EFFECTS OF AN ENZYME TREATMENT ON YARN PROPERTIES

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Introduction

Recent advances in cellulase treatments of cotton fabrics have resulted in improved softness, enhanced drapeability, and reduced piling. These changes can transform low-quality fabrics into higher quality textiles in an environmentally friendly manner. Several studies have reported the effects of cellulase enzymes on fabrics made of cotton, cotton/polyester and cotton/wool blends [1,2,4,6]. However, the literature reveals a tack of information about effects of cellulase enzyme treatments on cotton yarn properties. This is to report on a study of impacts of enzyme treatment on properties of both ring-spun and rotor-spun yarns.

Procedure

Two distinct Upland cotton fibers were chosen; Fiber A was long, strong, and mature; Fiber B was short, weak and immature. Fiber properties were measured with the Spinlab High Volume Instrument, the Uster Advanced Fiber Information System, and the Shirley Fiber/Maturity Tester. Results are tabulated in Exhibits 1 and 2.

Yarns were spun both on the Saco Lowell SF-3H ring frame and Schlafhorst Autocoro SE-9 rotor spinning machine, then wound into 10 gram skeins for the enzyme treatment. Nominal Ne 30/1 yam sizes were spun on both systems. Skeins were scoured with 1% non-ionic detergent (on the weight of the yam), at 90+C for 30 minutes in a Gaston County skein dyeing machine. A separate bath was set with a pH of 4.5 using sodium acetate as a buffer. Acetic acid was used to keep the pH at 4.5. Cellulose enzymes used were of industrial grade with an -activity of 100 CCU/gram. Enzymes (0.4 CCU per skein) were added and the skeins were agitated for 30 minutes at 60+C, then 4% soda ash (on the weight of the yam) was added to neutralize the bath pH. The skeins were then washed in deionized water at 90+C, and air-dried. For the experimental control, identical yam skeins were treated with the same procedure except no enzymes were added.

The yarn samples were then subjected to four physical tests to assess their mechanical properties. These were the following: (1) single strand strength using an Instron Tester, (2) surface friction using a

Exhibit 1.
Fiber Properties measured by HVI

Fiber Properties	Fiber A	Fiber B
1/8″ gauge strength (g/tex)	31.6	21.4
Elongation (%)	7.6	9.2
Length (in.)	1.23	.096
Uniformity Ration (%)	86.3	80.1
Micronaire Index	3.8	3.2
Reflectance (Rd)	76.1	79.2
Yellowness (+b)	10.2	9.3
Color Grade	22	21
Leaf Grade	3	2

Exhibit 2.
Fiber Properties measured by AFIS & Shirley F/MT

Fiber Properties	Fiber A	Fiber B
Upper Quartile Length (w)(in)	1.29	0.98
Mean Length (in)	1.06	0.81
Percent Short Fiber (%)	6.4	11.8
Diameter (um)	11.6	13.5
Neps	253	441
Total Trash	613	543
F/MT Fineness (mg/tex)	147	132
F/MT Maturity (%)	84.0	74.2

Lawson Hemphill Friction Meter, (3) abrasion resistance using a Stoll Abrasion Tester, and (4) bending rigidity using a Drape-Flex Stiffness Tester. Diameters of the yarns were measured using an Olympus Compound microscope with 100X magnification. Visual examination was made of the yam structures using a Bausch & Lomb Stereo Microscope with 19.5X magnification. Yarn counts were also measured before and after treatment.

Results

Yarn properties before and after enzyme treatment are shown in Exhibit 3 for ring-spun yams and Exhibit 4 for rotor-spun yarns: The yarn counts were increased by 5-7%, i.e., the yarns became lighter per unit of length. Visual examination of the yarn also revealed that the enzyme treated yarn had less protruding fibers thin did control yarn surface; of course the protruding fibers are the first ones affected. Major conclusions from results in Exhibits 3 and 4 include the following:

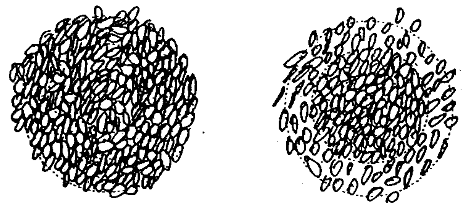
1. While the breaking strength of both ring and rotor spun yarns decreased after the enzyme treatment, the percentage loss was greater for ring-spun yams. Indeed, for the low quality fiber (fiber B), the break strength of the enzyme treated rotor spun yarn is approximately equal to that of the enzyme treated ring spun yarn. For fiber A, break strength after enzyme treatment remains tower for rotor spun yarn. These results are apparently due to the structural differences between ring and rotor spun yarns. As shown in Exhibit 5, the fibers in the ring spun yarn are evenly distributed in the cross section, whereas the fibers in the rotor spun yarn are in two layers in

Exhibit 3. Yarn Properties .9 Control and Treated Ring Spun Yarn

Yarn Properties	Fiber A			Fiber B		
	Control	Treated	% Change	Control	Treated	% Change
Count(Ne)	29.70	31.60	+6.40	29.30	31.30	+6.83
Break Strength (lbf)	0.72	0.61	-15.28	0.52	0.46	-11.54
Abrasion Resistance (number of cycles)		992	459	-53.72	221	111 -49.78
BendingLength(cm)	3.54	3.25	-8.19	3.51	3.27	-6.84
Friction Coefficient	0.23G	0.241	+2.12	0.247	0.238	-3.64
Diameter(microns)	170	184	+8.2	162	171	+5.56

Exhibit 4. Yam Properties of Control and Treated Rotor Spun Yarn

Yarn Properties	Fiber A			Fiber B		
	Control	Treated	% Change	Control	Treated	% Change
Count (Ne)	29.50	31.10	+5.42	29.20	31.10	+6.51
Break Strength (lbf)	0.60	0.53	-11.67	0.49	0.46	-6.12
Abrasion Resistance (number of cycles)	884	473	-46.49	246	134	-45.52
Bending Length (cm)	3.43	3.23	-5.83	3.37	3.01	-10.68
Friction Coefficient	0.231	0.237	+2.15	0.242	0.240	-0.83
Diameter	154.0	183.0	+18.83	156.0	169.0	+8.33



Ring Yarn Cross section Rotor Yarn Cross Section

Exhibit 5. The cross section of ring and rotor spun yarns

the cross section. The inside layer is relatively tight and dense, while the outside (wrapping) layer is relatively loose [3]. Therefore, with ring spun yarns, all the fibers in the cross section contribute equally to yarn strength, but with rotor spun yarns the outer layer of yarn had a much smaller contribution to yarn strength than the central core. Since enzymes begin attacking the yarn exterior, the central core of rotor-spun yarn escapes much of the damage; therefore, the yarn retains more of its strength.

2. The reduction in abrasion resistance was substantial for both ring and rotor yarns. The abrasion resistance of the enzyme treated, ring spun yarns was reduced by about 50-54% while that of rotor spun yarns was reduced by 45-47%. As with breaking strength, the somewhat smaller reduction for rotor-spun yarn can be attributed to the yarn structure.

Abrasion resistance is remarkably better for the higher quality cotton (fiber A) than for the lower quality cotton (fiber B). It is noteworthy, however, that after enzyme treatment, the abrasion resistance of the fiber A yarn is greater with rotor spinning. Furthermore, the abrasion resistance of the fiber B yarn is greater with rotor spinning, both before and after enzyme treatment.

3. The rigidity (i.e., bending' length) of the yarns were reduced between 6% and 11% by enzyme treatment—with the greatest reduction being for the lower quality cotton (fiber B) which was rotor spun. Of course, reduced rigidity means increased yarn softness, which should also increase fabric softness.

4. The coefficients, of friction were little changed by enzyme treatment. However, the yarn made from fiber A showed a slight increase in friction, while the yarn made from fiber B showed a slight decrease.

5. Yarn diameter was increased by the enzyme treatment. The increase in yarn diameter entails a "bulkier" yarn, which in turn imparts a softer feel to the fabric. The percentage increases were greater for the rotor spun yarns. This result is attributed to the outer layer of "wrap fibers" typical of rotor spun yarns [5]. The wrap fibers were weakened after enzyme treatment; therefore, they exerted less dimensional restraint on yarns. Consequently, rotor spun yarns had greater diameter increase.

Also noteworthy is that in rotor spinning the yarn from fiber A had a greater diameter increase than did yarn from fiber B. This was because the added length of fiber A resulted in more wrap fibers, so the impact from enzyme treatment was greater.

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