ANALYZING THE EFFECT OF BLENDING RATIO AND SPINNING SYSTEM ON THE PROPERTIES OF BAMBOO/COTTON FABRICS DYED WITH ACORN DYESTUFF

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ABSTRACT

In the context of sustainable development goals, a diverse array of contributing studies has emerged within the textile sector. It is evident that the majority of these studies encompass both legal and customer obligations. The objective of contemporary businesses is to manufacture products that demonstrate a high level of environmental sensitivity. For instance, the objective is to reduce the quantity of waste products, to achieve energy-efficient production, to minimize the amount of chemicals employed, to reduce water consumption, to utilize energy derived from renewable sources, and thus to diminish the carbon footprint. From an environmental standpoint, the chemicals utilized in textile product manufacturing have emerged as a significant consideration. It is preferable that the chemicals employed in the dyeing process (dyestuffs, bleaching agents, softeners, etc.) are environmentally sensitive. Furthermore, the use of organic dyes in the dyeing process is also employed as a means of obtaining a more sustainable product. In the context of this study, the production of bamboo/cotton yarn was conducted at varying blend ratios (67/33%, 50/50%, and 33/67%) through the use of three distinct production methods (open end, vortex, and ring systems). Single jersey knitted fabrics were produced using these yarns with the same production parameters. Subsequently, the fabrics were dyed using acorn natural dyestuff. Pilling, fastness and CIELab analyses were performed on the fabric samples, and the results were subjected to statistical analysis.

KEYWORDS

Sustainability; Organic dye; Acorn dye; Color fastness.

INTRODUCTION

The production of textiles is a highly intricate process, encompassing various mechanical, chemical, and physicochemical steps. These processes often involve the use of hazardous substances, including heavy metals and pesticides. However, they are subject to extensive monitoring and regulation by standards such as ZDHC (Zero Discharge of Hazardous Chemicals), OEKO-TEX (International Association for Research and Testing in the Field of Textile and Leather Ecology), and GOTS (Global Organic Textile Standard), with the aim of ensuring safety and reducing environmental impact [1].

In the present era, environmental sustainability represents a pivotal concern for the textile industry. The rapid changing fashion industry and the intensive use of chemicals present a significant challenge to achieving a sustainable future, with adverse effects on both the environment and human health. The textile industry is seeking novel and creative solutions that will enable it to become environmentally sustainable, with a view to reducing its reliance on natural resources, minimizing its carbon footprint and eliminating the generation of harmful chemical waste. In this context, dyeing with natural sources are attracting attention as an alternative to dyeing with synthetic dyestuff, offering a promising potential for sustainability.

Dyeing with natural sources is generally defined as the process of imparting color to textile products through the use of pigments derived from plants, minerals and other organic materials. The extraction of natural dye process typically begins with the collection of plant materials like roots, leaves, flowers, or bark. The dyes are then extracted using methods such as boiling, soaking, or fermentation [2-4]. The production of natural colorants promotes plantation, contributing to the reduction of atmospheric CO_2 and increasing oxygen levels. It can be asserted that there

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are certain disadvantages associated with the use of natural colors. Despite the necessity for a certain amount of time to obtain natural colorants, the yields are typically very low. The commercial production of natural colorant sources is not feasible on a large scale. Consequently, the low yield of natural colorants results in correspondingly high production costs [5].

The literature includes studies that examine the properties of textile products obtained from a variety of natural dyes. These studies investigate the application of different natural dyes on diverse raw materials and the associated quality analyses [6-16].

This study examined the use of acorn natural dyestuff in the production of single jersey fabrics produced nine different yarns with varying blend ratio and spinning systems.

EXPERIMENTAL

Materials

In this study, bamboo and cotton fibers were used in order to produce yarn samples at three different blend ratios (67/33%, 50/50%, and 33/67%). Yarns and knitted fabrics were produced with these blends. Fabrics were dyed with natural acorn dyestuff. In these dyeing processes $KAl(SO_4)_2$ was used as mordant.

Methods

To examine and compare the spinning systems, open end rotor, ring and vortex systems were chosen for yarn spinning in this study. Ne 30/1 nine different yarn samples with α_e 3.6 twist coefficient were obtained, then these yarns were knitted at the same production parameters. Single jersey knitted fabrics were dyed with acorn natural dyestuff. Tenacity and elongation, hairiness, imperfections and unevenness properties were carried out in accordance with related standards. In addition, weight, thickness, pilling, color fastness to water and rubbing (dry and wet) properties were also determined with related standards. Results were analyzed statistically using SPSS package program.

RESULTS AND DISCUSSION

Fiber Properties

In this study, 2 types of fibres were used. The properties of these fibres are presented in Table 1. These fibres were blended at different blend ratios and used to produce yarns in 3 different systems (ring, open end rotor and vortex).

Yarn properties

In this study, bamboo and cotton fibers with known fiber properties were blended in 3 different blend ratios and these blends were used in the production of ring, rotor and vortex yarns. Various yarn tests were carried out to determine the properties of the yarns produced. The measurements were taken in accordance with the following standards:

- TS EN ISO 2062 for strength and elongation tests,
- ISO 16549 for unevenness and yarn faults, and
- TS 12863 for unevenness determination.

In order to evaluate the results and ascertain the effects of the blend ratios of the fibers and the spinning system in which the yarn is produced, ANOVA tests were performed (Table 2). According to the results of this test, the spinning system has a statistically significant effect on all measured properties of the yarn. When the effect of blend ratio was analyzed, the effects of this parameter on yarn faults, strength and elongation were found to be significant.

When the yarn characteristics were analyzed (see Fig. 1), it was seen that ring-spun yarns have higher strength and elongation, lower yarn faults and unevenness values, and also the highest hairiness values. The lowest hairiness values were observed in vortex yarns for all blend ratios. Additionally, the tensile strength and elongation values of the yarns produced with the Vortex system are inferior to those of ring yarns. Rotor yarns were found to have the highest yarn faults, the highest unevenness values and the lowest strength and elongation. The data obtained in this study are similar to the literature [17] [18].

Table 1. Fiber Properties.

Fiber	Fineness [dtex]	Staple Length [mm]	Density [g/cm^3]	Strength [cN/tex]
Cotton	1.2	32	1,52	31,2
Bamboo	1.33	38	1.32	34

Table 2. Analysis of Variance Results of Yarn Properties.

Independent Variables	Dependent Variables				
	Unevenness [U%]	IPI	Hairiness [Uster H]	Elongation [%]	Tenacity [kgf*Nm]
Spinning system	**0.022***	**0.000***	**0.000***	**0.003***	**0.008***
Blend Ratio	0.086	**0.006***	0.262	**0.002***	**0.037***

*Statistically significant at 0.05 confidence level

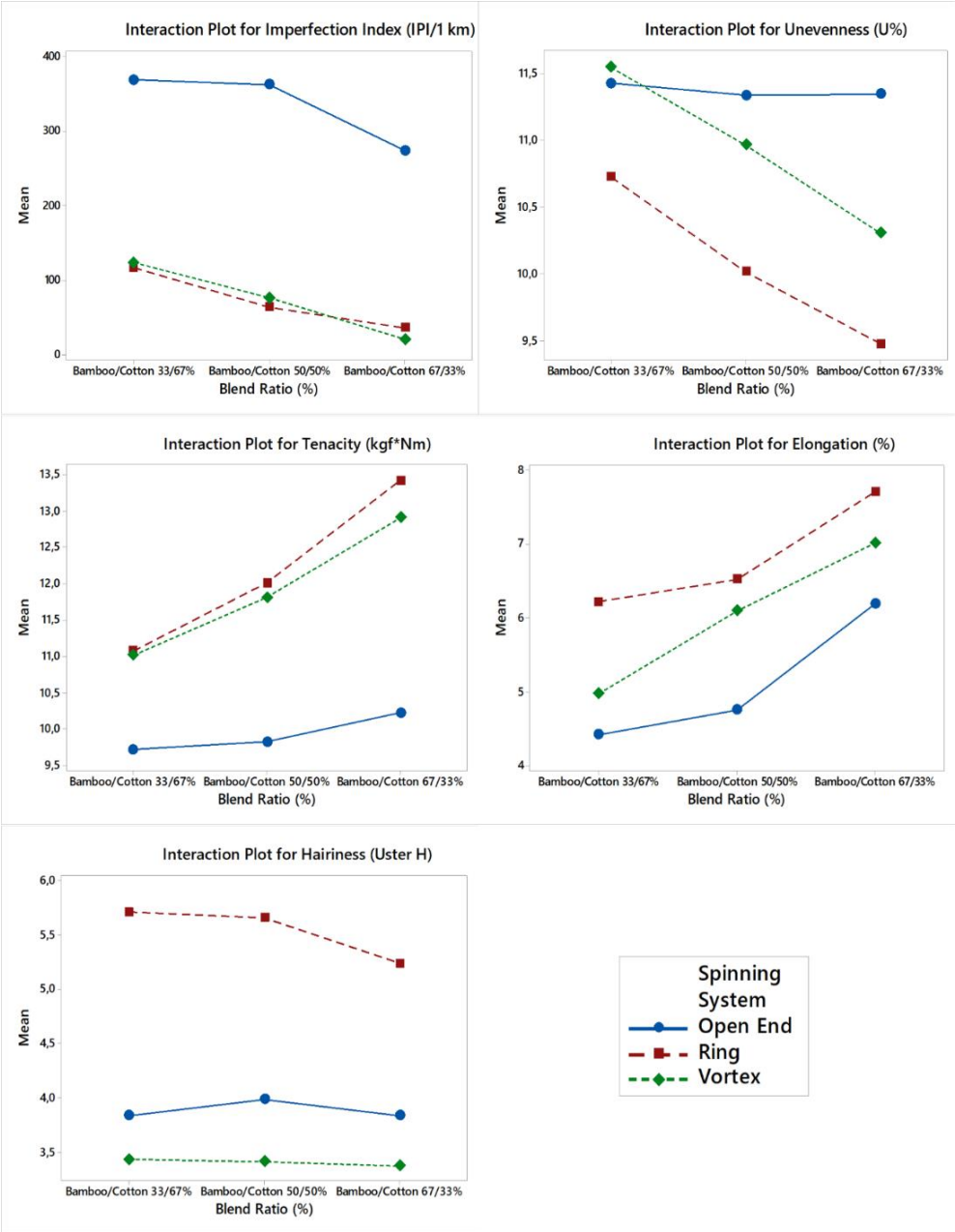

Figure 1. Interaction plots for different yarn characteristics.

When the yarn properties were evaluated within the framework of the blend ratio, it was found that an increase in the proportion of cotton in the blend caused higher unevenness values and more yarn faults. However, higher strength and elongation values were obtained in yarns with high bamboo content. It was an expected result that the increase in the ratio of bamboo fiber, which has higher strength, in the yarn positively affected the yarn strength. Hairiness was not much affected by the blend ratio. It was evident that hairiness was more influenced by the spinning system than by the raw material.

Fabric properties

As mentioned in the methods, single jersey fabrics were knitted using the same parameters. After fabric production all of these fabrics were dyed using acorn natural dyestuff. A number of tests were carried out to determine the properties of these dyed fabrics. The test results of these fabrics are given in Table 3.

When the results given in Table 3 are analyzed, it is seen that the highest air permeability is found in open end fabrics. This is an expected result in view of the low hairiness of rotor yarns. The difference in terms of blend ratio and spinning system as independent variables, is statistically significant according to ANOVA tests ($p=0.001<0.05$ for spinning system and $p=0.031$ for blend ratio). When pill grade values were analyzed, it was determined that the highest pilling resistance was achieved in fabrics produced with vortex yarns.

Table 3. Fabric properies.

Blend Ratio (B/C%)	Yarn Type	Thickness	Air Permeability	Pilling resistance
67/33	Ring	0.62	1358.68	2/3
50/50	Ring	0.59	1268.16	2/3
33/67	Ring	0.63	1415.42	2/3
67/33	Open End	0.53	1725.35	3/4
50/50	Open End	0.54	1866.49	3/4
33/67	Open End	0.57	1526.9	3/4
67/33	Vortex	0.62	1263.84	4/5
50/50	Vortex	0.62	1269.29	4/5
33/67	Vortex	0.65	1766.55	4/5

Table 4. Color Properties of acorn dyed fabrics.

Blend Ratio (B/C%)	Spinning System	Illuminant (D65 10 Deg)				
		L*	a*	b*	C*	h*
67/33	Ring	77.97	3.27	18.87	19.15	80.16
50/50	Ring	77.94	3.39	19.62	19.91	80.19
33/67	Ring	74.86	3.88	20.34	20.71	79.79
67/33	Open End	86.87	3.28	19.08	19.36	80.24
50/50	Open End	72.89	5.57	19.67	20.45	74.2
33/67	Open End	75.7	3.75	19.37	19.73	79.03
67/33	Vortex	77.06	3.61	19.37	19.7	79.43
50/50	Vortex	75.25	4.37	19.09	19.59	77.11
33/67	Vortex	75.15	4.29	19.66	20.12	77.69

Table 5. Color fastness to washing results.

Blend Ratio (B/C%)	Spinning System	Staining					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
67/33	Ring	4/5	4	4	4/5	4/5	4/5
50/50	Ring	4/5	4	4	4/5	4/5	4/5
33/67	Ring	4/5	4	4	4/5	4/5	4/5
67/33	Open End	4/5	4	4	4/5	4/5	4/5
50/50	Open End	4/5	4	4	4/5	4/5	4/5
33/67	Open End	4/5	4	4	4/5	4/5	4/5
67/33	Vortex	4/5	4	4	4/5	4/5	4/5
50/50	Vortex	4/5	4	4	4/5	4/5	4/5
33/67	Vortex	4/5	4	4	4/5	4/5	4/5

Table 6. Color fastness to rubbing results.

Blend Ratio (B/C%)	Spinning System	Rubbing	
		Dry	Wet
67/33	Ring	4	3/4
50/50	Ring	4	3/4
33/67	Ring	4	3/4
67/33	Open End	4	3/4
50/50	Open End	4	3/4
33/67	Open End	4	3/4
67/33	Vortex	4	3/4
50/50	Vortex	4	3/4
33/67	Vortex	4	3/4

Fabrics were dyed with acorn dyestuff as mentioned before. The color properties of these fabrics are given in Table 4. L value results indicate that the lightness of the fabrics increased with higher bamboo content. According to the other parameters in Table 4, it can be said that although there are some variations in the color of these fabrics, similar dyeing results were obtained.

Color fastness of these fabrics to water and rubbing (wet and dry) were also tested. Results of the staining on multifiber fabric after water treatment are given in Table 5. It can be seen from the results that the change in the spinning systems used for yarn production and the change in blend ratio for bamboo and cotton fibers did not affect these values.

Results of the staining on multifiber fabric after water treatment are given in Table 6. These results also indicate that there is no difference between the color fastness to rubbing results in terms of blend ratio and spinning system as independent variables.

CONCLUSIONS

In this study, acorn natural dyestuff was used in order to dye nine different types of single jersey bamboo-cotton blended knitted fabrics. Initially, yarns were produced with 3 different spinning systems (ring, rotor and vortex) with 3 different blend ratios (67%Bamboo-33%cotton, 50%bamboo-50%cotton and 33%bamboo-67%cotton). All these yarns were produced using the same αe 3.6 twist coefficient. After yarn productions single jersey fabrics were knitted using the same knitting parameters. In the end, fabrics were dyed, again, using the same dyeing parameters.

All the tests carried out during this study were done according to standards. These results were obtained at the end:

· Spinning system and blend ratio significantly affected yarn properties.

· Higher bamboo content in the blend resulted with lighter shades in fabrics.

· As both fibers are cellulosic and have similar structures, fastness results we investigated were similar (because of their interactions with the dye).

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