Research on the Finishing of Wearing characteristics of Organic Cotton Men’s Shirt Fabric

Zhilin Li¹, Jianping Wang¹,²,⁴, Liuying¹ and Xiaona Chen²,³

¹ College of Fashion and Art Design, Donghua University, PR China
² Key Laboratory of Clothing Design & Technology, Donghua University, Ministry of Education, Shanghai 200051, China
³ School of Textiles and Fashion, Shanghai University of Engineering Science, Shanghai, China
⁴ Shanghai Institute of Design and Innovation, Tongji University, PR China

wangjp@dhu.edu.cn

Abstract. In order to improve the wearing characters of organic cotton men's shirt fabrics and explore the effective finishing path, this article combining with the strength reagent 501, explored the differences of the wearing characters of 20S organic cotton men’s shirt fabric after different dipping times and drying temperature, used the fuzzy comprehensive evaluation analysis method to evaluate the wearing characters comprehensively, and formulated three finishing technical path to improve the wearing characteristics of organic cotton men’s shirt fabric according the comprehensive evaluation result. The process provides a reference about development of organic cotton products for the enterprise in future and study of organic cotton for the experts and scholars.

1. Introduction
With the rapid economic development and the continuous improvement of living standards, people have higher and higher requirements for quality of life, and green and healthy consumer awareness is becoming stronger and stronger [1]. Organic cotton, as a natural non-polluting green fiber, not only meets people's pursuit of environmental protection concepts, but also meets the requirements of sustainable development in the 21st century [2-3]. However, at present, the technology of organic cotton textiles in China is still immature. Organic cotton yarns are of lower quality than ordinary cotton yarns, and the wearing characters of fabrics is generally inferior to ordinary cottons. Domestic researches mainly focus on the development prospect of organic cotton, the behavior of organic cotton consumers and the comparative of organic cotton common cotton [4-5]. There are few researches on the finishing of organic cotton, so this article mainly explores the wearing characters and effective finishing process of organic cotton men's shirt fabric.

There is no significant difference in the crease resistance, pilling resistance, drapability, air permeability, thermal insulation and moisture permeability between the organic cotton and ordinary cotton men's shirt fabrics with the same yarn size. The mechanical properties of 20s organic cotton men's shirt fabrics are worse than those of 40s and 50s organic cotton men's shirt fabrics, especially the warp breaking strength and warp tearing strength just exceed the strength standard line of woven fabrics. Therefore, it is necessary to seek effective solutions to improve the mechanical properties of organic cotton men's shirt fabrics.
2. Experiment

2.1. Samples, Drugs and Instruments

Sample: 20s pure woven organic cotton men's shirt fabric (21x21 66x54 plain)

Drugs: the strength reagent 501(solution concentration of 5%).

Instrument: P - BO - Horizontal /P - BO - vertical uniform rolling car (Taiwan (Xiamen) Ruby company), M- TENTER continuous fabric heat setting machine (Taiwan (Xiamen) Ruby company)

2.2. Finishing Process

The finishing process of organic cotton men's shirt fabric is as follows:

| Organic cotton men's shirt fabric | The strength reagent Concentration of 5% | One-times dipping | Two-times dipping | Three -times dipping | Drying (140℃) | Drying (150℃) | Drying (160℃) | Drying (170℃) | Drying (180℃) | Drying (190℃) | Washing | Drying (140℃) |
|---------------------------------|----------------------------------------|------------------|------------------|-------------------|---------------|---------------|---------------|---------------|---------------|---------------|----------|----------------|

2.3. Testing Instruments and Standards

Crease resistance: using YG541E automatic laser fabric crease elasticity instrument, referring to GB/T 3819-1997, the crease recovery angle (°) is used to measure the crease resistance of the organic cotton fabric after finishing.

Pilling resistance: using YG401C type fabric leveling instrument and YG982C standard light source instrument, referring to GB/t 4802.2-2008, the Martin pare method is used to measure the pilling resistance performance of the organic cotton fabric after finishing.

Drapability: using XDP-1A type fabric drape tester, referring to GB/T23329-2009, the static drape coefficient is used to characterize the drape of the organic cotton fabric after finishing.

Air permeability: using YG461E type air permeability tester, referring to GB/T 5453-1997, the air permeability is used to characterize the breathability of the organic cotton fabric after finishing.

Thermal insulation: using YG606E type thermal resistance tester, referring to GB/T 11048-2008, the heat insulation rate is used to characterize the heat insulation property of the organic cotton fabric after finishing.

Moisture permeability: using M261 type moisture permeability tester, referring to GB/T 12704-1991, the moisture permeability of organic cotton fabric was measured by the moisture permeation cup method.

Tensile property: using HD026N+ type electronic fabric strength machine, referring to GB/T 3923.1-1997, use the strip method to measure the breaking strength of the organic cotton fabric.

Tear property: using HD026N+ type electronic fabric tear tester, referring to GB/T 3917.2-1997, the tongue shaped sample method is used to measure the tear strength of the organic cotton fabric after finishing.

Bursting property: using HD026N+ type electronic fabric strength tester, referring to GB/T 19976-2005, using the spherical mandrel (steel ball method) to measure the full strength of the organic cotton fabric after finishing.

Wear resistance: using Y522 type flat grinding machine, referring to FZ/T 01121-2014, using flat grinding method to measure the friction speed of the organic cotton fabric after finishing.
3. Results and discussion

3.1. Fuzzy comprehensive evaluation

The fuzzy comprehensive evaluation is based on the fuzzy mathematics theory and obeys the principle of subordination degree, which makes it difficult to quantify factors for quantitative analysis, fuzzy factors for qualitative analysis and multi factors for comprehensive analysis\cite{9}. This method evaluates and analyzes the wearing characteristics of 20s organic cotton men's shirting fabrics one by one, combining with its own specific evaluation value, ranking the importance of comprehensive evaluation results. The best finishing process is selected after comparing and analyzing the advantages and disadvantages.

3.2. Determine factor combination $U$

20s organic cotton men's shirt fabric has been tested for its tensile property, tear property and bursting property after being dipped and dried. 12 representative index values have been obtained. After exchanges with the foreign trade customers of the organic cotton shirts, 9 representative indicators are retained.

$$U = \{U_1, U_2, U_3, U_4, U_5, U_6, U_7, U_8, U_9\}$$

$U_1$ represents warp breaking strength, $U_2$ represents warp tearing strength, $U_3$ represents bursting strength, $U_4$ represents frictional revolution, $U_5$ represents retarded elastic wrinkle recovery angle, $U_6$ represents draping rate, and $U_7$ represents air permeability, $U_8$ represents heat preservation rate, $U_9$ represents moisture permeability.

3.3. Determine the relationship matrix $R$

The extreme value normalization of the test results is used to determine the relationship matrix $R$.

$$R = \begin{pmatrix}
0.486 & 0.499 & 0.401 & \cdots & 0.367 & 0.564 & 0.588 & 0.524 & 0.395 \\
0.550 & 0.523 & 0.512 & \cdots & 0.542 & 0.432 & 0.438 & 0.535 & 0.532 \\
0.621 & 0.423 & 0.549 & \cdots & 0.516 & 0.312 & 0.417 & 0.445 & 0.448 \\
0.590 & 0.650 & 0.463 & \cdots & 0.489 & 0.647 & 0.504 & 0.460 & 0.533 \\
0.327 & 0.453 & 0.459 & \cdots & 0.606 & 0.508 & 0.481 & 0.466 & 0.574 \\
0.624 & 0.706 & 0.363 & \cdots & 0.510 & 0.521 & 0.419 & 0.447 & 0.556 \\
0.548 & 0.390 & 0.597 & \cdots & 0.668 & 0.413 & 0.547 & 0.463 & 0.249 \\
0.568 & 0.515 & 0.562 & \cdots & 0.607 & 0.420 & 0.495 & 0.630 & 0.456 \\
0.540 & 0.523 & 0.630 & \cdots & 0.402 & 0.422 & 0.659 & 0.336 & 0.506
\end{pmatrix}$$

3.4. Determine the weight set $A$

According to the actual experience of the organic cotton men's shirt foreign trade brand customers, the grading indexes of 20s organic cotton men's shirt fabrics are sorted according to the scoring method. The most important characterization is to mark 9 points, the next most important is 8 points, and so on until 1 point. The weight coefficient $A$ of each characterization index is obtained by the weighted calculation method. Table 1 shows the results of the weighting coefficients of 20S organic cotton men's shirt fabrics.

| Table 1. 20S organic cotton men's shirt fabric characterization index weight coefficient. |
|---------------------------------|---------|--------|--------|---------|
| Investigation brand            | 1      | 2      | 3      | Total score | Weight coefficient |
| Investigation brand            | 7      | 8      | 9      | 24         | 0.178             |
| Breaking strength              | 3      | 4      | 3      | 10         | 0.074             |
| Tearing strength               | 2      | 1      | 1      | 4          | 0.030             |
| Bursting Strength              | 5      | 9      | 8      | 22         | 0.163             |
| 0.163Friction coefficient      | 6      | 5      | 7      | 18         | 0.133             |
| Overhanging rate               | 4      | 3      | 4      | 11         | 0.081             |
From Table 1, we can see that the weight coefficient of the 20s organic cotton shirt is $A = (0.178, 0.074, 0.030, 0.163, 0.081, 0.156, 0.037, 0.148)$.

3.5. Comprehensive evaluation results and analysis of wearing characteristics

$$B = A \cdot R = (0.5225, 0.5209, 0.4988, 0.5078, 0.4301, 0.4637, 0.4683, 0.4580, 0.4615, 0.4501, 0.5169, 0.5367, 0.5097, 0.5087, 0.4994, 0.5308, 0.4646, 0.4620)$$

According to the principle of maximum membership, the wearing performance of 20s organic cotton shirt is evaluated by fuzzy comprehensive evaluation after different finishing processes. The result is shown in Table 2.

Table 2. Ranking of wearing characteristics of 20s organic cotton men's shirt fabrics after different finishing processes.

| ranking | Comprehensive | Grade | Proportion | Times of rolling | Drying temperature |
|---------|---------------|-------|------------|------------------|-------------------|
| 1       | 0.5367        | Excellent | 5%          | 2                | 190               |
| 2       | 0.5308        | Good     | 20%         | 3                | 170               |
| 3       | 0.5225        | Good     | 20%         | 1                | 140               |
| 4       | 0.5209        | Good     | 20%         | 1                | 150               |
| 5       | 0.5169        | Good     | 20%         | 2                | 180               |
| 6       | 0.5097        | Good     | 20%         | 3                | 140               |
| 7       | 0.5087        | Good     | 20%         | 3                | 150               |
| 8       | 0.5078        | Good     | 20%         | 1                | 170               |
| 9       | 0.4994        | Average  | 70%         | 3                | 160               |
| 10      | 0.4988        | Average  | 70%         | 1                | 160               |
| 11      | 0.4683        | Average  | 70%         | 2                | 140               |
| 12      | 0.4646        | Average  | 70%         | 3                | 180               |
| 13      | 0.4637        | Average  | 70%         | 1                | 190               |
| 14      | 0.4620        | Average  | 70%         | 3                | 190               |
| 15      | 0.4615        | Average  | 70%         | 2                | 160               |
| 16      | 0.4580        | Average  | 70%         | 2                | 150               |
| 17      | 0.4501        | Average  | 70%         | 2                | 170               |
| 18      | 0.4301        | Bad      | 5%          | 1                | 180               |

After two-times dipping and drying at a temperature of 190°, the 20s organic cotton shirt fabric has the best comprehensive wear performance; After three-times dipping and drying at a temperature of 170°, the 20s organic cotton shirt has the second comprehensive wear performance; the 20S organic cotton men's shirt fabric after one-time dipping and drying at a temperature of 140° has the third comprehensive performance.

20s organic cotton men's shirt fabric can effectively improve mechanical properties while maintaining the best comprehensive wear performance. The best finishing technology path is: the strength reagent 501(solution concentration of 5%) + two-times dipping + 190°C drying temperature.
20s organic cotton men's shirt fabric can improve the mechanical properties while maintaining the second comprehensive wear performance. The best finishing technology path is: the strength reagent 501(solution concentration of 5%) + three-times dipping + 170°C drying temperature.

20s organic cotton men's shirt fabric improves mechanical properties while maintaining the acceptable comprehensive wear performance of energy saving finishing technology path is: the strength reagent 501(solution concentration of 5%) + one-time dipping + 140 °C drying temperature.

4. Conclusion
In this paper, the finishing agent 501 is used to explore the difference of wearing characters of 20s organic cotton shirt fabric after finishing by different times of dipping and temperature of drying, and the experimental data of wearing characters is comprehensively evaluated by the method of fuzzy comprehensive evaluation analysis. Finally, based on the comprehensive evaluation results, three post-finishing process technology paths that effectively improve the wearing characters of organic cotton men's shirt fabrics are as follows:

For sports brand men's shirts that focus on the mechanical properties of organic cotton men's shirt fabrics, we can choose the strength reagent 501 (solution concentration of 5%) + three-times dipping + 170 °C drying temperature finishing technology path. It can strongly improve the mechanical properties of organic cotton men's shirt fabrics while maintaining its comfort performance.

For casual brand men's shirts that focus on the comfort of organic cotton men's shirt fabrics, we can choose the strength reagent 501 (solution concentration of 5%) + one-times dipping + 140°C drying temperature finishing technology path. It can maintain the comfort of the organic cotton men's shirt fabric while improving its mechanical properties to a certain extent.

For sports and leisure brand men's shirts, which not only focus on the mechanical properties of organic cotton men's shirt fabrics, but also pay attention to their comfort performance, we can choose the strength reagent 501 (solution concentration of 5%) + two-times dipping + 190°C drying temperature finishing technology path. It can effectively improve the mechanical properties of organic cotton men's shirt fabrics while maintaining its comfortable performance.

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