*Research Article*

# Investigation of the Comfort and Quality Properties of Knitted Garments Produced with Raised Yarn

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## Abstract

*The raising process is a finishing treatment applied to textile surfaces to impart softness and bulkiness. Traditionally performed on fabrics, this process creates a fluffy structure by pulling fiber ends to the surface, resulting in a fuller handle and enhanced comfort. In recent years, the adaptation of this technique to yarn form, known as the "yarn-level raising process," has emerged as an innovative approach in textile manufacturing. When applied to yarns, the process generates a micro-level hairiness on fiber surfaces, increasing yarn volume and heat retention capacity. Consequently, fabrics knitted from such yarns exhibit higher air-holding capacity, lower thermal*

*conductivity, and improved moisture management, leading to enhanced tactile softness and overall thermal comfort.*
*This study aims to investigate the effects of the yarn-level raising process on the thermal comfort performance of knitted garments. In today's textile industry, the demand for comfort-oriented products—particularly those providing thermal comfort—has been steadily increasing. Although knitted fabrics offer advantages such as flexibility, lightness, and softness, their thermal insulation and moisture transfer capacities remain limited and require improvement.*
*Within the scope of this research, process parameters including fiber type, fiber fineness (nm), and feed rate (m/min) will be examined. Their influence on key performance criteria such as thermal conductivity, air permeability, and moisture transfer will be experimentally analyzed. All tests will be conducted using internationally recognized standard methods.*
*The findings are expected to contribute to the development of comfort- and quality-oriented process strategies in knitted garment production and to scientifically demonstrate the potential of yarn-level raising as an effective method to enhance thermal comfort and moisture management in textile materials.*

**Keywords:** Yarn-level raising process, thermal comfort, knitted fabric, thermal insulation, fiber fineness, air permeability

## 1. Introduction

In recent years, the textile industry has focused its product development on user comfort. Demand for clothing that provides thermal comfort has increased significantly, particularly in seasonal wear and high-performance textiles. Clothing thermophysiological comfort is a complex area in textile science and [1] necessitates understanding the heat and moisture transfer mechanisms within the skin-clothing-environment system. While previously developed comfort models were primarily based on human thermoregulation [1], the impact of the air space (microclimate) between human skin and the clothing layer on heat and moisture transfer has often been overlooked.

Knitted fabrics offer significant advantages in terms of wear comfort by offering high flexibility, soft handle, and air permeability due to their structural properties. Academic studies emphasize that the loop structure and yarn properties of knitwear are determinants of thermophysiological comfort parameters [2][3]. The porous and flexible structure of knitwear surfaces facilitates both heat and moisture transfer, contributing to the balance of the microclimate between the body and the environment. Furthermore, the type of fiber used (cotton, wool, polyester, etc.) and yarn structure (plain, fancy, raised) directly affect the fabric's thermal resistance, air permeability, and moisture management properties. Therefore, optimizing comfort in knitwear fabrics is considered a multidimensional design process that requires the combined consideration of fiber selection, knit structure, and finishing processes.[4][5]

A study conducted on the raising process indicated that fabric raising is the most commonly applied finishing process to increase comfort in knitted fabrics.[6] Raising is a physical finishing process based on the mechanical pulling of the fibers on the back surface of the fabric to the surface and is of critical importance in terms of thermal insulation and soft handle, especially in three-thread fleece fabrics. In this study, different raising conditions (speed, number of passes, pre- and post-softening chemicals) were examined and it was determined that the single-pass raising process at a speed of 15 m/min gave the best results. Another study reported that raising improved thermal comfort by increasing thermal contact resistance in two-thread fleece fabrics.[7]

Three-thread knitted fabrics are produced on specialized flat circular knitting machines equipped with different cam sets, special sinker systems, and guides fed from three different yarn directions. In these types of fleece fabrics, one of the two yarns, usually of the same count or thickness, serves as the face yarn, forming the base, while the other serves as the binding yarn, which serves as the filling. The third yarn, the thicker of the two, is the fleece yarn, which forms the back side. While the face of the fabric has a plain knit appearance, the back side displays floats.[8]The raising process plays an important role in achieving thermal comfort in the production of three-thread fleece fabrics. In these types of fabrics, raising is applied to the back surface of the fabric, which is in contact with the skin. The raising process is a mechanical finishing process based on the physical pulling of fibers from the fabric yarns. This process results in a layer of fibers on the fabric surface. The thickness and effect of this layer vary depending on the length of the fibers, how they are arranged and counter-arranged (pile or counter-pile), and the number of passes. This layer gives the fabric a more voluminous structure, trapping air within the fabric pores, creating an air cushion-like effect. This also increases the fabric's heat-retention capacity. During the raising process, cylinders covered with sharp metal wires are used to mechanically pull the fibers. Hooks on one cylinder pull the fibers from the fabric, while hooks mounted at opposite angles on the other cylinder comb the fibers.[9]Raising is a mechanical finishing process used to create a soft, fuzzy texture on the yarn surface. This process is achieved by passing the yarn through special raising machines consisting of wire-covered front and back rollers. The brushing action of the machines pulls the fibers from the yarn surface, creating a fine fuzzy layer; this results in a more voluminous, rougher, and softer surface. Raising results in a fuller texture, a softer handle, and increased thermal insulation. This process significantly contributes to the maintenance of body temperature by increasing the fabric's air retention capacity and is generally preferred for winter textiles. Studies have shown that raising and lamination processes improve thermal resistance properties, while raising alone increases air permeability.[10] The machines used to raise the yarn are shown in Figure 1.

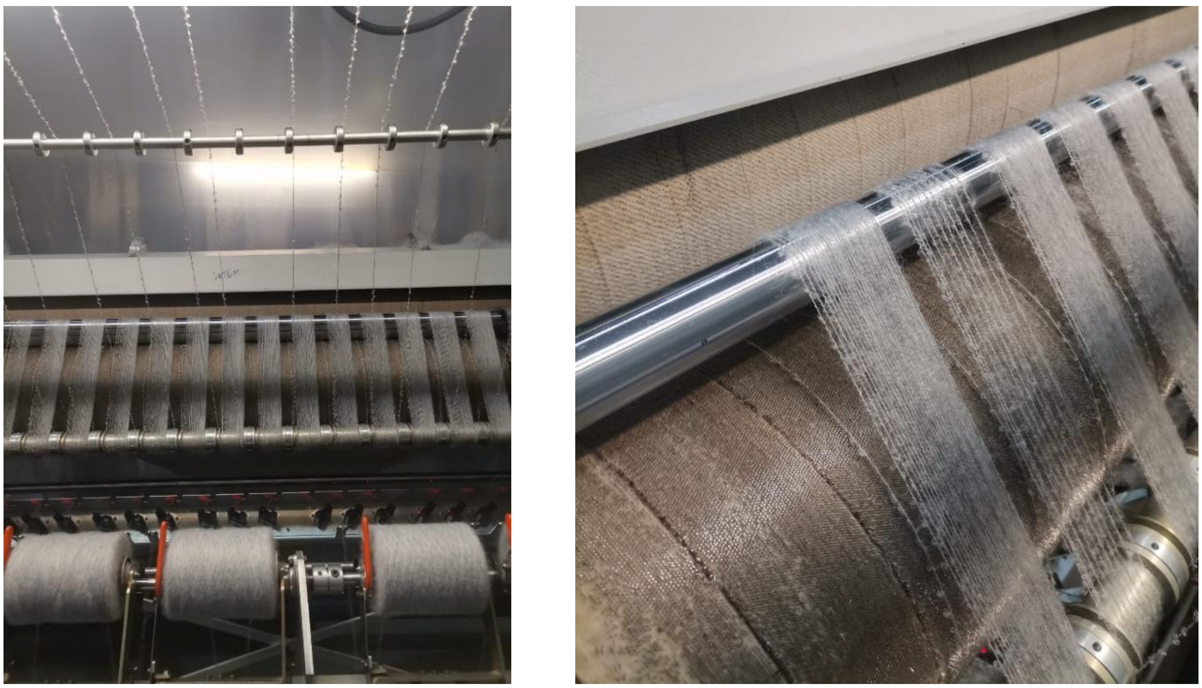

**Figure 1.** Raising machine and raising rollers

This study aimed to systematically investigate the effects of the yarn raising process in order to increase the thermal comfort properties and enhance product quality of knitwear produced by İntem Triko. The main objective of this experimental study was to reveal the effect of the critical parameter of feed speed (m/min), selected as a variable in the yarn raising process, and the resulting raise density, on the thermal and durability performance of fabrics. Test methods in accordance with international standards were used for the scientific evaluation of thermal comfort. In this context, performance criteria such as thermal conductivity (TS EN ISO 11092), air permeability (TS 391 EN ISO 9237:1999), water vapor permeability (TS EN ISO 11092), and bursting strength (TS EN ISO 13938-2) of fabrics obtained from raised yarns using different parameters were investigated. Within the scope of the experimental analysis, Uster tests were applied to the resulting raised yarns, and the structural properties of the yarns were examined.

## 2. Materials and Methods

The study examined the variable feed speed (m/min), which affects yarn raising, and examined the effects of this parameter on the fabric's thermal conductivity, air permeability, water vapor permeability, and bursting strength. First, two yarns with a 20% acrylic/80% polyamide blend ratio, manufactured in a count of Nm 10.5, were produced at two different feed speeds, resulting in different raise densities. The main difference between these two yarns is the amount of raising caused by the difference in feed speed; one yarn exhibited a higher raised structure due to the higher feed speed (200 m/min). Images of the two yarns are shown in Figure 2.

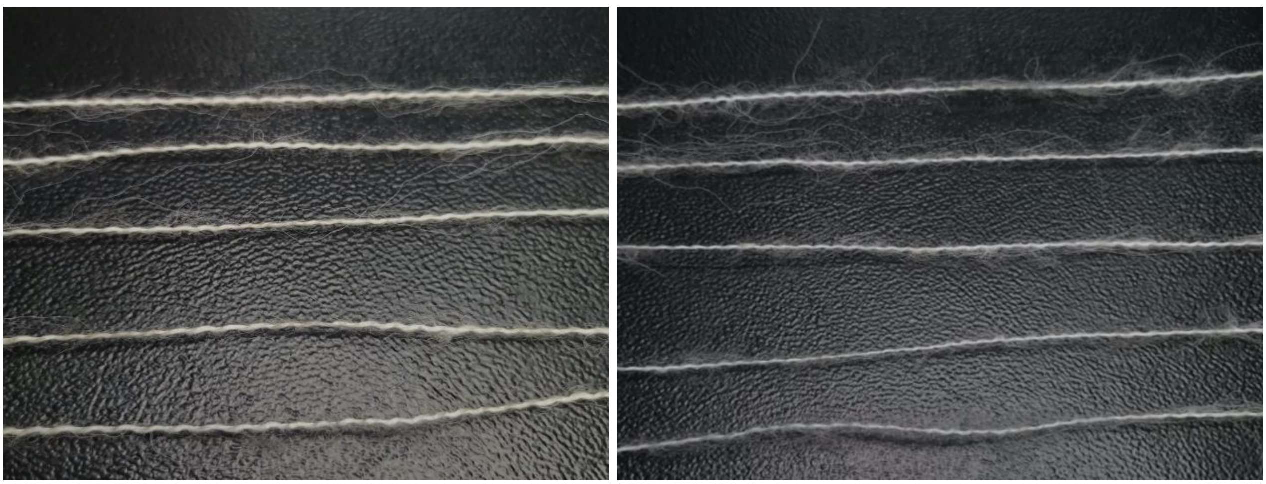

**Figure 2.** Yarns with low and high raising density

As part of the experimental analysis, fabric production was carried out using raised yarns on a Shima Seiki 14-gauge system tricot knitting machine with a single-plate knit structure. Factors that could affect the knitting performance of the yarns were kept constant during the knitting process, and only the specified yarn types (20% acrylic/80% polyamide) with feed speeds of 200 m/min and 120 m/min) were used. Production repeatability was ensured by maintaining needle density, loop setting, and machine speed under standard conditions during knitting. While both fabrics had the same yarn count and twist amount, the difference in feed speed had a decisive effect on the structural density, porosity, and thickness of the fabrics. Photographs of the fabric panels are shown in Figure 3.

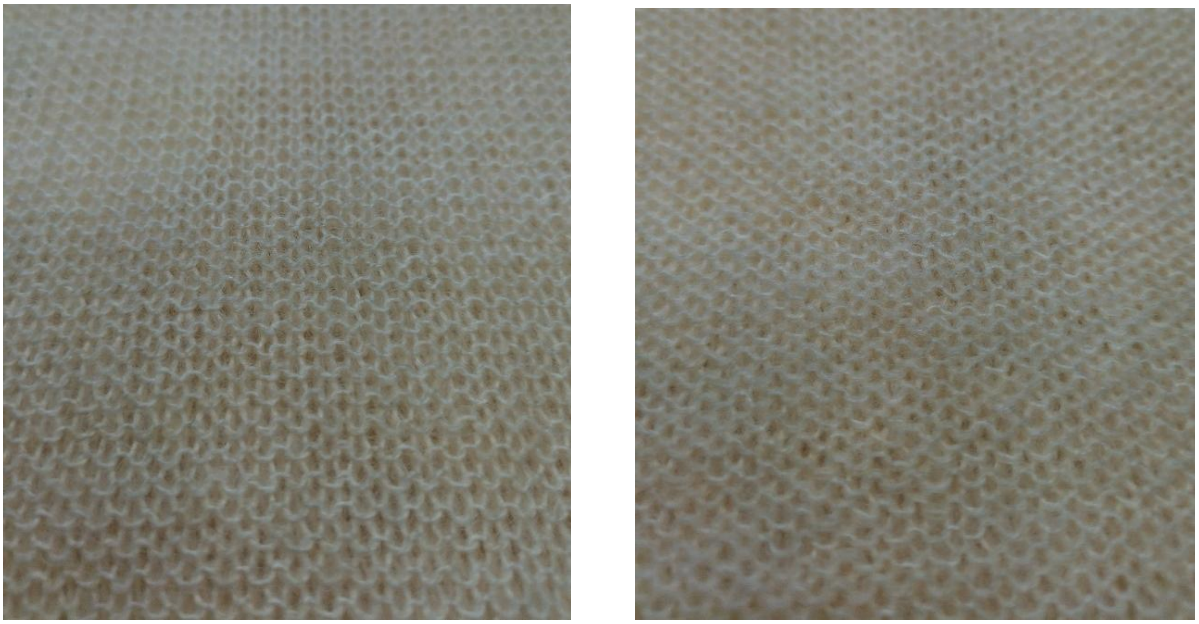

**Figure 3.** Fabric panels produced from yarns with low and high raising density

### 2.1. Applied Tests and Standards

Uster and yarn strength tests were applied to two yarns with different structures (20% acrylic/80% polyamide raw material, 380 turns/m twist, and feed speeds of 200 m/min and 120 m/min) at the Karacasu Tekstil Tic. ve San. A.Ş. R&D Center.

Textile comfort tests were conducted in accordance with international standards to scientifically evaluate the thermal comfort of the knitwear fabrics produced. In this context, performance criteria such as thermal conductivity (TS EN ISO 11092), air permeability (TS 391 EN ISO 9237:1999), water vapor permeability (TS EN ISO 11092), and bursting strength (TS EN ISO 13938-2) of fabrics produced from raised yarns using different parameters were examined. The relevant tests were conducted at the laboratories of the Textile Engineering Department at Bursa Uludağ University.

OR CLEVER Science & Research Group

*Figure 1: Test for Figure Name*

## 3. Results

When examining the yarn strength test results, the yarn with low raising density had a strength value of 13.05 (Rkm), while the yarn with high raising density had a strength value of 11.74 (Rkm). Increasing the raising intensity decreased strength. Furthermore, as expected, the yarn's evenness parameters also deteriorated. This is evident when examining the H index values. The low-raising yarn had an H value of 36.07, while the yarn with a 200 m/min yarn feed rate was 60.17. This indicates that yarn evenness and variation increased. It can be said that increasing the feed rate results in more intense raising on the yarn surface, resulting in increased fiber end protrusion and surface irregularity. This is an indication that raising was more successful in high-feeding yarns. These results indicated that fiber integrity in the yarn structure was partially weakened. Consequently, increasing the feed rate strengthened the raising effect, giving the yarn a more voluminous structure, but it also had a negative impact on evenness and strength.

In fancy yarns, the feed speed (m/min) refers to the difference between the effect (roving) yarn and the ground yarn, and it directly affects the yarn's appearance and structural properties. When the effect yarn is fed at a higher speed than the ground yarn, characteristic effects such as knots, loops, or raised yarns appear on the yarn surface. As the feed rate increases, the yarn's fuzz and volume increase, contributing to a more pronounced hairy surface after the raising process. The fabric produced from a panel with a feed of 120 m/min, 10.5 Nm yarn, and a twist of 380 turns/m has a more open texture and an air permeability of 4778 L/m² s. The fabric produced from a panel with a feed of 200 m/min, 10.5 Nm yarn, and a twist of 380 turns/m was measured as 3458 L/m² s. This difference indicates that as the feed rate increases, the fabric becomes tighter and porosity decreases. Therefore, the fabric with a 120 m/min feed is more breathable and facilitates air circulation, while the fabric with a 200 m/min feed exhibits a more closed and fuller structure.

In terms of thermal properties, both fabrics showed low thermal conductivity values. The thermal conductivity of the fabric with a 120 m/min feed was measured as $33.1\times10^{-3}$ W/m K, while that of the 200 m/min feed was $35.1\times10^{-3}$ W/m K. The thermal resistance values were $39.4\times10^{-3}$ m² K/W and $46.5\times10^{-3}$ m² K/W, respectively, and the 200 m/min feed fabric was found to have greater heat retention capacity thanks to its higher thickness (1.63 mm). In contrast, the fabric with a 120 m/min feed, with its thinner structure (1.30 mm) and high air permeability, conducts body heat away more quickly, providing a feeling of coolness. This situation shows that the structure with 120 m/min feed is more suitable for summer and active use products, while the structure with 200 m/min feed is more suitable for winter and products requiring thermal insulation.

Both fabrics exhibited similar water vapor permeability. The permeability rate was determined to be 38.6% for the fabric with a 120 m/min feed and 38.3% for the fabric with a 200 m/min feed. Water vapor permeability resistances were also very similar, and it was concluded that both fabrics offered balanced performance in terms of moisture management.

In bursting strength tests, the fabric with a 120 m/min feed rate reached 135.8 kPa, while the fabric with a 200 m/min feed rate reached 107.8 kPa. This result demonstrates that the fabric with a lower feed rate exhibits a more flexible and durable structure due to the higher deformation capacity of the yarns. Increasing the number of feeds increased structure density but reduced bursting strength by limiting yarn mobility.

## 4. Discussion and Conclusion

When a general evaluation is made, the fabric with a yarn count of Nm 10.5 and a twist value of 380 turns/m fed at 120 m/min stands out with its high air permeability, high strength and cool retention properties thanks to the more controlled raising effect. In contrast, the fabric produced with the same yarn and twist values but at a feeding speed of 200 m/min gained a thicker, bulkier and hairier structure, with fibers clearly protruding from the surface as a result of the more intense raising effect. This increased the fabric's thermal resistance and improved its warm retention property. While the increase in feeding speed increased the raising density and improved the fabric's thermal comfort properties, it led to a certain decrease in air permeability and bursting strength. Therefore, while the structure produced at a feeding speed of 120 m/min is more suitable for textile products where breathability and mechanical strength are priorities; The structure obtained with an intensive raising effect at a feeding speed of 200 m/min exhibits more advantageous performance for winter clothes or home textile products where thermal comfort is at the forefront.

This experimental work will be expanded into an R&D project. In the next stages, new yarns will be produced using various fiber types and their blending ratios. Furthermore, different knitwear structures will be produced using the yarns obtained, taking into account production parameters such as feed speed and yarn count. This will allow for a more comprehensive analysis of the effects of different production conditions on thermal comfort, mechanical strength, and surface properties of knitwear fabrics.

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