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Seam Slippage Characteristics of Woven Upholstery Fabrics Incorporating Recycled Polypropylene

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Abstract

Growing concerns regarding the environmental impacts of textile production have increased interest in recycled raw materials and more sustainable manufacturing practices. Within this context, recycled fibers offer important opportunities for conserving resources, reducing carbon emissions, and promoting circularity in the textile industry. This study investigates the seam slippage behavior of woven upholstery fabrics produced with filament weft yarns containing different proportions of recycled polypropylene (r-PP) and virgin polypropylene (v-PP). In this study, r-PP and v-PP granules were blended at different ratios and converted into filament yarns using the melt-spinning method. The resulting yarns were incorporated into woven upholstery fabrics as weft yarns, after which the fabrics were evaluated for seam slippage performance. The effects of recycled polypropylene content and fabric construction, defined by the combined weft yarn fineness and density settings, were examined statistically. The findings showed that seam slippage differed between the investigated fabric constructions. A significant interaction between blend ratio and fabric construction was detected for weft seam opening. Within the 1050 denier/7 picks/cm construction, fabrics containing 20% r-PP exhibited significantly greater weft seam opening than virgin PP fabrics. No statistically significant difference between 10% and 20% r-PP was detected for warp slippage in the 700 denier/14 picks/cm fabrics. These results suggest that the use of recycled polypropylene in upholstery fabric weft yarns is conditional on appropriate fabric construction and verification against application-specific seam performance requirements.

Keywords

Recycled Polypropylene Yarn, Seam Slippage, Upholstery Fabric, Recycling, Sustainability

1. Introduction

Textile production involves processes that harm the environment, such as high water consumption, chemical use, and carbon emissions. Therefore, the sector is turning to methods such as energy-saving production techniques, use of organic and renewable raw materials, and recycling of waste textile products. Sustainability in the textile sector means adopting environmentally friendly methods in production processes, minimizing the use of natural resources and applying circular economy principles. Recycling is one of the fundamental components of sustainable textile production, enabling waste textile products or surplus production materials to be converted back into raw materials and incorporated into the production cycle. Thus, the need for new raw materials is reduced, contributing to the protection of natural resources, reducing energy consumption, and improving waste management. Recycling reduces waste, reduces the need for raw materials, extends product life cycles, and thus reduces the environmental footprint. In addition, textile products produced using recycled fibers support the reduction of the carbon footprint in the sector and constitute an important tool for achieving environmental sustainability goals. The increasing environmental awareness of consumers and the pressure of global regulations are encouraging the rapid spread of recycling and sustainable production practices in the textile sector. Many countries and regions are introducing strict regulations for environmentally friendly production and sustainable products. Environmental regulations, especially in regions such as the European Union, are forcing companies to adopt sustainable production processes. Compliance with these regulations prevents companies from encountering legal problems and provides a competitive advantage in international markets. In short, sustainability and recycling practices in the textile sector have become a strategic necessity not only for reducing environmental impacts, but also for increasing brand value, gaining competitive advantage in the market, and long-term business model transformation.

Recycling can be defined as the inclusion of recyclable waste materials that have been used or disposed of in any way into the production process as raw materials using different methods. In this way, the product life cycles of the products are extended, and their re-evaluation is ensured. Today, many different waste materials can be recycled and reused, and applications are made based on two different recycling methods. Closed-loop recycling is a highly beneficial recycling method, and it is the recycling of the product after consumer use in order to use it in the production of the same product. In this system, post-consumer textile waste is collected, and fiber and yarn are produced again to be used in products. In the closed-loop recycling system in the textile sector, the inputs are pre-consumer and post-consumer textile waste [1]. The open-loop recycling method is widely applied. It is a recycling method applied to extend the product life cycle of products and to be reused in a different production system with a different area of use.

When the studies in the literature are examined, it is seen that recycling activi-

ties in textile production are mostly concentrated on polyester obtained from synthetic fibers and cotton obtained from natural fibers. However, there are relatively few studies on the recycling of polypropylene (PP) fiber and its use in the textile sector. It is seen that studies where recycled polypropylene is generally used in nonwoven and composite surfaces are common. Nevertheless, polypropylene is a raw material with many advantageous properties and is widely used, especially in clothing, upholstery fabrics, carpets, and technical textiles. The reasons for preferring PP fibers in textile materials can be summarized as low cost, easy processability, high strength, low pilling problems, and excellent chemical resistance [2]. Therefore, the recycling of polypropylene raw material textile products and their reuse in the textile industry are very important in terms of reducing textile waste, extending product life cycles, and contributing to sustainability.

Some studies on the use of polypropylene and recycled polypropylene materials in the textile industry are summarized below:

Sözcü [3] recycled polypropylene yarn and carpet waste to produce new PP yarns, on which mechanical performance tests were conducted. Subsequently, the recycled PP yarns were applied to carpet surfaces to examine their influence on carpet properties. The study aimed to reutilize PP yarn waste derived from imported commercial PP raw materials, thereby preventing economic loss and minimizing the environmental impact of production. Rokbi *et al.* [4] investigated the influence of key processing parameters (temperature and pressure) on the tensile properties of composites made from recycled polypropylene reinforced with plain woven jute fabrics. They produced multiple composite laminates under varying pressure and temperature conditions and found that these parameters significantly affect mechanical performance, with optimal processing conditions improving tensile strength and modulus by enhancing fiber-matrix impregnation. The study highlights how manufacturing conditions can be tailored to improve the performance of r-PP-based natural fiber composites. Akram *et al.* [5] investigated the effects of fabric yarn density (EPI/PPI), seam type, stitch type, and stitch density (SPI) on the seam performance of woven linen fabrics. Their results demonstrated that seam strength and seam slippage are strongly influenced by seam construction, stitch type, stitch density, and fabric yarn density, with higher end and pick densities (EPI/PPI) leading to improved seam performance and reduced seam slippage. Esi and Baykal [6] aimed to create an optimization model that minimizes seam slippage in chenille upholstery fabrics produced using recycled and virgin polyester yarns. For this purpose, 32 chenille yarns were produced using r-PET and virgin polyester yarns in the binder and/or pile yarn structure, and these chenille yarns were then used as weft to produce chenille upholstery fabric. As a result, the amount of seam slippage was minimized within the constraints of the mathematical model solution, and optimum values for some physical and performance properties of the fabrics were determined. Hussain *et al.* [7] investigated the sustainable fabrication of polypropylene-postconsumer cotton fiber (PP-PCCF) reinforced composites by developing a pilot model that integrates recycled polypropylene with post-consumer cotton

waste using compression and injection molding techniques. The study examined the processing, microstructure, mechanical, thermal, wear, and surface properties of the resulting composites at different fiber loadings, demonstrating that composites with optimized cotton fiber content (e.g., 10 wt%) exhibit favorable tensile strength, modulus, and performance characteristics suitable for commercial applications. This work provides a framework for implementing closed-loop manufacturing of polymer composites, highlighting the potential of using textile waste streams to produce sustainable, high-performance composite materials. Altay *et al.* [8] investigated the effects of stitch type (lockstitch and overlock), stitch density (4 and 6 stitches/cm), and sewing direction (warp, weft, and bias) on the seam slippage and seam strength of 100% cotton satin woven fabrics. The results showed that a stitch density of 6 stitches/cm, lockstitch, and bias (45˚) sewing direction provided the lowest seam slippage and the highest seam performance, indicating that this combination offers the optimum sewing conditions for cotton satin fabrics. Hübner *et al.* [9] aimed to comparatively investigate the surface properties and melt-spinning spinnability of recycled polypropylene (r-PP) and virgin polypropylene (v-PP) fibers. In the study, the potential increase in fiber surface wettability and thus fiber-matrix interaction due to the higher degree of oxidation in r-PP was evaluated, while the high shear stresses and thermal effects caused by multiple recycling cycles were discussed as limiting factors affecting mechanical properties and processability. The findings provide important insights into fiber production and surface performance using sustainable r-PP materials. Lukoschek *et al.* [10] cleaned and processed post-consumer polypropylene waste and converted it into fibers through melt spinning. Their findings demonstrated that, when processed under appropriate conditions, recycled PP can yield monofilaments with high mechanical performance suitable for commercial applications. Furthermore, it was reported that optimizing processing parameters such as temperature and drawing ratio enables the production of fibers with performance levels comparable to those of virgin materials. Frankenbach *et al.* [11] examined the feasibility of mechanically recycled polypropylene (r-PP) from post-consumer sources for use in multifilament yarn production, along with its potential contributions to a circular economy in the textile industry. The results indicated that r-PP can be effectively utilized in multifilament yarn manufacturing when proper processing parameters are applied, and that the mechanical properties of recycled PP are adequate for specific textile applications.

Polypropylene is one of the most widely used polymers in the plastics and textile industries owing to its low cost, ease of processing, low density, high strength, and excellent chemical resistance [12]. In the textile sector, polypropylene fibers are commonly used in carpets and rugs because of their light weight, color fastness, and stain resistance; in upholstery fabrics and curtains due to their resistance to moisture and mold; and in pillows and blankets because of their low density and economic advantages. Furthermore, polypropylene is a thermoplastic polymer that can be repeatedly melted, reprocessed, and reshaped, making it highly suita-

ble for recycling [13]. Although previous studies have investigated the use of recycled polypropylene, research has primarily focused on composite materials and nonwoven structures, while studies on woven textile applications remain limited. In particular, information regarding the seam performance of woven upholstery fabrics produced with recycled polypropylene filament yarns is scarce. Seam slippage is one of the most critical quality parameters for upholstery fabrics because excessive yarn displacement along the seam line adversely affects both the functional performance and aesthetic appearance of the final product. Since the incorporation of recycled polypropylene may alter yarn characteristics and fabric structure, its influence on seam slippage should be evaluated before its broader application in upholstery fabrics. Therefore, this study investigates the effect of recycled polypropylene content and the combined effect of weft yarn fineness and density on the seam slippage behavior of woven upholstery fabrics produced with filament yarns containing different proportions of virgin and recycled polypropylene. The findings are expected to contribute to the development of more sustainable upholstery textiles by providing evidence on the relationship between recycled polypropylene content, fabric construction, and seam slippage performance, while informing assessments of suitability for specific upholstery applications.

2. Material and Method

The v-PP and r-PP granules were obtained from a textile manufacturer in Istanbul engaged in filament yarn and woven fabric production. While v-PP consisted of pure polypropylene, r-PP was derived from mechanically recycled PP textile wastes, mainly carpet and yarn residues. Both materials were processed directly in melt spinning, without any pre-treatment or compounding steps. The supplied granules were first subjected to an MFI (melt flow index) test. The MFI test measures the melt flow behavior (processability) of the polymer before processing, such as fiber or yarn production under specified temperature and load conditions. In accordance with ASTM D1238, the melt flow rate of both materials was determined at 230˚C under a 2.16 kg load over a duration of 10 minutes. Following this, fully drawn yarns (FDY) incorporating recycled and virgin PP at various blend ratios were produced via the melt spinning technique. A laboratory-scale FET100 melt spinning machine was employed in the production. The diameter and length of the spinneret capillary holes were 0.4 mm and 1.6 mm, respectively. The processing parameters used in the study are presented in **Table 1** [14]. The fabrics previously characterized for tensile strength in reference [14] were used in this study to investigate seam slippage behavior.

Filament yarn production was carried out using recycled polypropylene (r-PP) granules at different blend ratios. All yarns were manufactured as 175 denier/36-filament, non-interlaced, with constant fineness and round cross-sections. The planned r-PP/v-PP blend ratios were 0/100, 10/90, 20/80, and 30/70. However, the production of yarns containing 30% r-PP was not possible. When the r-PP content

exceeded 20%, the increased proportion of recycled granules caused filament breakages during the drawing stage, preventing stable yarn formation.

Table 1. Production parameters of filament yarns.

Extruder Parameters	Zone-1 Temperature	210˚C
	Zone-2 Temperature	215˚C
	Zone-3 Temperature	225˚C
	Zone-4 Temperature	240˚C
	Extruder Speed	20.1 rpm
	Extruder Pressure	110 bar
	Pump Speed	18 rpm
Drawing Unit Parameters	Godet-1 Speed	300 mpm
	Godet-2 Speed	650 mpm
	Godet-3 Speed	975 mpm
	Winder Speed	1000 mpm

The produced yarns were then subjected to an air-jet texturing process and subsequently used as weft yarns in upholstery fabric samples. In this study, the yarn finenesses were determined by considering the yarn finenesses used by upholstery fabric manufacturers, and folding processes were applied to the produced yarns accordingly to obtain final yarns with linear densities of 700 denier and 1050 denier.

Prior to fabric production, a breaking strength test was conducted on the filament yarns. The samples were conditioned for 24 hours under standard atmospheric conditions of 20˚C ± 2˚C and 65% ± 2% relative humidity. Tensile strength measurements were performed based on the TS EN ISO 2062 standard using a Zwick/Roell testing device, and the strength values were recorded in cN/tex [15].

In the upholstery fabrics, 300 denier polyester warp yarns were used with a warp density of 33 ends per cm. For the weft, 700 and 1050 denier filament yarns were woven at 14 and 7 picks per cm, respectively. To evaluate the effect of recycled PP content in weft yarns of different fineness on tensile performance, all warp-related parameters were kept constant. Six types of plain-woven upholstery fabric samples were produced using six different weft yarn variations. In fabrics coded 700-V and 1050-V, the weft yarns consisted entirely of virgin PP. In samples 700-R10 and 1050-R10, 10% recycled PP was incorporated into the weft, while samples 700-R20 and 1050-R20 contained 20% recycled PP in the weft yarn. The technical specifications of the fabricated fabric samples are presented in **Table 2** [14].

Table 2. Technical properties of upholstery fabrics.

Fabric Code	r-PP/v-PP Blend Ratio in Weft Yarn Structure (%)	Weft Yarn Fineness (Denier)	Weft Density (Picks/cm)	Warp Yarn Fineness and Raw Material	Warp Density (Ends/cm)	Weave Type	Weight (g/m²)
700-V	0/100	700 denier	14	300 denier/PES	33	Plain	252
700-R10	10/90	700 denier	14	300 denier/PES	33	Plain	253
700-R20	20/80	700 denier	14	300 denier/PES	33	Plain	243
1050-V	0/100	1050 denier	7	300 denier/PES	33	Plain	218
1050-R10	10/90	1050 denier	7	300 denier/PES	33	Plain	215
1050-R20	20/80	1050 denier	7	300 denier/PES	33	Plain	207

The upholstery fabrics were woven on a Dornier rapier loom in a textile manufacturing facility located in Istanbul. The produced filament yarns were used as weft yarns, and each of the six fabric types was woven once as an approximately 1.5 m section, with no independent production replication. The technical specifications and machine parameters used during the weaving process are provided in Table 3 [14].

Table 3. Weaving machine production parameters of upholstery fabrics.

Loom speed	465 r/min
Width of weaving machine	160 cm
Width of fabric	140 cm
Weave type	Plain
Weft yarn type	Polypropylene yarn
Warp yarn type	Polyester yarn
Weft yarn fineness	700 ve 1050 denier
Warp yarn fineness	300 denier
Weft density	14 and 7 picks/cm
Warp density	33 ends/cm

In this study, seam slippage tests were conducted on samples to evaluate the effect of incorporating recycled polypropylene (r-PP) yarns into the structure of upholstery fabrics on seam slippage in the fabrics. The tests were carried out in accordance with the TS EN ISO 13936-2 standard [16]. Five specimens for each test direction were taken from different locations within each woven section in accordance with the sampling requirements of TS EN ISO 13936-2. A total of 60 specimens were prepared, comprising 30 specimens per direction. Specimens were prepared with a superimposed seam using type 301 lockstitches, a stitch density of 32 ± 2 stitches per 100 mm, a 100% polyester core-spun sewing thread, and a 12 mm seam allowance. Conditioning and testing were performed in the standard atmosphere specified in ISO 139. The tensile load was applied perpendicular to the seam line, in-

creased to 180 N, and then reduced to 5 N before measuring the seam opening. Warp and weft slippage refer to the yarns displaced, which were perpendicular to the loading direction. Statistical analyses were performed using IBM SPSS Statistics 24 at $\alpha = 0.05$. Weft seam opening was analyzed using two-way ANOVA with blend ratio, fabric construction (combined weft yarn fineness-density settings), and their interaction. Blend ratios were compared within each construction using the pooled ANOVA error term, with Bonferroni adjustment across six comparisons. Warp seam opening was analyzed only for the 700-denier fabrics using one-way ANOVA followed by Tukey HSD at $\alpha = 0.016$, set by dividing 0.05 by three comparisons and rounding down as an additional conservative adjustment. Each fabric type was woven once. Individual specimen measurements were analyzed as subsamples of each woven section, and statistical comparisons are therefore limited to the tested sections.

3. Results and Discussions

The melt flow index (MFI) of virgin and recycled polypropylene granules was determined prior to filament yarn production in order to evaluate their flow behavior. The measurements were carried out at 230˚C under a load of 2.16 kg according to ASTM D1238. The MFI values of virgin polypropylene (v-PP) and recycled polypropylene (r-PP) granules were found to be 22.58 g/10 min and 53.32 g/10 min, respectively [14]. Accordingly, an increase in the r-PP/v-PP blending ratio resulted in a gradual increase in the melt flowability of the weft yarn material. The increase in MFI indicates a reduction in the molecular weight of r-PP due to chain scission and thermal-mechanical degradation during recycling. Previous studies have reported that such degradation leads to higher MFI values and lower molecular weight, which negatively affect mechanical properties and process stability [17]. Consistently, the higher flowability observed for r-PP in this study correlates with the processing instabilities and filament breakages encountered at higher r-PP blending ratios during yarn production.

In the experimental study, the breaking strengths of filament yarns produced for use in weft yarns of upholstery fabrics were determined. As a result of the test, the strength values of 700 denier v-PP; 10/90 r-PP/v-PP and 20/80 r-PP/v-PP yarns were 15.3; 13.8 and 13.3 cN/tex, respectively. The strength values of 1050 denier v-PP; 10/90 r-PP/v-PP and 20/80 r-PP/v-PP yarns were 16; 12.6 and 10.9 cN/tex, respectively [14]. It is observed that the breaking strength of filament yarns containing v-PP is higher. It is thought that the bond between the polymers weakens with the increase in the r-PP ratio and, as a result, there is a decrease in strength [3]. However, during the recycling processes applied to polypropylene polymer, deterioration in the physical and chemical properties of the fiber can be observed as a result of contamination by foreign substances. This can lead to a decrease in fiber molecular weight and a decrease in yarn strength [18] [19].

The produced yarns were used as weft yarns to produce plain-weave upholstery fabrics, and the seam slippage values of the fabrics were determined. The seam slip-

page results of the fabric in the weft and warp directions are presented in Table 4. In the evaluation of seam slippage in the weft direction, the opening of weft yarns over the warp yarns was examined, while in the evaluation of seam slippage in the warp direction, the opening of warp yarns over the weft yarns was investigated.

Table 4. Seam slippage measurement results in warp and weft directions.

Fabric Code	Weft Seam Slippage (mm)		Fabric Code	Warp Seam Slippage (mm)	
	Mean	Standard Deviation		Mean	Standard Deviation
700-V	1.1	0.224	700-V	2	0.1
700-R10	1.3	0.274	700-R10	1.2	0.274
700-R20	1	0.1	700-R20	1.1	0.224
1050-V	4.7	0.447	1050-V	The yarns were slipped	-
1050-R10	5.2	0.447	1050-R10	The yarns were slipped	-
1050-R20	5.8	0.447	1050-R20	The yarns were slipped	-

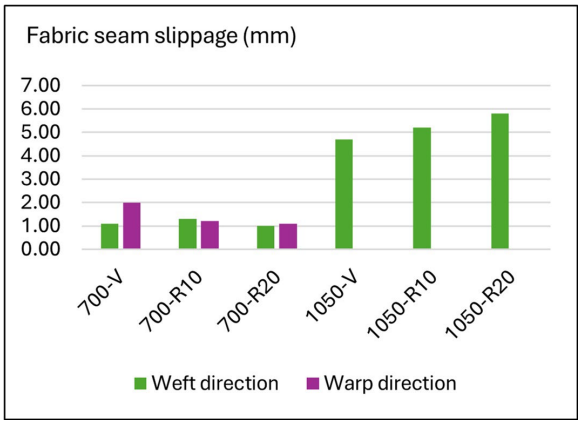


Figure 1. Seam slippage values in the weft and warp directions.

According to the seam slippage results in Table 4, the seam opening values were generally lower in fabrics produced with 700 denier weft yarns at 14 picks/cm than in those produced with 1050 denier weft yarns at 7 picks/cm. Since weft yarn fineness and density varied simultaneously, these differences should be interpreted as a combined fabric-construction effect. The weft density is higher in fabrics with a weft yarn of 700 denier. In these fabrics, the weight is also higher in association with this construction. Higher weft density can increase fabric compactness, restrict yarn movement, and improve resistance to seam slippage, providing a possible explanation for the observed differences. These results are consistent with previous studies [20]-[22]. During the warp seam slippage tests on fabrics with 1050 denier weft yarns, the warp yarns were observed to slip out of the seam, preventing numerical measurement of the seam opening. During the seam slippage test, the tensile load was applied perpendicular to the seam line. In the 1050 denier/7 picks/cm construction, this behavior may be associated with insufficient yarn restraint, allowing the warp yarns parallel to the seam line and perpendicular

to the loading direction to slip out of the seam. The 700 denier/14 picks/cm construction generally exhibited lower weft seam opening values than the 1050 denier/7 picks/cm construction, while measurable warp seam opening values were obtained only for the former. The results are shown graphically in Figure 1.

All 30 weft direction measurements were included in the two-way ANOVA, the results of which are presented in Table 5. The r-PP/v-PP blend ratio, the combined weft yarn fineness-density construction factor, and their interaction were statistically significant for weft-direction seam opening (Sig.(p) < 0.05). Fabric construction refers to the combined weft yarn fineness and density settings: 700 denier/14 picks/cm and 1050 denier/7 picks/cm. Following the significant blend ratio × fabric construction interaction, pairwise blend-ratio comparisons were performed separately within each fabric construction using the pooled error term from the two-way ANOVA. Bonferroni adjustment was applied across the six comparisons, and adjusted p-values were evaluated at $\alpha = 0.05$. The results of these comparisons are presented in Table 6.

Table 5. Two-way ANOVA results for weft seam slippage.

Performance Property	Source		df	F	Sig.(p)
Weft seam slippage	Main effect	Blend ratio	2	5.374	0.012*
		Fabric construction	1	1029.184	0.000*
	Interaction	Blend ratio × Fabric construction	2	7.959	0.002*

*Statistically significant (5% significance level).

Table 6. Pairwise blend-ratio comparisons within each fabric construction for weft seam slippage.

Comparison (Fabric Codes)	Mean Difference (mm)*	Adjusted p
700-V vs. 700-R10	−0.200	1.000
700-V vs. 700-R20	0.100	1.000
700-R10 vs. 700-R20	0.300	1.000
1050-V vs. 1050-R10	−0.500	0.200
1050-V vs. 1050-R20	−1.100	<0.001
1050-R10 vs. 1050-R20	−0.600	0.073

*The mean difference is calculated by subtracting the second group mean from the first. Comparisons use the pooled error term from the two-way ANOVA, with Bonferroni adjustment across all six comparisons. Adjusted p-values below 0.05 indicate statistical significance.

In the warp direction, yarn slippage out of the seam prevented completion of the measurements for the 1050-V, 1050-R10, and 1050-R20 fabrics. This behavior was reported qualitatively in Table 4, without assigning numerical values. Consequently, the warp-direction statistical analysis included only the 15 measurements from the 700-V, 700-R10, and 700-R20 fabrics. These measurements were evalu-

ated using one-way ANOVA with blend ratio as the sole factor, and the results are presented in Table 7.

The significant blend ratio × fabric construction interaction ($p = 0.002$; Table 5) indicates that the blend ratio response differed between the tested constructions. Examination of Table 6 shows that no significant pairwise differences were detected within the 700 denier/14 picks/cm construction after Bonferroni adjustment (all adjusted $p = 1.000$). Within the 1050 denier/7 picks/cm construction, R20 exhibited significantly greater weft seam opening than V (adjusted $p < 0.001$), whereas the V - R10 and R10 - R20 comparisons were not significant (adjusted $p = 0.200$ and 0.073, respectively).

Table 7. One-way ANOVA results for warp seam slippage.

Seam Slippage of Warp Direction					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.433	2	1.217	27.037	0.000
Within Groups	0.540	12	0.045		
Total	2.973	14			

In order to determine whether there is a difference between the groups, when Table 7 is examined, significant values are less than 0.05. In other words, there is a statistically significant difference between the groups. A post-hoc test was performed to understand which group caused this statistical difference. Pairwise comparisons among the three blend-ratio groups in the warp slippage analysis were performed using Tukey HSD. Before conducting the post-hoc test, the significance level was set to 0.016, based on dividing 0.05 by the three pairwise comparisons and rounding down. This constitutes an additional conservative adjustment to the multiple-comparison control provided by Tukey HSD. The results are shown in Table 8.

Table 8. Post-hoc results for warp seam slippage.

Dependent Variable: Seam Slippage in the Warp Direction						
	(I) r-PP/v-PP blend ratio in weft yarn	(J) r-PP/v-PP blend ratio in weft yarn	Mean Difference (I - J)	Sig.	98.4% Confidence Interval	
					Lower Bound	Upper Bound
Tukey HSD	V-PP	10/90% r-PP/V-PP	0.80000*	0.000	0.3564	1.2436
		20/80% r-PP/V-PP	0.90000*	0.000	0.4564	1.3436
	10/90% r-PP/V-PP	V-PP	−0.80000*	0.000	−1.2436	−0.3564
		20/80% r-PP/V-PP	0.10000	0.742	−0.3436	0.5436
	20/80% r-PP/V-PP	V-PP	−0.90000*	0.000	−1.3436	−0.4564
		10/90% r-PP/V-PP	−0.10000	0.742	−0.5436	0.3436

*The mean difference is significant at the 0.016 level.

As shown in Table 8, the Tukey HSD comparisons for warp seam slippage in the 700 denier/14 picks/cm fabrics revealed significant differences between the virgin PP group and both the 10% and 20% r-PP groups ($p < 0.001$). The r-PP-containing fabrics exhibited lower mean seam opening values than the virgin PP fabrics. However, no statistically significant difference was detected between the 10% and 20% r-PP groups ($p = 0.742$). Within this construction, these results indicate that increasing the r-PP content from 10% to 20% was not associated with a statistically detectable change in warp seam opening. This nonsignificant result does not establish equivalent performance and should not be generalized to the 1050 denier/7 picks/cm construction or to weft seam slippage.

4. Conclusions

Polypropylene is a material used in home textiles. In the textile industry, it is preferred due to its lightweight and durable structure, resistance to stains and moisture, colorfastness, hypoallergenic properties, and low production costs. Considering that the textile industry is among the most polluting sectors for the environment, studies on recycling and sustainability within the sector are of great importance. From an environmental perspective, it is valuable for a product to have multiple life cycles and for circular material flow systems to be employed [23]. The literature shows that studies on the use of recycled polypropylene mainly focus on composite materials and nonwoven structures. However, it is understood that studies on evaluating this material in yarn production using melt spinning techniques, examining the structural and mechanical properties of the resulting yarns, and developing woven or knitted fabric structures from these yarns are limited. One of the most important performance characteristics in woven upholstery fabrics is the determination of the amount of seam opening; therefore, this study aims to investigate the effect of using recycled yarns in the weft on fabric seam slippage. In this context, the aim of the presented study is to contribute to the widespread adoption of sustainable yarn and fabric production approaches and to make a significant contribution to the literature on the potential use of recycled polymers in textile applications.

In the study, yarns produced from granules containing recycled polypropylene and virgin polypropylene in different blend ratios were used in upholstery fabrics, and the seam slippage properties of the fabrics were evaluated. The results showed that seam slippage performance differed between the investigated fabric constructions, while the response to recycled PP content depended on the construction and test direction. Weft seam opening values were generally higher in the 1050 denier/7 picks/cm construction than in the 700 denier/14 picks/cm construction. In the warp slippage tests, yarn slippage out of the seam prevented numerical measurement for the 1050 denier/7 picks/cm fabrics. Since weft yarn fineness and density varied simultaneously, the differences between the constructions should be interpreted as a combined fabric-construction effect. The weft-direction findings are consistent with the findings of Pashayev *et al.* [21], who reported that higher

weft densities reduced seam slippage in chenille upholstery fabrics. Greater mechanical interlocking and friction between yarns may explain the higher seam slippage resistance observed in the 700 denier/14 picks/cm construction. For warp slippage in the 700 denier/14 picks/cm fabrics, increasing the recycled PP ratio from 10% to 20% did not result in a statistically significant difference. These findings are limited to the tested fabric sections because no independent production replicates were available. Therefore, the use of recycled PP in upholstery fabric weft yarns should be considered in conjunction with appropriate fabric construction and verification against application-specific seam performance requirements. Several limitations should be acknowledged. Each fabric type was produced only once, and weft yarn fineness and density varied simultaneously, preventing their independent effects from being separated. Warp-direction yarn pullout prevented numerical seam-opening measurements in the 1050 denier/7 picks/cm fabrics. Furthermore, the spinning trial containing 30% r-PP was unsuccessful under the selected processing conditions. As no application-specific seam-opening acceptance criterion was applied, the present findings do not establish general suitability for upholstery use.

Recycling and reusing polypropylene-based materials may contribute to reducing virgin resource consumption and waste generation. The findings of this study highlight the importance of fabric construction when considering recycled polypropylene for upholstery applications; however, suitability requires verification against application-specific seam performance criteria. Future studies are recommended to conduct detailed cost analyses to evaluate the economic feasibility of using recycled polypropylene and environmental assessments to quantify potential sustainability benefits. Furthermore, comprehensive research can be conducted using a wider range of recycled PP contents, independently varied yarn fineness and density settings, and replicated production trials to assess their effects on seam performance.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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