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Influence Of Yarn Count & Micron On The Dyeability Of Woven Wool Fabrics Dyed With Acid Jacquard Dyes

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Abstract
This work aimed to specify if there is any relation between yarn count, fiber fineness, and rate of dye uptake on fabrics during the dyeing process. Worsted woven wool fabrics in different yarn counts; (30/2, 40/2, 50/2, 60/2, 70/2) metric and different fineness; (17.08 -23.25) were dyed via acid Jacquard dye to investigate this relation. The dyeing variables were studied to achieve the optimum dye uptake which were achieved via 2% of acid Jacquard Dye in acedic media (pH $_3$) at high temp. (90 °C) for 1 hr. Then the fabrics in different yarn counts and fineness were dyed in the optimum conditions to examine their color strength to record their Impact on the fabric dyeability and its mechanical properties. Count 60/2 with a fineness of 21.50 micron, recorded the highest color intensity whereas count 40/2 with a fineness of 21.23 micron, recorded the lowest color intensity. The highest tensile strength results for woolen fabrics from 30/2 to 40/2 metric yarn were achieved using filaments with a spinning fineness of (18.09 to 17.08) microns, respectively. These filaments were considered to be fine-diameter filaments with small length.

Keywords: *Acid dye, textile fiber, Jacquard Acid, Medium pH, hydrolysis.*

INTRODUCTION:

The textile industry is a cornerstone of global manufacturing, with a process of dyeing that plays a critical role in determining the aesthetics and functional attribution of the fabrics (Manzoor et al., 2023). Among various dyes, acid dyes, specifically Jacquard dyes, are important, vibrant, and uniform in color to woven fabric made of protein-based fibers, mostly wool and silk.

Several factors, including yarn count and fiber micron, influence the effectiveness of the dyeing procedure. A yarn count refers to the thickness or fineness of yarn by measuring the diameter of fiber by micron (Ebraheem, 2021). The advancement in dyeing technologies achieves a consistent dyeability that remains a persistent challenge for textile manufacturing. The variation in yarn count and fiber micron be leads to issues like uneven coloration, reduced dye uptake, and compromised fabric durability, ultimately affecting consumer satisfaction and market competitiveness. Therefore, the interplay between those factors and the dyeing behavior of woven fabric is crucial for optimizing the production process (He et al., 2021). The influence of yarn count and a fiber micron on the dyeability of the woven fabrics dyed with an acid Jacquard dye has not been comprehensively studied, which may result in gaps in knowledge and inefficiency in dyeing practices with this kind of dye. (Abdel-Aziz et al., 2023). . This gap may lead to rather inconsistent product quality, increasing production costs, and wastage of resources. These address the issues essential to enhance the dyeability, sustainability, and efficiency of the textile dyeing industry.

A dyeing mechanism with an acid dye includes Jacquard dyes, involves an ionic bonding between a dye molecule and a fiber amino group. This makes a process highly dependent on fiber characteristics and dyeing conditions. A study emphasized optimizing fiber and fabric properties by achieving desired dyeing outcomes. The influence of yarn count on dyeing behavior directly impacts the surface area available for dye uptake. The study revealed a fined yarn characterized by higher yarn counts and larger surface area, facilitating better dye penetration. Excessive fineness leads to issues like reduced fabric strength and increased dye consumption. A role of fiber micron in dye-ability demonstrates that the finer fiber (lower microns) exhibits a higher dye uptake because of the surface-to-volume ratio. An interaction between yarn count and fiber micron combined an effect of yarn count and fiber micron on a dyeability that has been sparsely explored in the existing literature.

MATERIALS AND METHODS

Materials:

Samples used in this research were produced from threads with different count numbers; (30/2, 40/2, 50/2, 60/2, 70/2) Metric. Each of them was spun with varying left twist factors; (480, 520, 690, 720, 760) Twm/meter. Then they were washed, bleached, and used to produce samples of worsted woven fabrics. All these processes were done in Golden Tex Spinning and Wool Company/Egypt.

Dyes:

Jacquard Acid 624 Turquoise Dye.

Chemicals:

Glacial acetic acid.
Sodium carbonate.
Non-ionic soap Hostapal CV-ET (Hoechst).

Fabric dyeing:

Study of ideal dyeing conditions:

To achieve the highest dye uptake during acid dyeing of wool fabrics produced in the research, some variables were studied to reach the ideal dyeing using count 60/2 metric with fineness of 18.09 microns. The study was as follows:

Study the effect of dye concentration:

Different concentrations (1%, 2%, 3%, 4%, 5%) of acid dye (Jacquard Acid 624 Turquoise Dye) were used to study the effect of different dye concentrations on the color strength achieved on wool. The dyeing conditions were as follows: the volume of the dyeing solution (L.R) was 1:100, pH was adjusted to 4, and dyeing was continued for 60 min at a temperature of ±97 °C.

Study the effect of pH:

In the case of acid dyeing, the low pH plays a role in forming hydrogen bonds that attract the acid dye to protein fibers such as wool, silk, and nylon fibers. The appropriate pH medium for dyeing is determined according to the type of acidic dye—some work in a moderately acidic medium, and some in a low acidic medium. To determine the appropriate medium for the acidic dye, dyeing was studied at different pH values (3, 3.5, 4, 5, 6, 7).

Study the effect of dyeing bath temperature:

Heat plays a significant role in dyeing processes. Most dyes have large molecules that make it difficult to penetrate the fibers, due to their presence in the aqueous medium at low temperatures. To improve dye penetration, raising the temperature ensures the ionization of these molecules and, therefore, the disintegration of molecular clusters into smaller molecules. However, on another side, the high dyeing temperature can harm wool fabric, so choosing a suitable temperature is important. Different temps. Were examined; (Room temperature, 40, 60, 80, 90)
°C for the dyeing process.

Study the effect of dyeing time:

The time variable controls the dye exhaustion. Inside fibers, the longer the dyeing time, the greater the depletion and the higher color strength of the achieved color, but the fibers may reach a state of saturation. When this state is reached, perhaps the process will reversed, causing the dye molecules to exit the material. Desorption and reaction with water, resulting in hydrolysis— dye molecules and thus loss of color. To ensure the use of the time factor to achieve a good dyeing rate and the highest required color intensity without increasing the time significantly, to protect the protein fibers from damage by exposure to high temperature for a long time, dyeing

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was studied at the following periods: (15, 30, 45, 60) minutes.

Dyeing wool fabrics with Different count and fineness in ideal dyeing conditions:

The ideal conditions for dyeing wool with Jacquard Acid 624 Turquoise Dye were deduced by reading the color strength of the dyed samples during the previous experiments and determining the best suitable dyeing conditions from dye concentration, adjusting the hydrogen medium, dyeing time, and temperature. Then, these conditions were applied to dyeing samples of the constant weight of wool fabrics (of different counts and fineness) which produced during the research.

Washing fabrics:

After dyeing, the dyed fabrics were washed to remove excess color using 2 g/L of soap at 40 °C for 15 minutes. Then, the color strengths K/S were measured on samples after drying to determine the highest reading.

Tests & Measurements

All laboratory tests were conducted in a standard atmosphere (humidity 65% ± 2%, temperature 20 ± 2°C) according to the ISO 21061:2021(en) Footwear — Chemical tests — General principles on the preparation of samples.

Measurement of mechanical properties of woollen fabrics of different counts and fineness:

The fineness of the hairs was measured according to ISO 1136:2015(en) Wool -Determination of mean diameter of fibres - Air permeability method.

The lengths of the hairs were measured according to ISO 6989:1981(en) Textile fibres — Determination of length and length distribution of staple fibres (by measurement of single fibres).

The acquired humidity was estimated according to the American specification (ASTM D2654-22) Standard Test Methods for Moisture in Textiles.

The breaking load and elongation of dyed textile materials are tested according to the American specification (ASTM D1682) Standard Methods (Withdrawn 1992) using an Electronic Strength and Extension Tester.

Measurement of Color strength K/S of dyed samples:

It was a completed measurement of the color strength of all dyed samples using a spectrophotometer Reflectance Measurements ICS-TEXICON Computerized Spectrophotometer, Model M 520220 (produced by ICS-TEXICON Limited Co., England).

The equation calculates the color strength:

Kubelka–Mun: $K/S = (1 - R)^2 / 2R$.

Where K is the dye absorption coefficient, S is the dye diffusion coefficient, and R is the reflection coefficient of the dyed materials. (AATCC, 1993).

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Table No. (1) Properties of filaments and yarns used in producing Worsted wool fabrics.

S.	Count (metric)	Count (tex)	Fineness (micron)	Length (mm)	Humidity (%)	No. of threads / a thread section
1	30/2	33.33	18.09	70	12	93.5
2	30/2	33.33	19.50	72	12.5	80
3	30/2	33.33	21.23	77	12.5	68
4	30/2	33.33	23.25	91	14	56.5
5	40/2	25	18.09	70	11	70
6	40/2	25	19.85	72.4	12.5	58
7	40/2	25	21.23	77	13	51
8	40/2	25	23.25	91	14	42.5
9	50/2	20	18.09	70	12	56
10	50/2	20	19.85	72.4	13	46.5
11	50/2	20	21.09	76	13.5	41
12	50/2	20	23.25	91	13.5	34
13	60/2	16.66	18.09	70	12	46.5
14	60/2	16.66	19.60	72.1	12.5	40
15	60/2	16.66	20.85	74.8	13	35
16	60/2	16.66	21.50	77.5	13.5	33
17	70/2	14.28	17.08	66	13	45
18	70/2	14.28	18.07	69	14.5	40
19	70/2	14.28	19.23	71.5	14	35.5

Fabric production and its executive specifications:

It was completed using the previous threads by warping each identical thread number on a warped cylinder, where the cylinder was divided according to the number of filaments used (microns) so that each yarn number is separate, and warping is done in this way on a special machine (Herjet sample warping machine) German-made model MS-1800/10 model 1987 AD. The machine can perform the warping process by spinning a single yarn. Then, the weaving process is done using a German-made automatic loom, the Dornier Rapier Weaving Machine, with a speed of 400 strokes/second and a loose and negative folding device. The method of opening the breath is a lower dub, and the ejection device uses a solid spear from both ends.

Table No. (2) shows the executive specifications of the fabric samples produced under investigation.

Thread count / Executive Specifications	30/2	40/2	50/2	60/2	70/2
The average number of cm threads per loom	14	19	21	22	23
The average number of cm wefts per loom	13	17	19	21.5	21
Warp width with weaving comb (cm)	180	180	178	176	176
Raw fabric with a selvage (cm)	167	168	168	168	168
Finished fabric with a selvage (cm)	151	154	154	154	154
Number of comb doors/cm	7	9.5	10.5	11	11.5

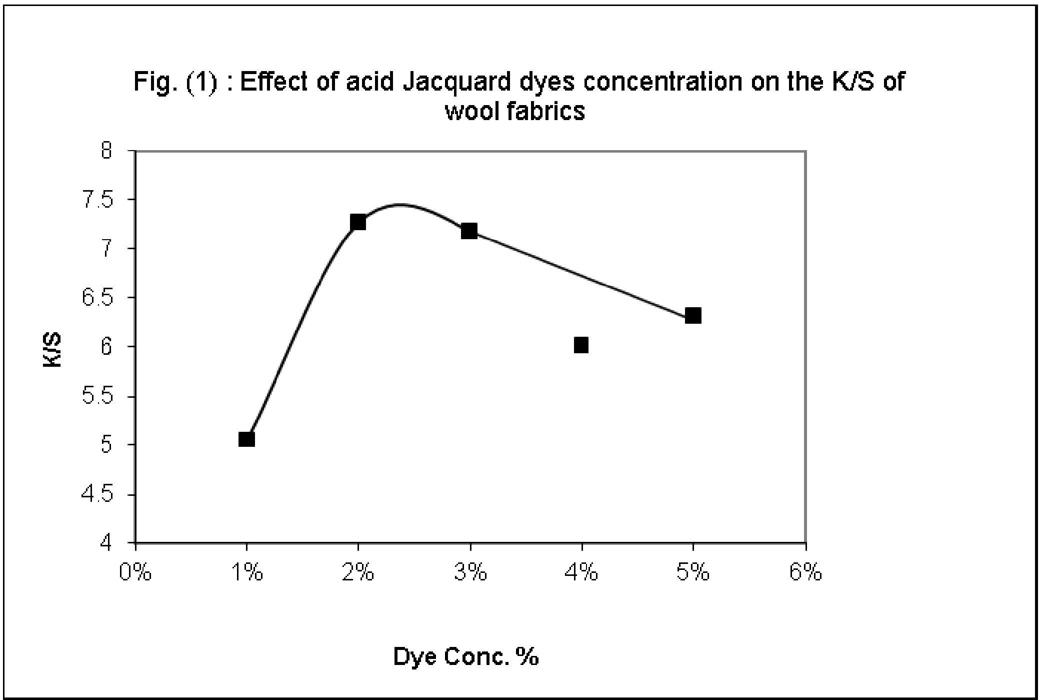
Throwing system (number of door twists)	2	2	2	2	2
Weight per square meter of raw fabric	220	210	185	170	143
Weight per linear meter of raw fabric	325	325	285	260	220

JACQUARD ACID DYES & ITS SPECIFICATIONS:

Ideal conditions for acid Jacquard dyeing of wool fabrics:

Experiments were conducted to determine the ideal conditions for the dyeing process. Then, the color strengths of the dyed samples were achieved at the end of these experiments were measured to determine the optimal condition for each one. Then, the ideal conditions for the whole dyeing process were determined.

Study the effect of dye concentration:



Applying dyeing conditions was as follows: The volume of the dye solution L.R 1:100, pH: 4, for 60 min, at ±97°C with different dye concentrations. The color strength of each sample was measured to determine the ideal concentration to achieve the highest possible color tone. It is clear from Figure No. (1) and Table No. (3), a concentration of 2%-3% of the dye achieves the highest color intensity (7.27-7.17).

Table No. (3): Effect of dye concentration on the color

Dye concentration **Dye Conc.**	1%	2%	3%	4%	5%
Color strength K/S	5.05	7.27	7.17	6.01	6.31

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The more the dye concentration increases, the less intense the color becomes, indicating that the material has reached a state of saturation. A saturated condition means that the spaces between the dye molecules are filled. Thus, the excess that the material needs remains on its surface without chemically combining with the material, and therefore, it is easily removed with washing. Hence, the best concentration for dyeing wool samples is 2% to ensure the color value while reducing the economic cost of using a smaller amount of dye.

Study the effect of pH:

The variable pH was studied, the woolen fabrics were dyed at different values in an acidic to neutral medium (3-7) using 4% of Jacquard dye (The experiment was conducted before determining the optimum dye concentration. So the strength of the resulting color as expected were lower than what will be expect when using 2% dye concentration in the dyeing bath.

Fig. (2) : Effect of acid Jacquard dyeing pH on the K/S of wool fabrics

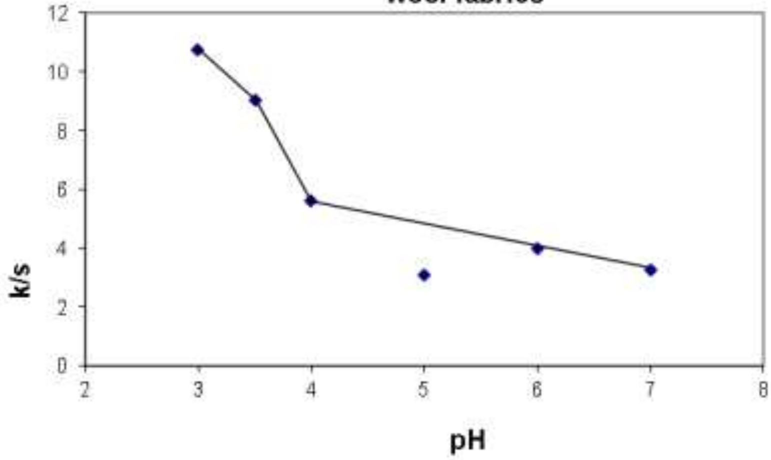

Table No. (4): Effect of difference in hydrogen medium pH of the dyeing process on the color strength of the dyed samples.

Dyeing pH	3	3.5	4	5	6	7
K/S	10.76	9.03	5.62	3.09	4.00	3.28

The Fig.(2) shows the highest color value was achieved at the highest acidic medium value at pH_3. This is because it is known that acidic dyes at low pH levels become able to bind to wool chains through the formation of hydrogen bonds, van der Waals bonds, in addition to the ionic bonds that arise between the basic amino groups NH_3 and the sulfonate groups SO_3. As wool gives positive charges to the amino groups in water, at the same time, acidic dyes form negatively charged sulfonate ions, which attract protein fibers, and the acid added to the dyeing medium acts as a catalyst to increase the formation of positive charges and thus increase the attraction and formation of ionic bonds.

As can be seen from the graph, the strength of the color decreases steadily upon reaching the neutral medium, where we find that the color strength has reduced by a percentage of about 47.79% when moving from pH_3 to pH4, reaching a 69.52% decrease in color intensity when reaching the neutral medium of pH_7.

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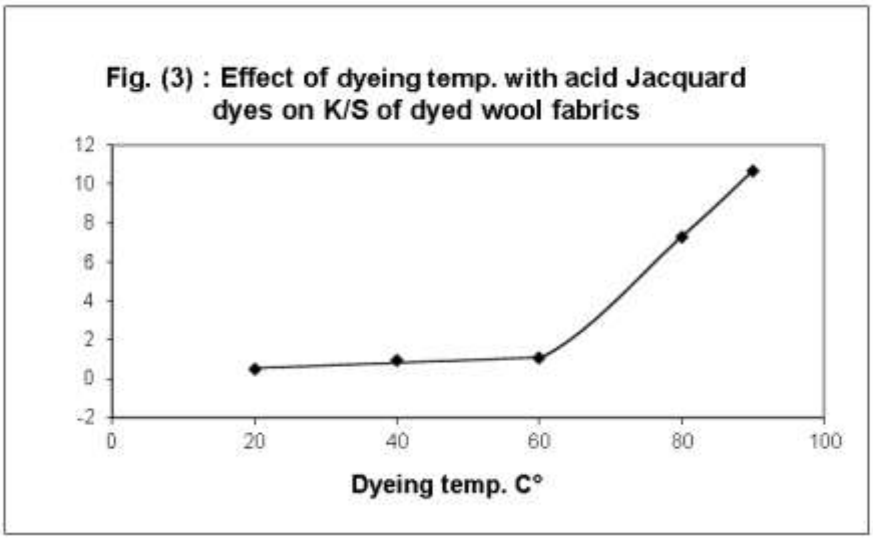
Study the effect of temperature on color intensity K/S for dyed samples:



Using dyeing in pH $_3$ medium and it is noted in Figure (3) that with the gradual increase in the temperature of the dyeing process, the intensity of the color increases until it reaches the degree 90 °C where the heat increases the ionization of the dye and thus increases the penetration rate and formation. The links between the dye and the fibers are clear in Table No. (5), that the increase in color until the dyeing bath temp. reaches at 60°C is considered a slight color strength increase. Then, it multiplied at high rates until it reached to degree 90 °C, confirming the increase in ionization and the formation of bonds.

Table No. (5): Effect of the dyeing process temperature on the color strength of dyed samples

Dyeing process temperature**Dyeing Temp.**	R.T °C	40 °C	60 °C	80 °C	90 °C
Color strength K/S	0.467	0.94	1.046	7.28	10.66

Study the effect of dyeing time On the strength of the color K/S for dyed samples:
It is noted from Figure (4) that the longer the dyeing process takes, the more exhaustion there is, thus increasing the color intensity achieved on the samples. Therefore, the highest color intensity was achieved (10.56) After passing 60 minutes of dyeing time. As shown in Table No. (6).

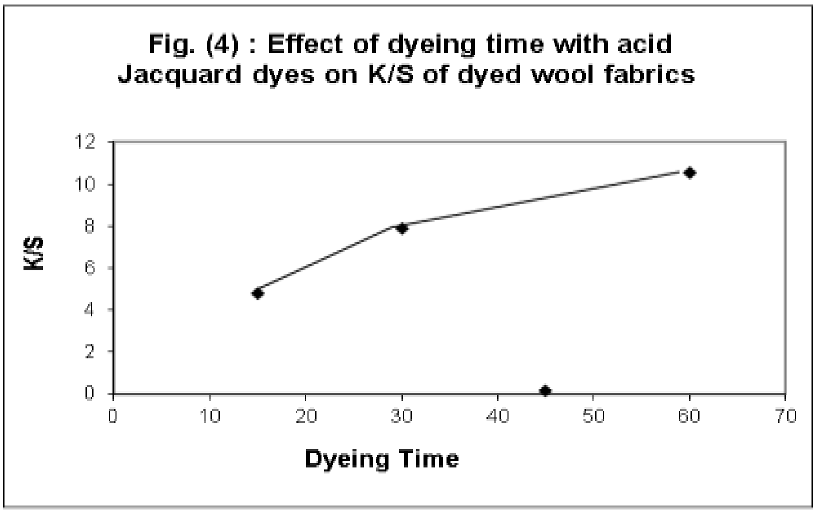


Table No. (6): Effect of dying process time on color intensity of dyed samples

Dyeing Time.	15΄	30΄	45΄	60΄
Color strength K/S	4.76	7.91	0.15	10.56

The results are consistent with what research and studies confirm: The dyeing rate is usually affected by some factors, which are:

Dye particle size.

The degree of aggregation of dye molecules in an aqueous solution of a de and disability of fibers, rate of dye adsorption in both directions into the dyeing solution or the fiber, dye bath temperature, and pH.

Dyeing of woollen fabrics of different hues and fineness under ideal dyeing conditions

After performing measurements to measure the color intensity of dyed samples to determine the ideal dyeing conditions, the perfect conditions were concluded as follows:

Table No. (7): Ideal conditions for dyeing wool with dye Acid turquoise 624 (Acid blue 7)

Dye concentration	Hydrogen medium	Temperature	Time
2%	pH = 3	90°C	60΄

The wool samples produced in the research were dyed at a fixed weight and under fixed conditions for all samples to determine whether or not there was an effect of the difference in thread number and fineness on the dye's behavior on the material. The results were recorded in Table No. (8).

Table No. (8): The effect of thread count and fineness on the color intensity of dyed wool samples

S.	Thread count (metric)	Fineness (micron)	Color intensity K/S	Sample arrangement According to the intensity of the color	Decrease rate Color intensity %
1	30/2	18.09	13.6798	13	20.75
2	30/2	19.50	14.2603	9	17.39
3	30/2	21.23	15.6263	3	9.48
4	30/2	23.25	14.3069	8	17.12
5	40/2	18.09	14.2603	9	17.39
6	40/2	19.85	13.9421	11	19.23
7	40/2	21.23	11.8729	17	31.22
8	40/2	23.25	12.7169	16	26.33
9	50/2	18.09	13.3852	14	22.46
10	50/2	19.85	12.7169	15	28.07
11	50/2	21.09	13.9421	11	19.23
12	50/2	23.25	13.7229	12	20.50
13	60/2	18.09	14.3537	7	16.85
14	60/2	19.60	14.1680	10	17.92
15	60/2	20.85	15.0412	4	12.86
16	60/2	21.50	17.2619	1	
17	70/2	17.08	14.6899	5	14.90
18	70/2	18.07	16.5581	2	4.08
19	70/2	19.23	14.5924	6	15.46

With an overview of the color intensity reading of the samples, despite the unification of dyeing conditions, the difference between the readings is as follows: Sample (16) - thread count 60/2 with fineness 21.50 microns recorded the highest color intensity (17.2619). Sample (7) thread count 40/2 with fineness 21.23 microns recorded the lowest color intensity, which is (11.8729), i.e., a decrease in the intensity of the color by 31.22% compared to the sample with the highest value because the finer the number is 60/2, the greater the number of twists in the thread section with micron accuracy, which may be attributed to the increase in the number of interstitial spaces that allow the dye to penetrate inside it and thus increase the depth of the color.
By observing the first order in terms of color intensity, we find that samples (1-7), whose score ranges between 60/2 and 70/2, i.e., the highest score, are the ones that recorded the highest readings. Samples count 50/2 Comparing the color intensity between them with each other, with only the difference in their resolution, there was no significant difference. This indicates that the tiger is the most reliable in terms of the difference in the intensity of the color, not the difference in microns, due to the similarity of the color between the different microns of the uniform tiger.
It is noted that the reading of the samples with the thickest number, 30/2, is close to that of the samples with the thinnest number. This may be attributed to the fact that the thick threads are characterized by a low twist coefficient, which may allow for somewhat greater penetration, compensating slightly for the lack of color resulting from the thickness of the thread and the small spaces between them. This conclusion means that using the thicker thread that have less expensive instead of using the higher-cost thread count give deeper shades of color to achieve good color values that if the smoothness and high gloss specifications are unnecessary.
The highest tensile strength for fabrics from 50/2 metric thread was achieved using woolen filaments with a spinning fineness of 19.85 microns. These filaments are considered medium filaments (in thickness and length). Unlike thin and thick-diameter fibers, where the medium- thickness and medium-length fibers are spun, they achieve good results. The highest tensile strength results for woolen fabrics from 60/2 70/2 metric yarn were achieved using filaments with a spinning fineness of (18.09 17.08) microns, respectively. These filaments are considered to be fine-diameter filaments with small length. When fine threads are spun from fine fibers, this allows for a large number of fibers in the thread section, which creates a large frictional surface between the fibers and thus increases the strength of the threads produced from these filaments.

Table No. (9): Results of tensile strength tests of fabrics produced in the research

S.	The thread count (metric)	Fineness (micron)	Average tensile strength (warp) of fabric Before dyeing	Average tensile strength (warp) of fabric After dyeing	Average tensile strength (Weft) of the fabric before dyeing	Average tensile strength (weft) of the fabric After dyeing
1	30/2	18.09	40.44	38.33	38.44	36.21
2	30/2	19.50	36.22	36.12	31.75	30.94
3	30/2	21.23	38.54	37.09	34.95	33.88
4	30/2	23.25	44.02	43.85	41.55	41.12
5	40/2	18.09	41.11	40.12	37.65	36.87
6	40/2	19.85	38.65	36.43	35.41	34.41
7	40/2	21.23	37.92	37.22	34.87	33.22
8	40/2	23.25	43.46	43.22	39.62	39.22
9	50/2	18.09	31.14	30.65	28.77	27.94
10	50/2	19.85	32.78	31.45	31.45	30.63
11	50/2	21.09	30.41	30.22	27.46	27.88
12	50/2	23.25	26.11	25.68	22.33	21.45
13	60/2	18.09	30.45	29.11	26.78	25.32
14	60/2	19.60	30.11	28.71	25.11	24.06
15	60/2	20.85	28.71	28.14	23.62	22.15
16	60/2	21.50	26.54	24.35	21.19	19.87
17	70/2	17.08	27.65	26.14	24.15	23.65
18	70/2	18.07	25.11	24.06	23.35	21.77
19	70/2	19.23	21.95	20.87	20.65	19.54

It is clear from the results of the tensile strength of the produced fabrics that all fabrics have decreased in tensile strength after the dyeing process. This may be due to the dyeing process at high temperatures and the subsequent washing of the material, i.e., water treatments, which may be accompanied by the material losing part of its filament strength and durability due to the penetration of water between the protein chains, which results in weakness in the internal bonds between them. There is also a decrease in attraction at the centres of the salt bonds. Thus, weakness may result in some bonds, which somewhat reduce tensile strength. Observing the limited decrease gives an advantage to this type of dye, which does not significantly harm the mechanical properties of the fibers.

Effect of different thread count and filament fineness on the percentage of elongation of samples Wool before and after dyeing:

The chemical composition of wool is characterized by the ability to elongate, which is attributed to the formation of the wool protein molecule, which consists of a chain of amino acids connected by salt and sulphur bonds. These bonds are found in the form of folds in the case of stretched hairs, and the flexibility is acquired from a spiral helical layer, a layer (Helices) that makes keratin molecules take on a large spring-like shape. It is clear from Table (10), there is a significant difference and a slight decrease between the elongation percentage rates before and after dyeing, which is attributed to the relationship between the fineness of the filaments, their length and number in the thread section, and the preoccupation of the interstitial spaces with dye molecules and their connection to the fibers with chemical bonds, which reduces the chance of fiber elongation.

Table No. (10): Elongation test results for fabrics produced in the research

S.	Thread count (metric)	Fineness (micron)	Average warp elongation of the fabric before dyeing (%)	Average warp elongation of the fabric After dyeing (%)	Average elongation (weft) of the fabric before dyeing (%)	Middle elongation (weft) For fabric after dyeing (%)
1	30/2	18.09	38.64	37.23	37.65	37.43
2	30/2	19.50	35.88	35.02	32.87	31.55
3	30/2	21.23	36.78	36.21	32.55	31.87
4	30/2	23.25	42.87	43.45	42.78	42.11
5	40/2	18.09	40.77	39.11	31.65	30.45
6	40/2	19.85	34.56	34.44	29.22	28.64
7	40/2	21.23	32.31	31.65	28.64	28.31
8	40/2	23.25	42.67	42.92	34.41	33.68
9	50/2	18.09	40.68	38.78	35.14	34.78
10	50/2	19.85	42.78	41.77	37.45	37.22
11	50/2	21.09	38.11	37.85	31.67	30.14
12	50/2	23.25	35.64	34.65	28.78	27.15
13	60/2	18.09	44.81	43.14	39.65	38.34
14	60/2	19.60	43.56	42.67	37.11	35.11
15	60/2	20.85	41.11	40.65	35.41	33.77
16	60/2	21.50	38.17	37.65	31.65	28.17
17	70/2	17.08	43.65	41.11	38.65	37.11
18	70/2	18.07	41.78	39.95	36.14	35.46
19	70/2	19.23	40.12	37.65	33.78	31.45

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DISCUSSION

Acidic dyes are poorly adsorbed due to their high solubility due to the containing watery enough roots. They are sulfur radicals, which increase the spread of dye ions on the outer surface of the material, resulting in accumulation (Ledakowicz & Paździor, 2021). For shipments and thus slow absorption, on the one hand, as it is due to these sulfur radicals, they are credited with forming salt bonds between acid dyes and protein fibers. Because of the formation of this bond, acid dyes may be considered dyes with high degrees of washing stability because the bonding is done through a first-degree bond (Yusof et al., 2025). The variable pH was studied, and the intensity of the resulting color was measured at different values in an acidic to neutral medium using the dye at a concentration of 4% (The experiment was conducted before determining the optimum dye concentration. The dyeing rate is expected to increase when performing all the following experiments at a dye concentration of 2%).

Natural fibers come in different lengths, which is important when choosing the right fiber for a particular purpose. Whenever the length is increased, the fiber is as thin as possible, and yarns are spun, and length helps to twist them well and easily during the yarn production process (Zu et al., 2021). Causing cohesive force that is the strength of the thread produced, and thus, the tensile strength of the fabric increased. The smaller the variation between the hair lengths (the greater the Regularity Length), The better the products we get in terms of the natural and mechanical properties of the fabric produced. Therefore, the length of the filaments is considered an essential element in estimating the price of the material when purchasing. Despite the advantages of long fibers, short fibers are sometimes preferred when it is desired to produce fabrics with a smooth, hairy surface and a warm touch because the threads are spun in short- staple lengths (Jayalakshmi, 2024). Staple contains air gaps that provide thermal insulation and provide a soft texture.

All fabricated fibers can absorb moisture from the air and release it when humidity changes. But wool alone (Figure 2) can absorb up to 35% of its weight in water, which is more than any other fiber; for example, the saturated water content in cotton is 24%, in nylon (polyamide) 7%, and in polyester 1%. The ability of the material to absorb water is one of the very important properties of textile materials (Nawab, 2024). The ability of the material to absorb reduces the costs of finishing and dyeing operations. Identify the behavior of threads with different numbers and fineness affecting the dyeing process and what it entails towards mechanical properties. Ensure a good dyeing rate and satisfactory use properties of worsted wool fabrics. (Ammayappan et al., 2024).

Producing fabrics includes many variables and is linked to some technological processes. Textile scientists have studied and analyzed these variables to achieve quality in production in terms of quantity and quality, achieve the best specifications in terms of appearance and use, and reduce consumption of raw materials, materials, and capital to achieve the principle of comprehensive quality in production (He et al., 2021). In the context of studying the variables affecting the textile industry, it was noted that the scarcity of studies that give the effect of changing the number of the fabric or changing the micron of the thread on the strength of the intensity of the color achieved on the material during the dyeing process is investigated.

Because wool is a raw material important in the textile industry, the type of product, its properties, and its clothing use are related to the specifications of the wool used, and the more flexible, the more in demand because it gives the clothing material distinctive usage properties (Doyle et al., 2021). The finer the wool fibers are and the higher their number, the better their usage specifications are, and consequently, the higher the cost of weaving them, which requires preserving those properties from the negative effects that may result from the dyeing process. Therefore, this research has dealt with the study of a relationship between the thread number and its fineness on the one hand and the dyeing rate of the fabric woven from it on the other hand, with a study of the dyeing conditions to achieve the maximum color value and its effect on some properties of the material (Wang et al., 2021).

Results of measuring the mechanical properties of woolen fabrics of different thicknesses and textures and the effect of dyeing on them: The effect of different thread counts and filament fineness on the tensile strength of wool fabric samples beforehand after dyeing: It is clear from Table No. (10), that the tensile strength results before and after dyeing for the warp and weft threads varied despite using the same number. This is attributed to the difference in the fineness of the filament for the same number and the resulting difference in the length and number of filaments in the thread section produced on the one hand and to the effect of the dye on the other hand. The results are summarized as follows:

The tensile strength of thicker threads (30/2, 40/2) metric gives higher results compared to thinner threads (50/2, 60/2, 70/2) metric for fabrics before and after dyeing, where the highest reading is given by threads of number 30/2, 40/2 using filaments with a spinning fineness of 23.5 microns because they are characterized by the length of their fibers and the roughness of their texture, which allows for the generation of a large frictional surface between the fibers, which gives the produced thread high durability. The average diameter of the filament significantly affects the tensile strength, as the strength increases with the increase in the average diameter of the filaments.

CONCLUSION

The difference in fineness and thread number affects the color intensity achieved on the produced material. The improvement in color absorption on the material is mainly related to the increase in yarn number. However, the decrease in twist coefficient in thicker yarns approximates the results. The average diameter of the filament significantly affects the tensile strength, as the strength increases with increasing average diameter of the filament. Drop dyeing has a limited effect on the elongation capacity of the fibre.

LIMITATIONS AND STRENGTHS

The study's primary limitations are focused on woven fabrics dyed with acid Jacquard dyes, encompassing a wider variety of textiles and dye types by the use of industry. In addition, a study finding may be influenced by a variation in an experimental condition like temperature, pH, and dyeing time that limits generalizability. These constraints the study strengthens lie in a systematic analysis by combining research (Liu, 2023). It provides practical insights that direct the benefits of manufacturers seeking enhancement in quality and process efficiency.

FUTURE IMPLICATIONS

The study's outcome has significant implications for the future of textile manufacturing by elucidating a relationship between yarn count, fiber microns, and dye-ability, and the research provides the foundation for developing predictive modeling and AI-driven tools for optimizing dyeing processes. An innovation could lead to more sustainable practices by minimizing resource consumption and reducing environmental impact.

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