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TEXTILE TECHNOLOGY

Neps, Seed-Coat Fragments, and Non-Seed Impurities in Processed Cotton

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INTERPRETIVE SUMMARY

Much research has been done to identify the origin of non-dyeing fibers in textiles. Cotton contaminants that could appear as white and light-colored specks in dyed textiles and fabrics are a source of great concern for the textile industry. There is experimental evidence that mechanical processing procedures contribute to the presence of defects in cotton. Deltapine (DPL) 50 cotton (*Gossypium hirsutum* L.) samples from four different ginning (cage, saw) and lint-cleaning (zero, one) combinations were microscopically examined (i) to study the presence of neps (clumps of immature fibers), seed-coat fragments, and non-seed impurities in processed cotton and (ii) to analyze how effectively specific fiber-processing steps reduce or remove impurities from cotton samples.

Neps were the major source of impurities, followed by seed-coat fragments and non-seed impurities in all four gin-type/lint-cleaning combinations. The numbers of neps detected with microscopy were higher than the numbers obtained using the AFIS (Advanced Fiber Information System) test method. Microscopic images demonstrate the distinct differences in size and appearance between neps observed in cage-ginned versus saw-ginned lint. These differences in size were not reflected in the AFIS data. We found that carding significantly reduced neps in cage-ginned/zero-lint cleaned cotton. Overall (from lint to combed finisher), combing significantly decreased most types of impurities in each of the four gin-type/lint-cleaning combinations.

ABSTRACT

We studied the effect of mechanical-processing procedures on the presence of defects in cotton. Deltapine (DPL) 50 cotton (*Gossypium hirsutum* L.) samples collected from four different ginning (cage, saw) and lint-cleaning (zero, one) combinations and collected after carding and combing were examined microscopically for neps, seed-coat fragments, and non-seed impurities. In all four gin-type/lint-cleaning combinations, the numbers of neps were highest, followed by seed-coat fragments and non-seed impurities. Microscopically obtained numbers of neps and seed-coat fragments were higher than numbers obtained with AFIS. Differences in size and appearance between neps in cage-ginned and in saw-ginned lint were documented with microscopy; however, AFIS data did not reflect this difference. Fiber processing, such as carding, significantly affected the number and the size of neps in cotton. Combing significantly decreased most types of impurities in each of the four gin-type/lint-cleaning combinations.

The production of high-quality fiber and textiles that meet the highest standards of the cotton industry has been a central and ongoing challenge in cotton research. Neps and white specks are imperfections that severely decrease textile quality at the consumer level and, therefore, have immense economic consequences. Neps are entanglements or clumps of immature fibers that produce imperfections when woven into fabric (Clegg and Harland, 1923; Pearson, 1933). Frequently, neps take up dye poorly and appear as light spots or

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Abbreviations: AFIS, Advanced Fiber Information System; AFIS-F&M, Advanced Fiber Information System with Fineness and Maturity module; DPL, Deltapine; HVI, high-volume instrumentation; SCF, seed or mote coat fragments; NSI, non-seed impurities.

white specks scattered randomly throughout dyed fabrics (Pearson, 1933; Watson and Jones, 1985; Smith, 1991). Seed-coat fragments are pieces of seed or mote (underdeveloped or aborted ovules) coats with fibers (mostly immature) attached that were broken or crushed during cotton processing (Brown and Ware, 1958). Motes are the main source of immature fibers, fiber clusters, and/or seed-coat fragments (Palmer [1924], Rea [1928] both cited in Pearson, 1933). Immature fibers are characterized by retarded fiber-wall growth with various degrees of secondary wall thickening. Immature fibers with little if any secondary wall accept dyes poorly (Smith, 1991). Consequently, fiber maturity is considered an important quality factor. Standard test methods, such as AFIS-F&M (Advanced Fiber Information System with Fineness and Maturity module), quantify physical fiber maturity in terms of fineness and circularity. In addition to maturity, factors such as strength, length, fineness, and uniformity determine the quality of cotton fibers (Bradow and Davidonis, 2000).

Mechanical processing procedures apparently contribute to the presence of defects in cotton fibers (Pearson, 1933). Neps or fiber clusters caused by seed-coat fragments are primarily formed during cotton processing or "manufacture" (Clegg and Harland, 1923; Hebert et al., 1986; Hughs et al., 1988; Mangialardi, 1992; Mangialardi and Anthony, 1998), but the ultimate origin of many neps and specks is thought to be in the biology of cotton seed development. It is preferable to eliminate neps before the fabric is made (Watson and Jones, 1985), but mechanical removal is difficult and frequently impossible to accomplish (Pearson, 1933).

Cotton processing begins with the handling of seed cotton at the gin stand. Damage occurs when fibers are separated from the cotton seed (Bargeron and Garner, 1989; W.F. Lalor, unpublished data, 1989; Wilkes et al., 1990). Modifications to gin stands have improved (i) fiber cleaning and seedcotton (Chapman et al., 1968; Baker and Griffin, 1984); (ii) lint removal and turnout (LePori et al., 1991; Cabrera Sixto and LePori, 1994); (iii) purity of ginned lint (e.g. reduced neps and seed-coat fragments which interfere with further processing of lint and yarn) (Bargeron and Garner, 1989). A variety of gin types (saw, roller, cage) have been developed and tested for effectiveness (Hughs et al., 1988; LePori et al., 1991; Lalor et al., 1992).

In the 1980s, a new ginning concept developed: the selective removal of long fibers (W.F. Lalor, unpublished data, 1990; Cabrera Sixto and LePori, 1994). The fibers removed by the selective gin were found to be longer, more uniform in length, and finer than lint removed by saw ginning. Later experiments showed that the selective gin could remove all fibers (long and short), and the gin was renamed "cage gin" (L.H. Wilkes, personal communication, 1990). Although fibers from a cage gin were usually higher quality fibers (L.H. Wilkes, personal communication, 1989; Wilkes et al., 1990; Cabrera Sixto and LePori, 1994), the lint turnout was 6 to 12% less than the turnout from the roller gin and the saw gin (L.H. Wilkes, personal communication, 1990). Fiber-quality measurements of saw-ginned and cage-ginned cotton were comparable, but consistently fewer neps were in cage-ginned lint than in saw-ginned lint and in most varieties (e.g. DPL 50) that were tested (L.H. Wilkes, unpublished data, 1989; Wilkes et al., 1990; Lalor et al., 1992).

The present study was performed on DPL 50 grown in Northern California. The objective was to examine the effects of individual steps of cotton processing (e.g., carding, combing) on the content of neps, seed-coat fragments, and non-seed impurities in cage-ginned and saw-ginned fiber samples with or without lint cleaning by the use of microscopy and the Advanced Fiber Information System (AFIS).

MATERIAL AND METHODS

Cotton Fiber Samples

Four samples of cotton (*Gossypium hirsutum* L. var. Deltapine 50), each consisting of ≈1 bale (≈250 kg), were removed from the central portion of a single cotton module harvested from a field near Chico, CA, in 1997. Each of the four cotton bales was processed differently at Cotton Incorporated (Raleigh, NC). Ginning was performed at Lummus (Savannah, GA) gin stands with "700" feeders. Two bales were cage-ginned using the Lummus Prototype gin stand and two bales were saw-ginned using the 118-saw Lummus "Super 800" gin stand.

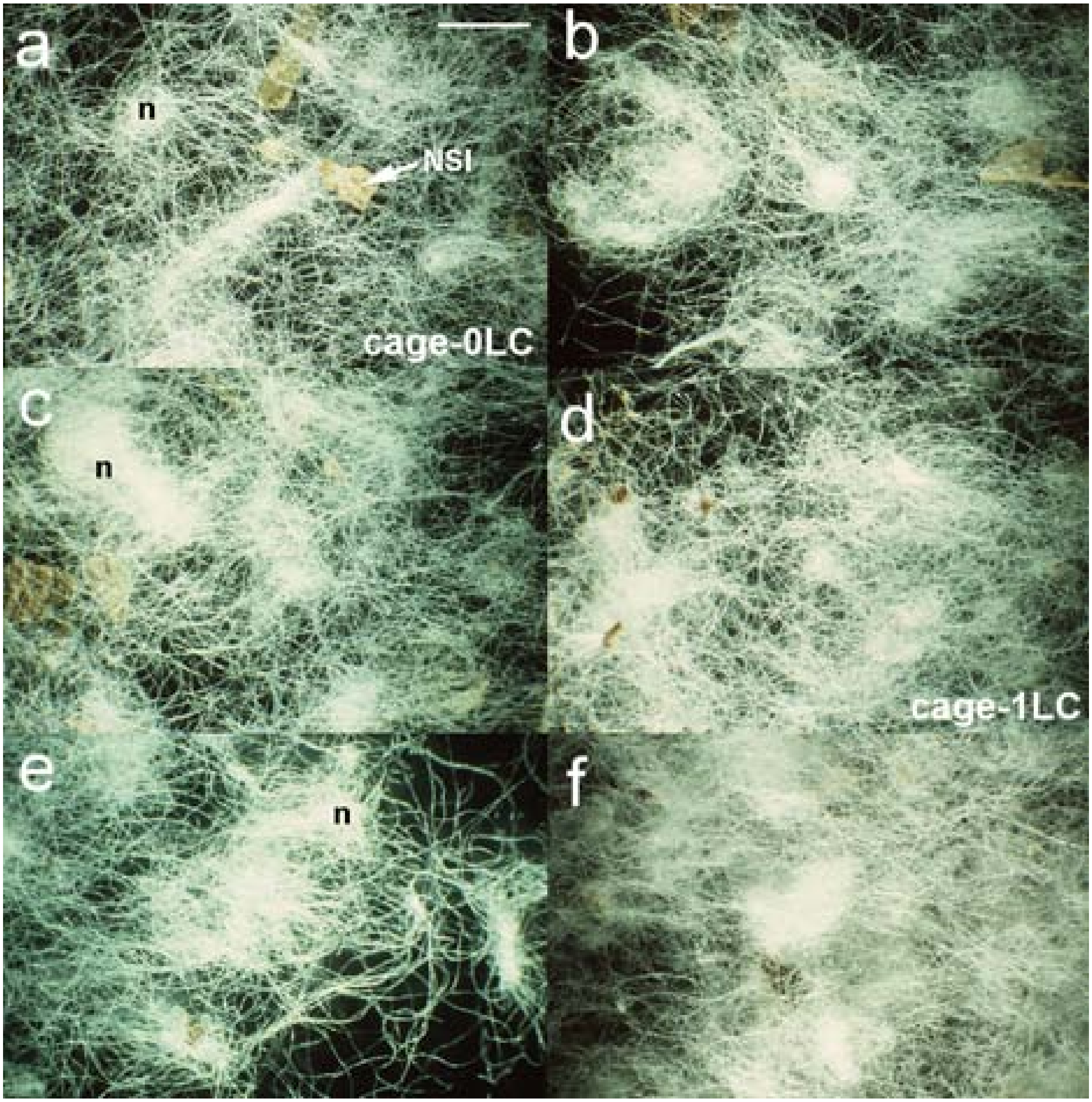

Fig. 1. Neps (n), seed-coat fragments (SCF), and non-seed impurities (NSI) found in lint fiber samples were spread about 1.5 cm^2 on a petri dish. Non-overlapping areas were chosen randomly and photographed at low (1X) magnification: (a-c) cage-ginned/zero-lint cleaning, (d-f) cage-ginned/one-lint cleaning, (g-i) saw-ginned/zero-lint cleaning, (k-m) saw-ginned/one-lint cleaning. Bar: 2 mm, for all images.

One bale from each gin type was lint-cleaned (1 lint cleaning) employing the Lummus "86" lint cleaner and one was not (0 lint cleaning). The raw cotton or lint of each of the four fiber-treatment conditions was passed through several opening and cleaning machines. The following textile equipment was used for the mechanical processing steps: opening hopper fiber controls, Rieter B1 coarse cleaner (Rieter, Spartanburg, SC), Rieter B60 fine opener, Hollingsworth Card 2000 (Hollingsworth, Greenville, SC), Rieter DO/5 draw frame, Rieter E7/4 comber, Rieter DO/5 draw frame (for breaker draw and finisher draw), and Rieter G5/1D ring spinning frame (for combed and carded yarn samples). After specific cotton processing steps (Fig. 1a-d), 20 cotton fiber samples were extracted.

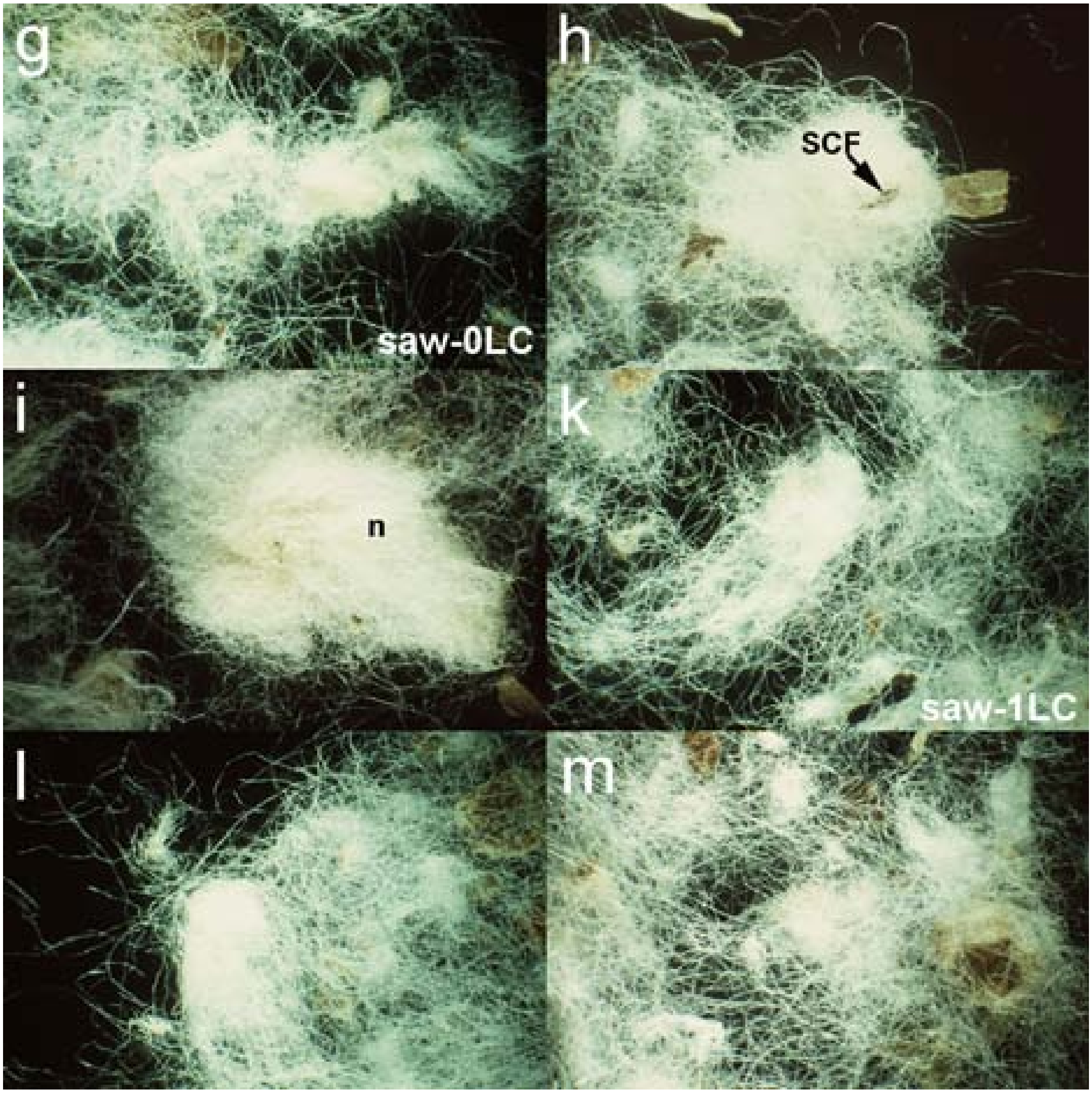

Fig. 1. (Continued). Neps (n), seed-coat fragments (SCF), and non-seed impurities (NSI) found in lint fiber samples were spread about 1.5 cm^2 on a petri dish. Non-overlapping areas were chosen randomly and photographed at low (1X) magnification: (a-c) cage-ginned/zero-lint cleaning, (d-f) cage-ginned/one-lint cleaning, (g-i) saw-ginned/zero-lint cleaning, (k-m) saw-ginned/one-lint cleaning.

Fiber Property Tests

Twenty lint fiber samples of each bale were extracted for fiber property tests with high-volume instrumentation (HVI) systems and the advanced fiber information system (AFIS, Zellweger Uster, ser. no. 1094-283) at Cotton Incorporated, Cary, NC. The fiber tests included various measurements, of which we used the nep and seed-coat fragment counts for statistical analyses and comparison with the data obtained with the microscope. The AFIS measurements of non-seed impurities (trash and dust particles) were categorized differently than the microscopically counted non-seed impurities and, therefore, were not included in the comparison.

Microscopy

From the samples extracted after each processing step, five subsamples of 80 to 160 mg were selected, weighed, and examined with a stereo-dissecting microscope. To detect impurities, individual fibers were separated manually using two pairs of forceps. We detected and counted three types of impurities (Hebert et al., 1986, 1988): entangled fibers (neps), seed or mote coat fragments, and non-seed impurities. The impurities were removed from the samples and photographed.

Microscopic examinations were carried out on a stereo-dissecting microscope (Olympus SZ H10, Olympus Corp., Precision Instruments Div., Lake Success, NY) and a compound microscope (Olympus BH-2; Southern Micro Instruments, Atlanta, GA), both with a standard film camera attachment. Micrographs were made using Kodak (Kodak, Rochester, NY) Ektachrome 160 T and Kodak Elite II 400 slide film. The photographic slides were scanned and converted to digital images using the Kodak Professional RFS2035 Plus Film Scanner and Adobe Photoshop 5.5 software (Adobe Systems, San Jose, CA).

Statistical Analyses

We report the results of the analysis of processing four cotton bales through two gins with and without lint cleaning. Because only one bale was processed through each one of the four gin-type/lint-cleaning combinations, we could not compare the effects of these treatments statistically. Cotton from each of the four fiber conditions was carded, combed, and finished through several steps. We analyzed multiple parameters at several steps in this sequence using the statistical analysis program SAS (SAS, Cary, NC). These parameters are the numbers of impurities in cotton samples after specific processing.

For the impurity analysis, we used two-factor analysis of variance (ANOVA) with impurity type and processing step as fixed factors. Before performing the ANOVAs, we tested the assumption of normal distribution with the Shapiro-Wilk W test and the assumption of homogeneity of variance with Bartlett's test for homogeneity. When the data did not conform to these assumptions, the values were ranked and analysis of variance was performed using the ranks rather than the original values (Zar, 1999). ANOVAs detected significant differences. Tukey's studentized range test was used to perform means comparisons of the number and weight of impurities in samples from sequential steps of cotton processing (lint to carded sliver, carded sliver to carded finisher or to combed sliver, combed sliver to combed finisher) and the overall processes (lint to carded finisher, lint to combed finisher).

RESULTS

Neps, Seed-Coat Fragments, and Non-Seed Impurities

We found and counted three types of impurities (neps [Fig. 2a], seed-coat fragments [Fig. 2b], and non-seed impurities [Fig. 2c]) in the cotton samples

Table 1. The effect of processing step and impurity type on the number of impurities. ANOVA was performed on ranked values.

Gin-type/lint-cleaning combination	Variable	Mean square	df	*F* value	*P* value
Cage gin/zero	Step	1089	4	13.71	<0.0001
	Impurity	10132	2	127.53	<0.0001
	Step*impurity	718	8	9.04	<0.0001
	Error	4767	60		
Cage gin/one	Step	750	4	5.78	0.0005
	Impurity	10667	2	82.26	<0.0001
	Step*impurity	378	8	2.92	0.0081
	Error	7781	60		
Saw gin/zero	Step	2659	4	16.90	<0.0001
	Impurity	6119	2	38.89	<0.0001
	Step*impurity	354	8	2.25	0.0357
	Error	9441	60		
Saw gin/one	Step	2564	4	14.10	<0.0001
	Impurity	5481	2	30.15	<0.0001
	Step*impurity	378	8	2.08	0.0519
	Error	10908	60		

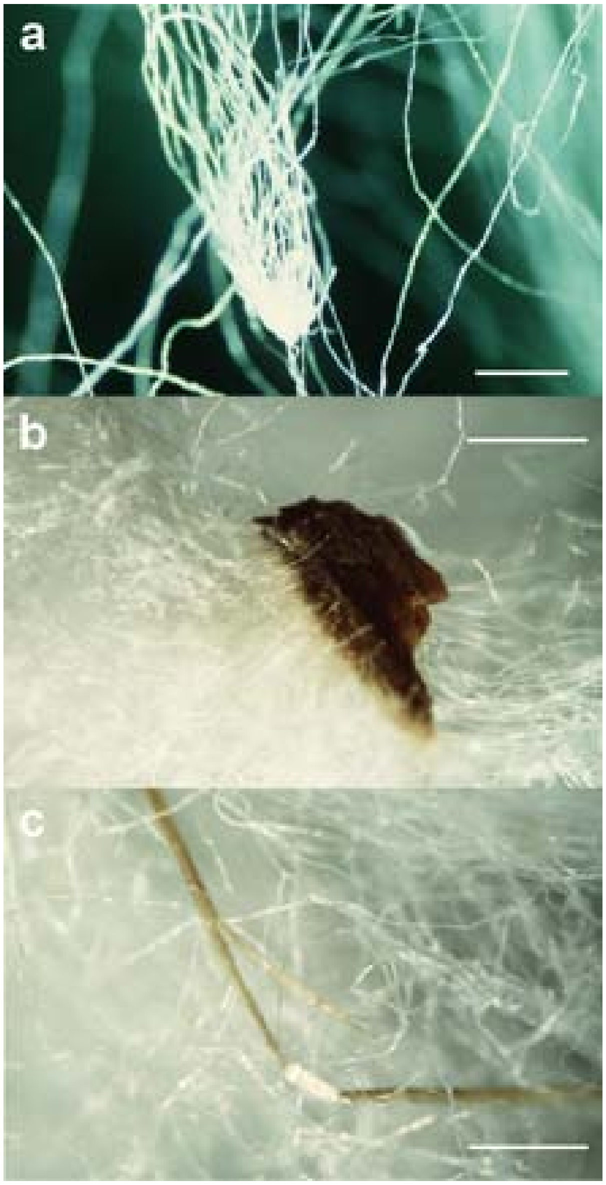

Fig. 2. Impurities in cotton: (a) fiber entanglement (nep), (b) seed-coat fragment with fibers attached to it, (c) unidentified non-seed impurity. Bars: 0.5 mm.

that we examined using a stereo-dissecting microscope. The numbers of each type of impurity per sample weight were statistically analyzed. The Shapiro-Wilk W test indicated that some of the counts of the nep, seed-coat fragment, and non-seed impurity samples were not normally distributed. For this reason, the values for the numbers of impurities were ranked, and analysis of variance was performed on the ranks. There were significant interactions ($p < 0.05$) between the processing step and type of impurity for three of the four gin-type/lint-cleaning combinations, and the interaction

Table 2. The effect of impurity type on the number of impurities within the processing steps of each gin-type/lint-cleaning (G/LC) combination. For all analyses, the numerator df was 2 and the denominator df was 12. ANOVA was performed on ranked values.

G/LC combination	Processing step	*F* value	*P* value
Cage gin/zero	Lint	13.18	0.0009
Cage gin/zero	Card sliver	13.44	0.0009
Cage gin/zero	Card finisher	6.40	0.0128
Cage gin/zero	Comb sliver	12.93	0.0010
Cage gin/zero	Comb finisher	13.12	0.0010
Cage gin/one	Lint	22.57	<0.0001
Cage gin/one	Card sliver	18.00	0.0002
Cage gin/one	Card finisher	7.79	0.0068
Cage gin/one	Comb sliver	18.30	0.0002
Cage gin/one	Comb finisher	8.81	0.0044
Saw gin/zero	Lint	0.99	0.3988
Saw gin/zero	Card sliver	13.18	0.0009
Saw gin/zero	Card finisher	7.95	0.0063
Saw gin/zero	Comb sliver	28.71	<0.0001
Saw gin/zero	Comb finisher	22.57	<0.0001
Saw gin/one	Lint	0.59	0.5679
Saw gin/one	Card sliver	28.71	<0.0001
Saw gin/one	Card finisher	3.34	0.0704
Saw gin/one	Comb sliver	1.78	0.2112
Saw gin/one	Comb finisher	18.00	0.0002

was significant at the level of 0.0519 for the fourth combination (Table 1). For this reason, means comparisons for the effects of processing step and impurity were examined for each of the gin-type/lint-cleaning combinations separately, using the Tukey studentized range test.

Significant differences among the numbers of the three types of impurities were found in all processed cotton samples of each gin-type/lint-cleaning combination (Fig. 3a-d; Table 2), except in saw-gin/0-lint cleaning lint samples and in saw-gin/one-lint cleaning lint, carded finisher, and combed sliver samples (Fig. 3a-d; Table 2). In all other cases, the number of neps exceeded the number of non-seed impurities. The number of seed-coat fragments was generally intermediate between the number of neps and non-seed impurities.

The counts of neps (Fig. 4a) and seed-coat fragments (Fig. 4b) obtained by examining lint fibers using the stereo-dissecting microscope were compared with measurements using AFIS tests. Some of the samples were not normally distributed. For this reason, the numbers of neps and seed-coat fragments were ranked within each gin-type/lint-cleaning combination, and analysis of variance was performed on these ranks. We found significant differences between the microscopic and AFIS counts of neps and seed-coat fragments for all of the gin-type/lint-cleaning combinations except neps in the saw-gin/one-lint cleaning combination (Fig. 4; Table 3). Where there were significant differences, the microscopic counts were substantially higher than the counts obtained with AFIS analysis.

In cage-ginned lint with zero-lint cleaning, AFIS detected about 230 neps per g of 760.3-µm average size; microscopic analysis resulted in about 800 neps per g of 1- to 2-mm size (Fig. 1a-c; Table 4). In cage-ginned lint plus one-lint cleaning, AFIS counted 302.3 neps per g of 751.7-µm size; microscopically about 829 neps per g of 1- to 2-mm size were counted (Fig. 1d-f; Table 4). Microscopic studies of saw-ginned/zero-lint cleaning lint fibers showed that most neps consisted of big clumps or fiber aggregates of 2 to 6 (or more) mm in size (Fig. 1g-i); however, the average nep size measured using AFIS was 761.7 µm (Table 4). In saw-ginned/zero-lint cleaning fiber samples, 264.3 neps per g were counted using AFIS and 198.8 neps per g using the

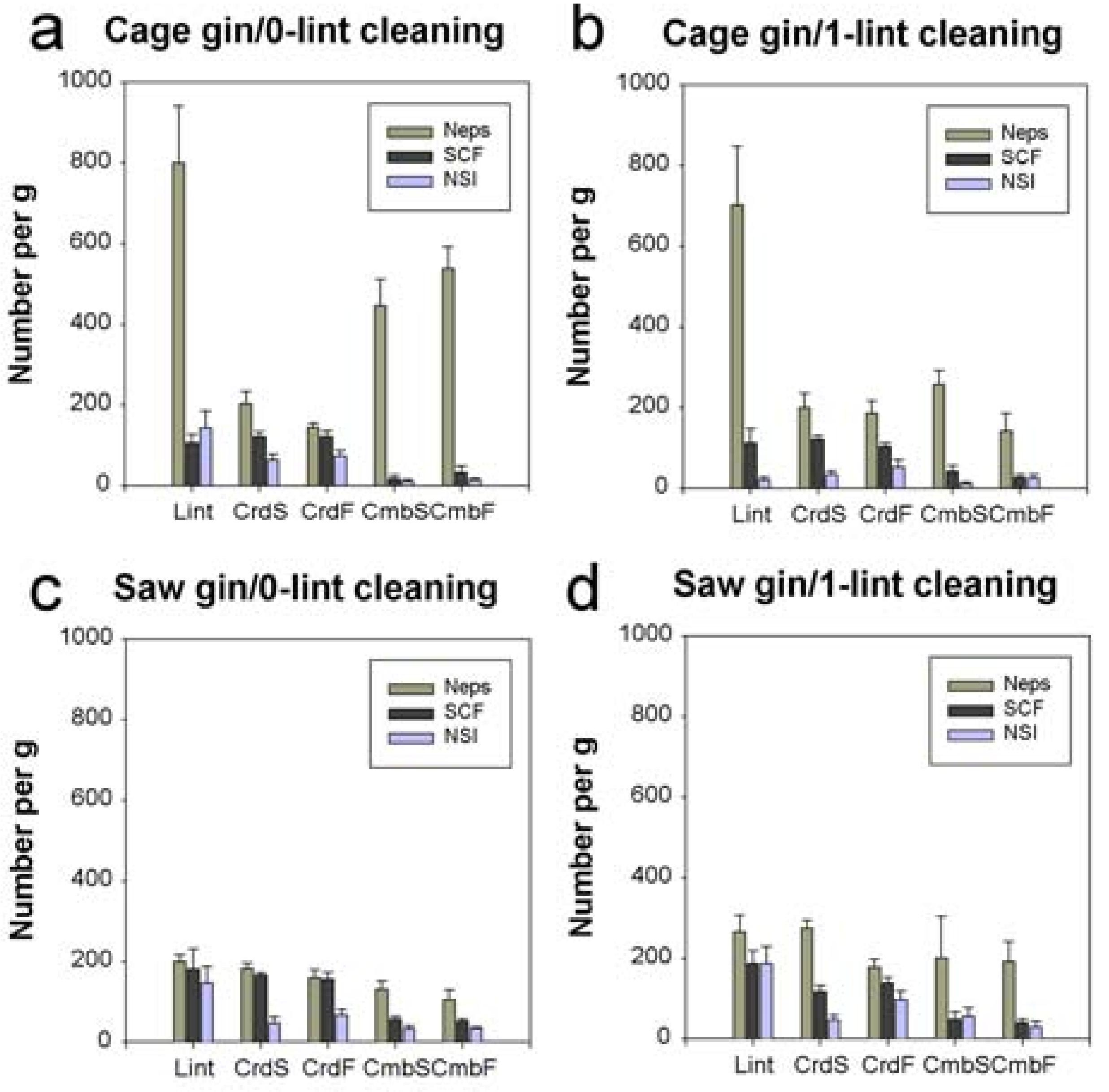

Fig. 3. Numbers of neps, seed-coat fragments (SCF), and non-seed impurities (NSI) within each gin-type/lint-cleaning combination determined microscopically: (a) cage-ginned/zero-lint cleaning, (b) cage-ginned/one-lint cleaning, (c) saw-ginned/zero-lint cleaning, (d) saw-ginned/one-lint cleaning. Error bars represent the standard error of the mean. Carded sliver (CrdS), carded finisher (CrdF), combed sliver (CmbS), combed finisher (CmbF).

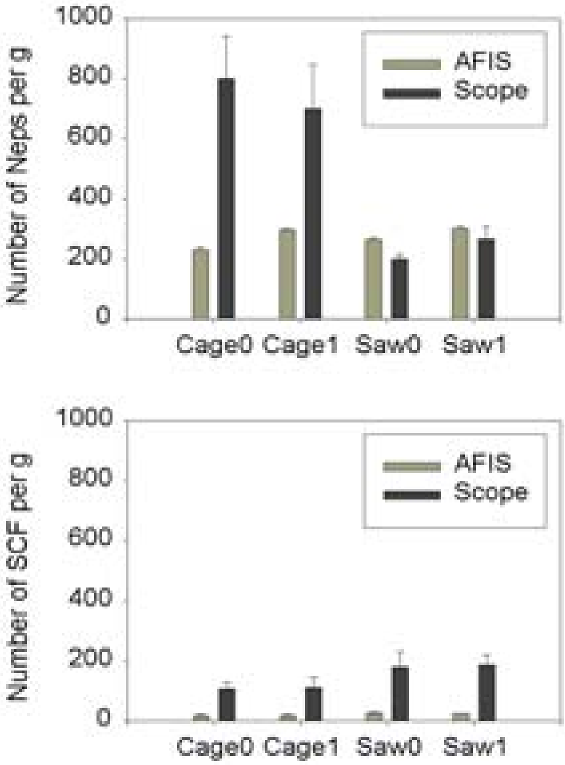

Fig. 4. Counts of neps and seed-coat fragments in lint determined by the advanced fiber information system (AFIS) and microscopically (Scope) for all gin-type/lint-cleaning combinations. (a) neps, (b) seed-coat fragments (SCF). Error bars represent the standard error of the mean.

microscope (Table 4). In lint samples of the saw-gin/one-lint cleaning combination, AFIS detected 302.3 neps per g versus 265.3 neps per g found using the microscope (Table 4). The nep sizes were 758.3 µm when measured with AFIS and 1 to 4 mm using the microscope (Fig. 1k-m).

Fiber Processing

Statistical analysis of the microscopic counts of neps, seed-coat fragments, and non-seed impurities found that there were significant differences for all impurities in all gin-type/lint-cleaning combinations, except for neps in the combination saw-gin/one-lint cleaning and for non-seed impurities in the combination cage-gin/one-lint cleaning (Table 5). Generally, neps found in lint (Fig. 1a-i, k-m) were larger than neps found in carded sliver samples (Fig. 5a-i, k-m) in all four gin-type/lint-cleaning combinations. Within the cage-gin/one-lint cleaning (Fig. 6b) and saw-gin/zero-lint cleaning (Fig. 6c) combinations, carding did not significantly affect the numbers of neps or the other types of impurities. Within the saw-gin/one-lint cleaning combination (Figs. 3d, 6d), carding reduced the numbers of non-seed impurities. When card sliver was combed, the numbers of each type of impurities were affected

Table 3. The effect of microscope counts and AFIS analysis on the number of neps and seed-coat fragments (SCF) in lint. For all analyses, the numerator df was 1 and the denominator df was 23. ANOVA was performed on ranked values.

Gin-type/lint-cleaning combination	Type of impurity	*F* value	*P* value
Cage gin/zero	Neps	21.33	<0.0001
Cage gin/zero	SCF	21.41	<0.0001
Cage gin/one	Neps	4.83	0.0383
Cage gin/one	SCF	17.22	0.0004
Saw gin/zero	Neps	14.70	0.0008
Saw gin/zero	SCF	21.49	<0.0001
Saw gin/one	Neps	0.66	0.4266
Saw gin/one	SCF	21.57	<0.0001

Table 5. ANOVA table for the effect of processing step on the number of neps, see-coat fragments (SCF), and non-seed impurities (NSI) within gin-type/lint-cleaning (G/LC) combinations and types of impurities. For all analyses, the numerator df was 4 and the denominator df was 20. ANOVA was performed on ranked values.

G/LC combination	Type of impurity	*F* value	*P* value
Cage gin/zero	Neps	15.39	<0.0001
Cage gin/zero	SCF	9.86	0.0001
Cage gin/zero	NSI	15.96	<0.0001
Cage gin/one	Neps	3.18	0.0355
Cage gin/one	SCF	6.61	0.0015
Cage gin/one	NSI	2.17	0.1089
Saw gin/zero	Neps	3.95	0.0161
Saw gin/zero	SCF	14.13	<0.0001
Saw gin/zero	NSI	3.93	0.0164
Saw gin/one	Neps	1.80	0.1686
Saw gin/one	SCF	9.68	0.0002
Saw gin/one	NSI	6.68	0.0014

Table 4. Means (and standard error of means) of the sizes and numbers of neps per g obtained using AFIS and microscope.

	Size of neps		Numbers of neps per g sample	
	AFIS (µm)	Images (mm)	AFIS	Microscope
Cage-zero	760.3 (2.2)	1 to 2 (Fig. 1a-c)	230.9 (8.5)	800.0 (141.7)
Cage-one	751.7 (1.9)	1 to 2 (Fig. 1d-f)	302.3 (6.4)	829.7 (146.9)
Saw-zero	761.7 (2.1)	2 to 6 (Fig. 1g-i)	264.3 (6.4)	198.8 (16.6)
Saw-one	758.3 (1.8)	1 to 4 (Fig. 1k-m)	302.3 (6.7)	265.3 (42.7)

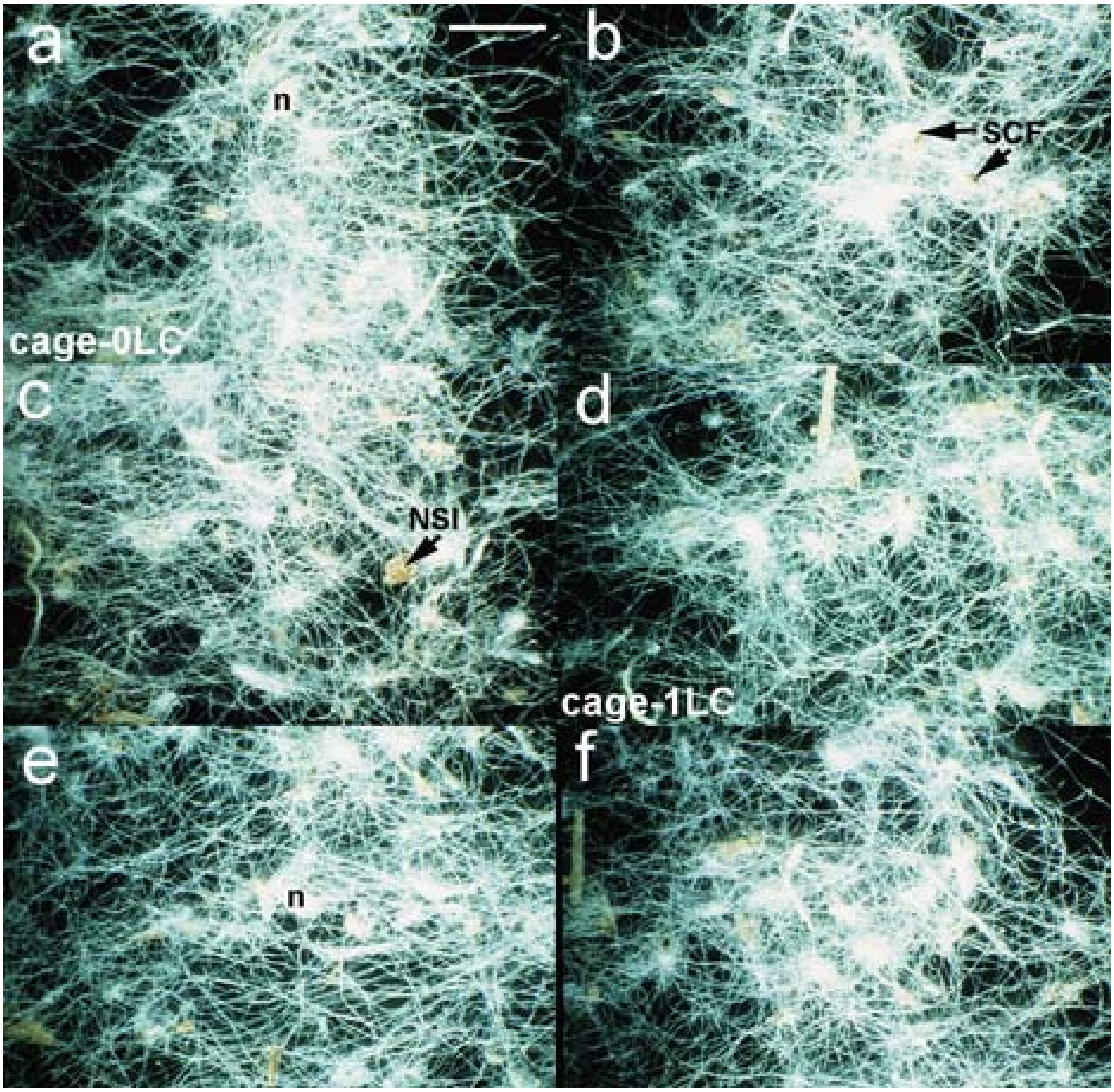

Fig. 5. Neps (n), seed-coat fragments (SCF), and non-seed impurities (NSI) found in card sliver samples were spread about 1.5 cm^2 on a petri dish. Non-overlapping areas were randomly chosen and photographed at low (1X) magnification: (a-c) cage-ginned/zero-lint cleaning, (d-f) cage-ginned/one-lint cleaning, (g-i) saw-ginned/zero-lint cleaning, (k-m) saw-ginned/one-lint cleaning. Bar: 2 mm, for all images.

differently within each gin-type/lint-cleaning combination. Within the cage-gin/zero lint cleaning combination, combing significantly increased the numbers of neps and significantly decreased the numbers of seed-coat fragments and non-seed impurities (Figs. 3a, 6a). Combing significantly decreased the number of seed-coat fragments in the saw-gin/zero-lint cleaning combination (Figs. 3c, 6c). However, combing had no significant effect on the numbers of impurities within the cage-gin/one-lint cleaning and saw-gin/one-lint cleaning combinations. The processing step from carded or combed sliver to carded or combed finisher sliver, respectively, is also known as the second drawing process and had no significant effect on the numbers of any type of impurities in any of the gin-type/lint-cleaning combinations (Figs. 3a-d, 6a-d). The sizes of neps observed in combed sliver samples appeared somewhat smaller (0.3 to 0.5 mm;

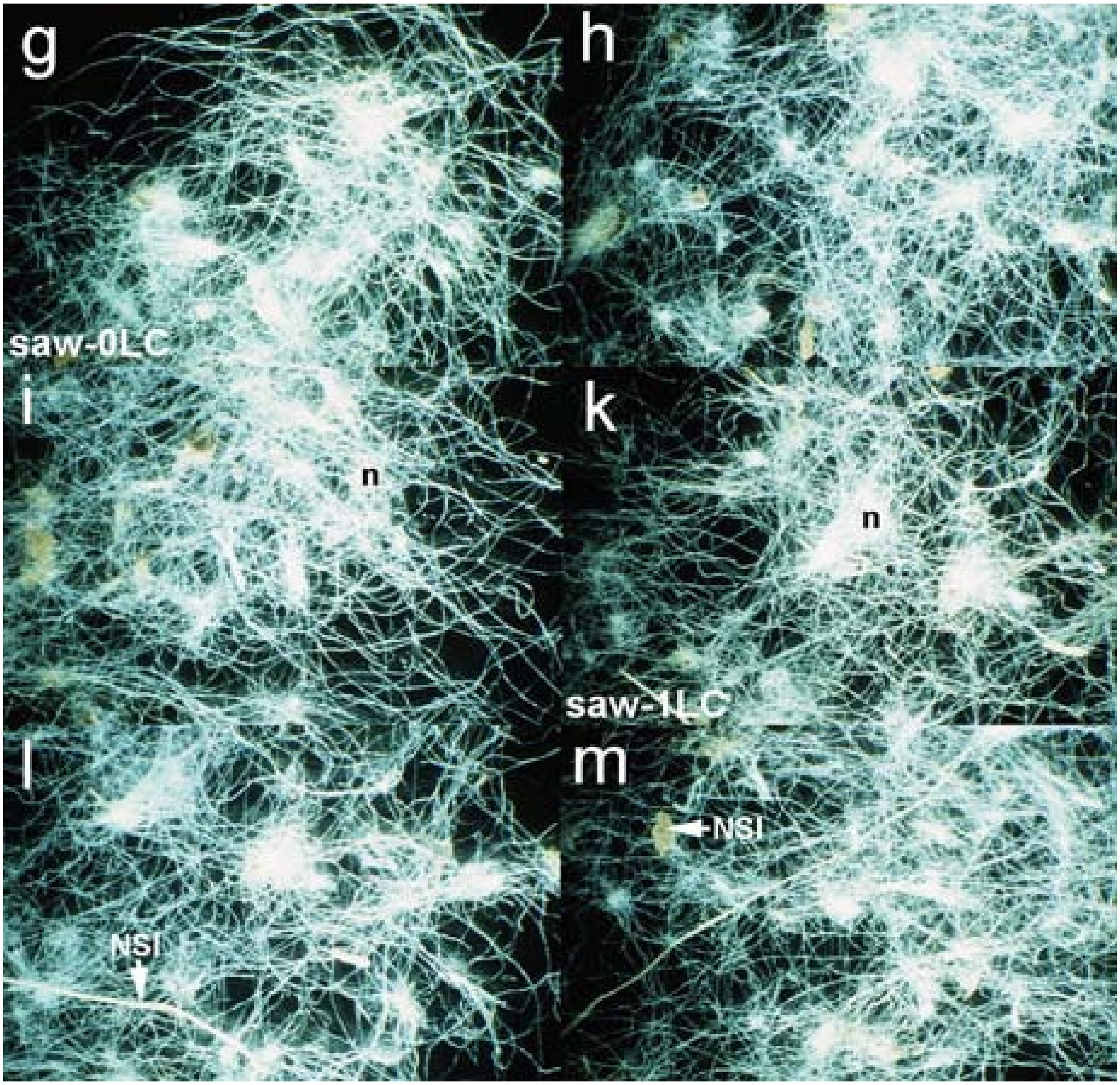

Fig. 5. (Continued). Neps (n), seed-coat fragments (SCF), and non-seed impurities (NSI) found in card sliver samples were spread about 1.5 cm^2 on a petri dish. Non-overlapping areas were randomly chosen and photographed at low (1X) magnification: (a-c) cage-ginned/zero-lint cleaning, (d-f) cage-ginned/one-lint cleaning, (g-i) saw-ginned/zero-lint cleaning, (k-m) saw-ginned/one-lint cleaning.

Fig. 7a-i, k-m) than most neps found in card sliver samples (about 0.5 mm; Fig. 5a-i, k-m).

DISCUSSION

Neps, Seed-Coat Fragments, and Non-Seed Impurities in Cotton

Our analysis of the frequency of neps, seed-coat fragments, and non-seed impurities in cotton confirmed that neps are the major source of impurities in cotton (Mangialardi, 1992), followed by seed-coat fragments and non-seed impurities. Our microscope counts resulted in relatively high numbers of neps in cage-ginned lint, which were not confirmed by AFIS measurements on fibers of the same sample or by the literature (Wilkes, personal communication, 1990; Wilkes et al., 1990). The numbers of neps were consistently lower when cage-ginning performance was

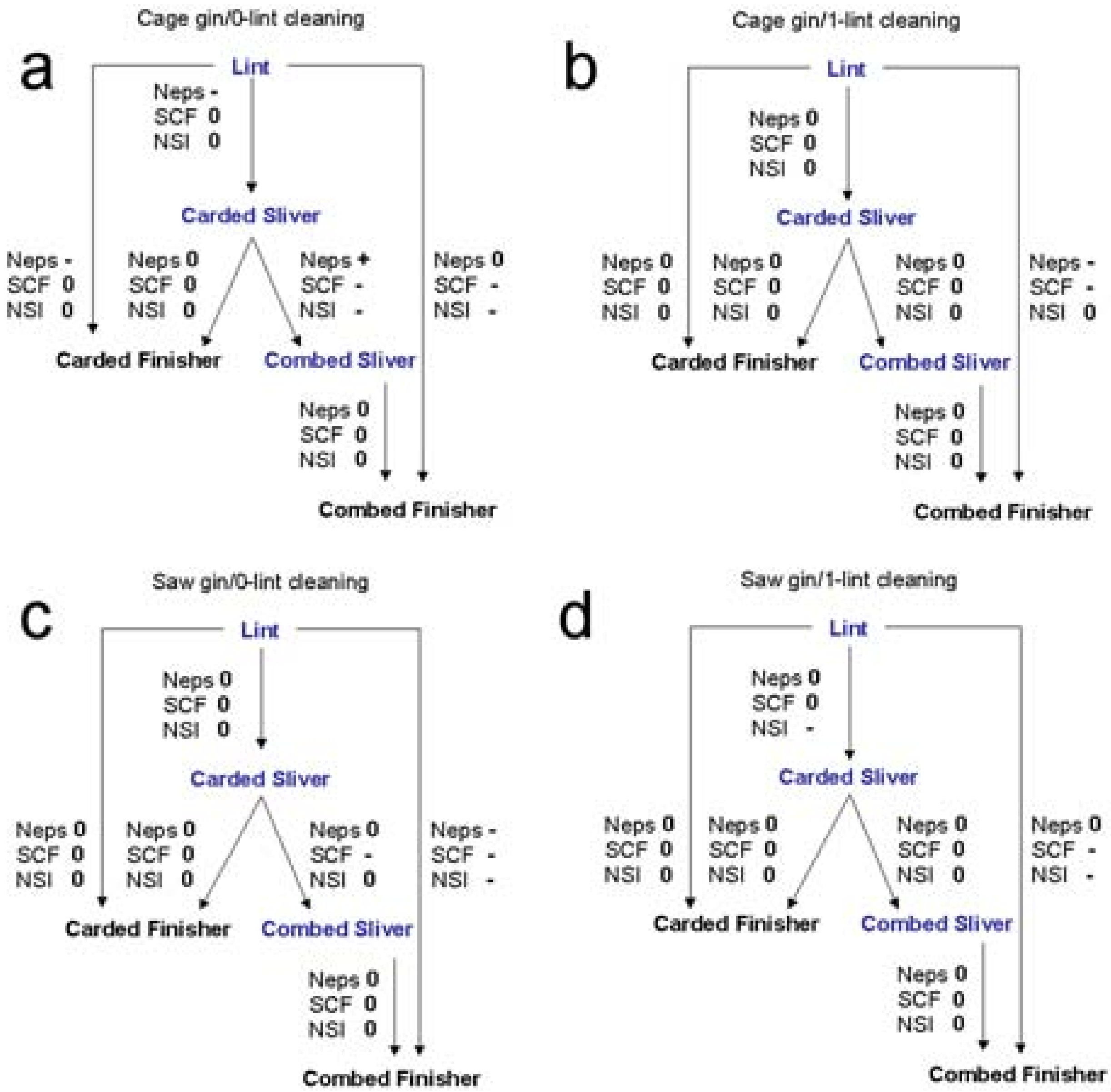

Fig. 6. Pair-wise comparison of means of the number of impurities from sequential processing steps (lint to carded sliver, carded sliver to carded finisher or to combed sliver, combed sliver to combed finisher) and the overall processes (lint to carded finisher, lint to combed finisher). Significant increases (+), decreases (-), or insignificant (0) changes in the numbers of impurities within (a) cage-ginned/zero-lint cleaning, (b) cage-ginned/one-lint cleaning, (c) saw-ginned/zero-lint cleaning, (d) saw-ginned/one-lint cleaning.

compared with saw-gin and/or roller-gin performance (Wilkes et al., 1990, 1991). Most cotton varieties that were used to test cage-gin performance produced relatively low numbers of neps, including the DPL 50 (Wilkes et al., 1990) variety used in our study. The gin effect on the size and morphology of neps presents a possible explanation for the discrepancy between the microscopically obtained data and AFIS measurements (and/or literature reports). The neps in cage-ginned lint were much smaller (2 mm) than neps in saw-ginned lint (>6 mm). In addition, the two gin types produce neps of distinctly different morphology: small fiber entanglements in cage-ginned lint versus large, dense clumps of fibers in saw-ginned lint.

We detected more neps than any other type of impurities in all four gin-type/lint-cleaning

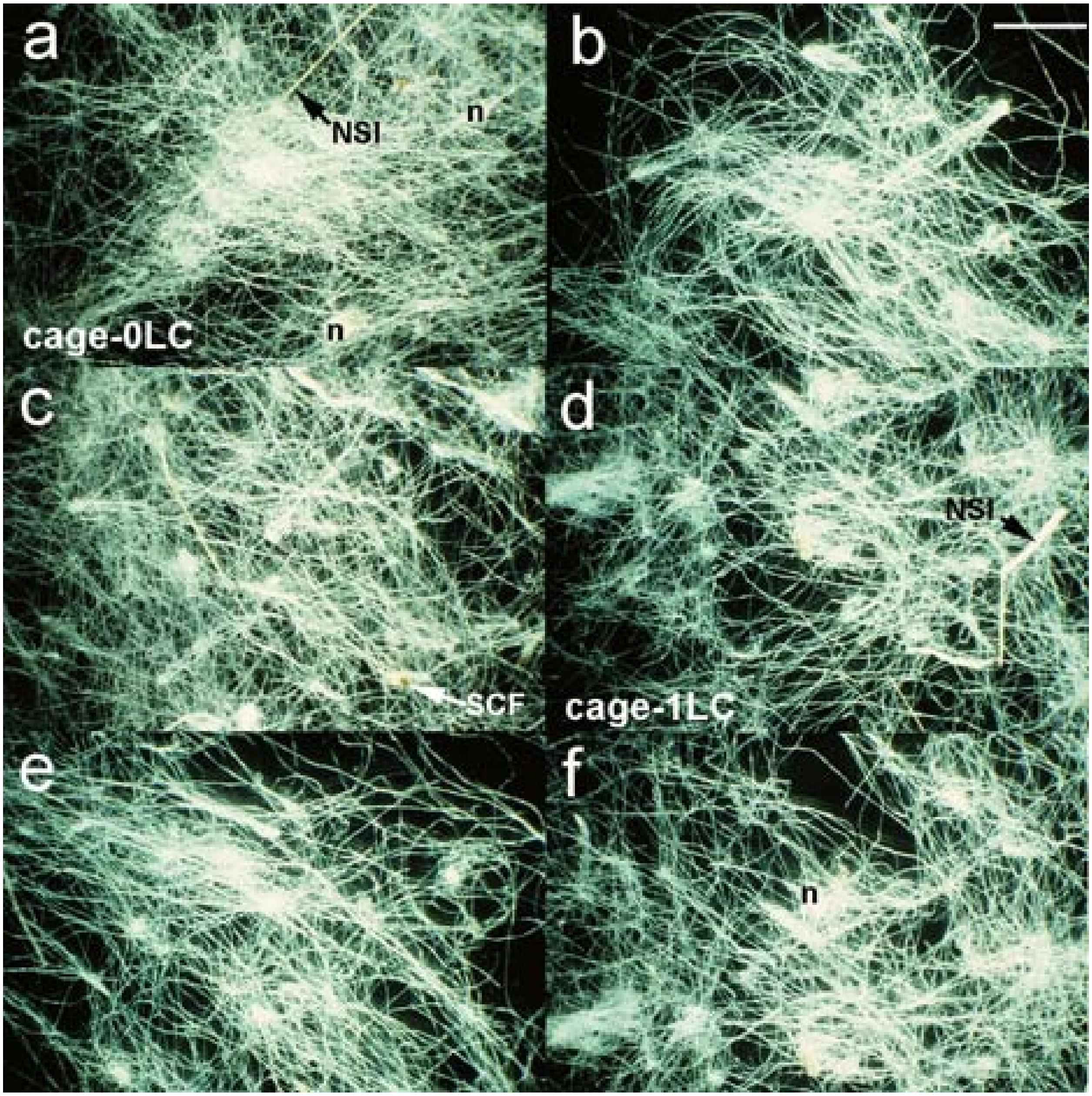

Fig. 7. Neps (n), seed-coat fragments (SCF), and non-seed impurities (NSI) found in combed sliver samples were spread about 1.5 cm^2 on a petri dish, non-overlapping areas were chosen randomly and photographed at low (1X) magnification: (a-c) cage-ginned/zero-lint cleaning, (d-f) cage-ginned/one-lint cleaning, (g-i) saw-ginned/zero-lint cleaning, (k-m) saw-ginned/one-lint cleaning. Bar: 2 mm, for all images.

combinations, which was consistent with Mangialardi (1992), who found three times more neps than seed-coat fragments per 645-cm^2 card-web. The microscopically obtained numbers of neps were significantly higher than the AFIS counts for both cage-ginned combinations, significantly lower for saw-gin/zero-lint cleaning, and not significantly different for saw-gin/one-lint cleaning. The numbers of seed-coat fragments counted microscopically (105.3 to 187.2 seed-coat fragments per g) were significantly higher than the AFIS counts (18.4 to 23.6 seed-coat fragments per g), in all four gin-type/lint-cleaning combinations. Our AFIS data are consistent with other measurements of 25 and 36 seed-coat fragments per g sample (Mangialardi and Anthony, 2000). The low instrument counts suggest that either the electro-optical particle sizer of the AFIS does not

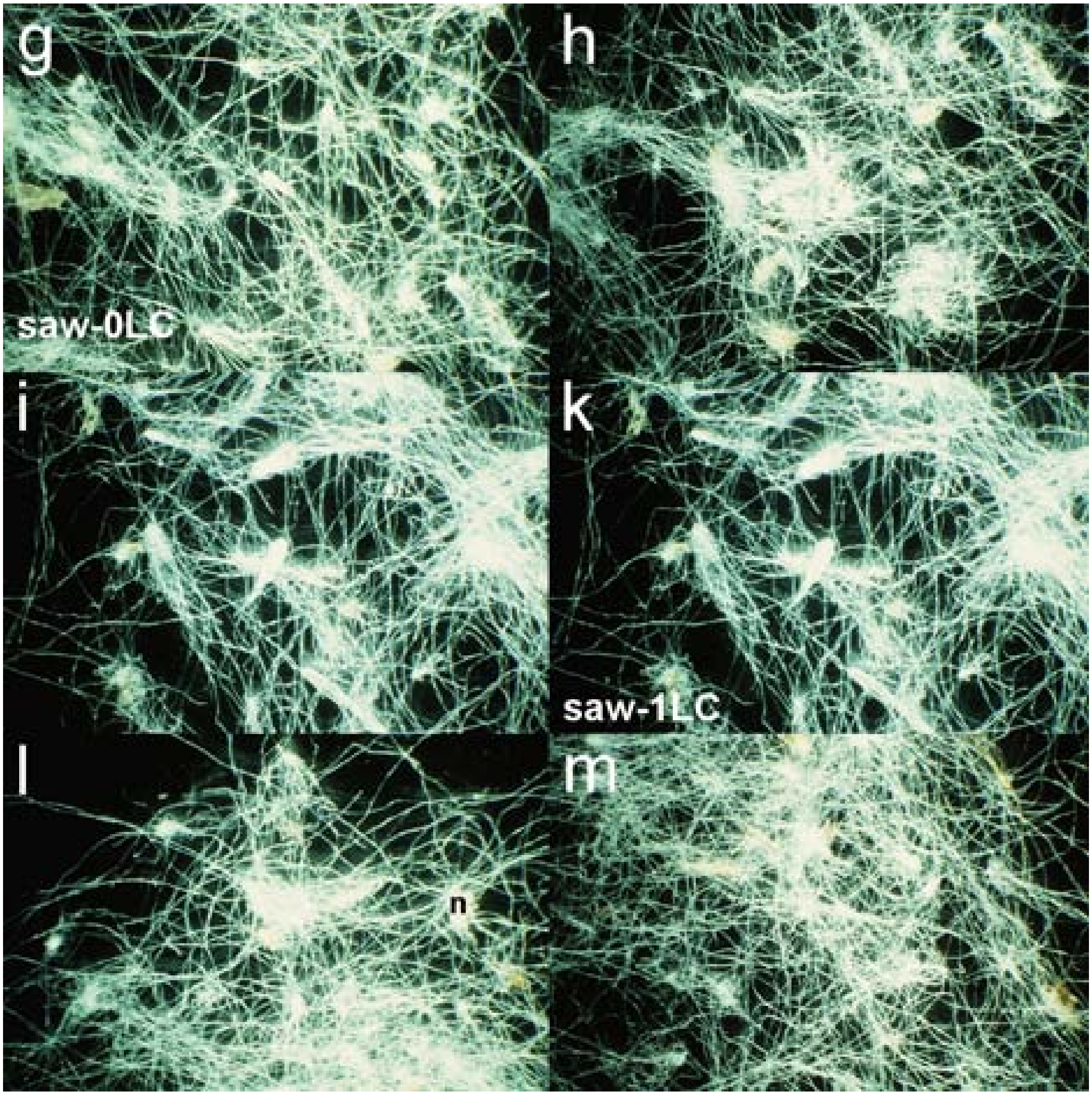

Fig. 7. (Continued). Neps (n), seed-coat fragments (SCF), and non-seed impurities (NSI) found in combed sliver samples were spread about 1.5 cm^2 on a petri dish, non-overlapping areas were chosen randomly and photographed at low (1X) magnification: (a-c) cage-ginned/zero-lint cleaning, (d-f) cage-ginned/one-lint cleaning, (g-i) saw-ginned/zero-lint cleaning, (k-m) saw-ginned/one-lint cleaning.

detect the same impurities counted by the experimenter or, more likely, the particles are categorized differently (e.g., trash instead of nep or seed-coat fragments).

Fiber Processing

This study analyzes the effects of fiber processing on the numbers of impurities within each gin-type/lint-cleaning combination. Previously we presented a statistical analysis of the effects of ginning and lint cleaning on impurities in cotton (Jacobsen et al., 2000), but this analysis was statistically flawed because only one cotton bale was used for each one of the four gin-type/lint-cleaning combinations.

There are multiple ways of processing and enormous variations in instrument settings that are more or less efficient in removing impurities (Watson and Jones, 1985). At carding, lint fibers are separated from one another and remaining impurities are removed (Brown and Ware, 1958; Perkins et al., 1984). In our study, however, the only significant decrease that we found in any type of impurities in cotton through the overall process from lint to carded finisher was in the number of neps in the cage-gin/zero-lint cleaning combination. In cotton processing, a combing step is included when uniform and very fine yarns are required (Brown and Ware, 1958). Our analysis showed that impurities were successfully removed during the combing process. When the carded sliver was combed, the seed-coat fragments in the combinations cage-gin/zero-lint cleaning and saw-gin/zero-lint cleaning and the non-seed impurities in cage-gin/zero-lint cleaning were reduced significantly. Overall (lint to combed finisher), combing decreased most of the impurities in each of the gin-type/lint-cleaning combinations.

CONCLUSIONS

Fiber entanglements or neps are the main source of impurities in cotton, followed by seed-coat fragments and non-seed impurities. Higher numbers of neps were detected in cage-ginned lint using the microscope versus AFIS measurements, probably because cage-ginned lint neps consisted of small fiber entanglements. Neps found in saw-ginned lint consisted of big clumps of fibers. Carding and combing affected the numbers of impurities in cotton; the second drawing process (finishing) did not. Card sliver neps were smaller than lint neps but of uniform size in all gin-type/lint-cleaning combinations. Neps found in combed sliver samples appeared to be slightly smaller than card neps and uniform in size in all gin-type/lint-cleaning combinations.

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