominent textile industry members a need was felt to create high count (thin) yarns from this waste such that the yarns created are suitable for generic end use and not restricted to the floor covering industry. Following these research objectives two types of high count yarns MRY1 and MRY2 were developed. Through the characterisation of the newly developed yarns the MRY1 was found to be of 0.44N^e count whereas MRY2 was of 0.98N^e count. The resultant developed yarns were much finer and therefore perceived suitable to be woven into fabrics for various uses ranging from apparels to home furnishings. The newly developed yarns were also characterised for their tensile strength and wash fastness properties. All the results were comparable to the existing RY yarns. Although in certain areas like breaking strength, the MRYs had higher values than the RYs. Also the parameters of colour fastness to washing, colour fastness to rubbing and colour fastness to perspiration was strong for the MRYs. However tenacity and CV% elongation at break tended to be feeble in both MRY1 and MRY2. This property can be improved by increasing the TPI of the yarns. Thus this research explored an established method of waste minimisation and improved it further resulting in the increase of the scope of this technique

References

Table 1. The details of the characterisation of the existing RY and colour sorted RY.

S. no	Test parameters		Test method	Test results Sample: RY 1			Test results Sample: RY 2
1)	Yarn count, Ne (with 30 readings)		IS:1315-1977	0.23s			0.28s
2) a)	Breaking strength, kgf CV% of strength (with 30 readings)		IS:1670-91	16.56 29.9			13.48 28.8
b)	Tenacity (RKM), g/tex		IS:1670-91	6.45			6.39
C)	Elongation at break, % CV% of elongation		IS:1670-91	14.56 31.5			8.98 24.2
S no	**Test parameters**	**Test method**	**Unit**	**Test results Sample: RY 1**			**Test results Sample: RY 2**
1.	Colour fastness to washing Change in Color Staining on Wool Staining on Acrylic Staining on Polyester Staining on Nylon Staining on Cotton Staining on Acetate	IS/ ISO 105-C10:2010 (A1)	Grade	 4 4-5 4-5 4-5 4-5 4-5			 4 3-4 3-4 4 3 2-3 4
2.	Colour fastness to rubbing dry wet	IS:766:1988 (reaffirmed 2009)	Grade	 4 3-4			 4 3
3.	Colour fastness to perspiration Change in Colour Staining on Wool Staining on Acrylic Staining on Polyester Staining on Nylon Staining on Cotton Staining on Acetate	IS:971:1983 (reaffirmed 2009)	Grade	acidic 4-5 4-5 4-5 4-5 4-5 4-5 4-5	alkaline 4-5 4-5 4-5 4-5 4-5 4-5 4-5	acidic 4-5 4-5 4-5 4-5 4-5 3-4 4-5	alkaline 4-5 4-5 4-5 4-5 4-5 3-4 4-5

Table 2. The details of the characterisation of the MRY.

S. no	Test parameters	Test method	Unit	Test results Sample-MRY1		Test results Sample MRY2	
1.	Colour fastness to washing Change in Colour Staining on Wool Staining on Acrylic Staining on Polyester Staining on Nylon Staining on Cotton Staining on Acetate	IS/ ISO 105-C10:2010 (A1)	Grade	 4 4-5 4 4-5 3 2 4-5		 4 4-5 4-5 4-5 3 2-3 4	
2.	Colour fastness to rubbing dry wet	IS:766:1988 (reaffirmed 2009)	Grade	 3-4 3		 4 3-4	
3.	Colour fastness to perspiration Change in Colour Staining on Wool Staining on Acrylic Staining on Polyester Staining on Nylon Staining on Cotton Staining on Acetate	IS:971:1983 (reaffirmed 2009)	Grade	acidic 4-5 4-5 4-5 4-5 3-4 3-4 4	alkaline 4-5 4-5 4-5 4-5 3-4 3-4 4	acidic 4-5 4-5 4-5 4-5 4-5 4 4-5	alkaline 4-5 4-5 4-5 4-5 4 4 4-5
S. no	**Test parameters**	**Test method**		**Test results Sample-MRY1**		**Test results Sample-MRY2**	
1)	Yarn count, Ne (with 30 readings)	IS:1315-1977		0.44s		0.98s	
2) a)	Breaking strength, kgf CV% of strength (with 30 readings)	IS:1670-91		27.04 40.3		48.88 29.2	
b)	Tenacity (RKM), g/tex	IS:1670-91		2.01		1.66	
C)	Elongation at break, % CV% of elongation	IS:1670-91		5.88 45.5		5.46 34.3	

1. Domask JJ. "Achieving goals in higher education: An experiential approach to sustainability studies". *Int J of Sust in High Edu 2007*;8(1):53-68.
2. Fletcher K ,Grose L. "Fashion & Sustainability: Design for Change". in *Fashion & Sustainability* 2012;124-129.
3. Sengupta S, Bagga S. "Katran Collection". 2011.
4. Pramanik AM, Agrawal A. "Aspects of Repurposed Yarns". *Int J of Home Sci 2020;* 6(3):40-44.
5. Yuk-lan L. "Reusing pre-consumer textile waste". 2015; 4(2): 27 .
6. Skains RL. "Creative Practice as Research: Discourse on Methodology". *J of Med Prac* 2018;19(1):82-97.
7. Smith H, Dean R T. Practice Led Research 2009;56(3):4-5.
8. Candy L, Edmonds E, "Practice-Based Research in the Creative Arts". *MIT Press J* 2018; 51 (1) :63–69.
9. Aus R. "Trash to Trend: Using Upcycling in Fashion Design". Estonian Academy of Arts 2011.
10. Song B, Lu WY. "Effect of Twist on Transverse Impact Response of Ballistic Fiber Yarns". *Int J of Impact Eng* 2015;85:1-4.
11. Wilson D. "Fiber Strength". in *Handbook of Properties of Textile and Technical Fibres* 2005.

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