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DIFFERENCES IN FIBER CONTENTS OF THE MAJOR CHEMICAL CONSTITUENTS DUE TO VARIETY AND GRADE OF SOME EGYPTIAN COTTONS

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Abstract

The present study was conducted to investigate the role of cotton varieties and lint grades as determinants of the major fiber chemical constituents of Egyptian cotton. The material used to carry out the study comprised the 3 extra-long staple (ELS) varieties Giza 45, Giza 70 and Giza 88 together with the 3 long staple (LS) varieties Giza 80, Giza 83 and Giza 89. Within each of the aforementioned varieties, the 4 lint cotton grades FG, G, FGF and GF were used.

The results obtained from this study showed that in the Egyptian cotton, the varietal differences in fiber chemical constituents were well established. However, Giza 83 variety attained the highest value of total reducing sugar content, Giza 89 had the highest cellulose content , while Giza 80 gave the highest values of both wax and ash contents. On the other hand, the least values of cellulose, wax, total reducing sugar and ash contents, were found in Giza 80, Giza 70 and Giza 89 varieties, respectively. Furthermore , lint grades which denote different levels of quality within a single variety, showed a consistent pattern of decrease in cellulose content and micronaire reading with lowering of the grade. Conversely, there was a general tendency of increase in wax , total reducing sugar and ash contents as the grade of cotton declined.

The analysis of variance evidenced that the variation in the chemical characteristics of cotton fibers, due to diversification of lint grades was markedly higher than that brought about by cotton varieties. Thus, it was concluded that, the impact of grades having different levels of quality is ascribed mainly to the effect of environmental conditions mainly fiber maturity, on fiber chemical constituents, was obviously higher than that attributed to cotton varieties having different genotypes. Furthermore, significant interaction between cotton varieties and lint grades was found to effect on fiber chemical characteristics, indicating that the variability in chemical constituents, within each variety, due to the alteration of lint grade differed from one variety to another.

INTRODUCTION

Cotton fibers are composed primarily of cellulose besides an admixture of non-cellulosic materials including protein, pectin, wax, ash, pigments, sugars and organic

acids. It is well recognized, however, that the secondary wall of cotton fiber is merely pure cellulose and the primary wall contains also much cellulose. The other non- cellulosic substances are almost entirely confined to the primary wall and the protoplasmic residues in the lumen. Nevertheless, cellulose, wax, reduced sugar and ash contents are the major chemical constituents of fibers, known to have a pronounced impact on the physical properties and processing efficiency of cotton fibers.

Al Ashwat (1974) reported that, the low grades of cultivars showed the highest percentage decrease in fiber weight as a result of open-kier and bleaching treatments, this was attributed to their lower maturity and higher content of non-cellulosic materials removed during those purification processes. Rollins (1965) reported that, the typical mature cotton fiber contains about 0.6% wax and most of the values reported in the literature ranged between 0.4 and 1.3 %. Sen and Ahmed (1938), reported that an increase of about 25% in yarn tensile strength was obtained when wax was extracted. Perkins (1983) reported that, sugar content, tends to fall steadily with boll age until it reaches the usual level in the typical mature fibers when bolls open normally. It seems worthwhile to mention that the generally accepted threshold limit for sugar in cotton is 0.3%. The higher the percentage of sugar, the higher is the likelihood of sticking of fibers to machine parts during processing. Nevertheless, honeydew which is a sugar – containing material , secreted by plant nectaries or insects such as aphids and whiteflies, has been reported to cause cotton stickiness. Brushwood and Perkins (1994) stated that, metal content of cotton is of increasing importance to cotton processors, both because of effects on processing and product qualities and because of potential environmental concerns and constraints. Metals can contribute to problems that occur in yarn manufacturing, fabric production, bleaching and dyeing processes. Disposal of both liquid and solid wastes containing certain metals must be carefully monitored and controlled.

Abdel-Aziz *et al.* (1996) found that as the micronaire reading increased, the wax, soluble sugar and other non-cellulosic material, contents of the fibers decreased. Namich (1997) reported that, the cellulose contents % in four Egyptian cultivars Giza 70, Giza77, Giza83 and Giza 85 were 94.2 %, 93.5 %, 92.26 % and 92.6 % , total reducing sugar contents % were 0.22 %, 0.17 %, 0.17 % and 0.40 %, wax contents % were 1.21 %, 1.71 %, 0.75 % and 0.95 % , while the ash contents % were 1.14 %, 1.35 %, 1.13 % and 1.36 % respectively. Mohamed (2001) found that, the averages of total reducing sugar % for grade Good of commercial Egyptian cotton cultivars were 0.13 % , 0.16%, 0.16 % for Giza 45, Giza 70, Giza 88 respectively, while the averages of wax % were 0.87 %, 0.80 %, 0.83 % for Giza 45, Giza 70, Giza 88 respectively.

MATERIALS AND METHODS

The materials used in the present study include six commercial Egyptian cotton varieties and four lint grades from each variety. The six concerned varieties were Giza 45, Giza 70, Giza 88 besides Giza 80, Giza 83 and Giza 89. The four grades secured from each variety, in a descending order, were Fully Good (FG), Good (G), Fully Good Fair (FGF) and Good Fair (GF). The samples of the aforementioned varieties and grades were taken from the 2001 cotton crop.

The chemical constituents which were taken into account in this study comprised cellulose, wax, total reducing sugar and ash contents. Prior to the chemical analysis, the samples were perfectly cleaned by the Microdust and Trash Monitor (MTM) to remove the non-lint material in order to obtain accurate and reliable chemical determinations. Each sample was chemically analyzed in triplicate and the results were averaged and statistically handled.

Cellulose content (%) was determined according to the method reported by Kettering and Conrad (1942). Wax content (%) was determined according to the method used by Conrad (1944).Total reducing sugar content (%) determined according to Smith *et al.* (1956). Ash content was estimated according to the method described by Brushwood and Perkins (1994). All chemical determinations were conducted at Cotton Chemistry and Textile Fibers Section, Cotton Research Institute, Agricultural Research Center in Giza, Egypt. The micronaire reading was tested according to A.S.T.M. D: 1448-97, (1998). The statistical procedures outlined by Little and Hills (1978) were applied to the data obtained in this study.

RESULTS AND DISCUSSION

1-Varietal differences in the chemical constituents of cotton fiber:

The data of table 1 and figures from 1 to 5 illustrate the average values of fiber chemical constituents i.e, cellulose %, wax %, total reducing sugar % , ash % and micronaire reading for combinations of varieties and lint grades of Egyptian cotton. These data clarify that the studied chemical constituents mostly differed significantly among varieties and grades of those varieties. However, the Egyptian cotton varieties, Giza 83 attained the highest value of total reducing sugar %, Giza 89 had the highest cellulose content while Giza 80 gave the highest values of both wax and ash contents. On the other hand, the least values of cellulose, wax, total reducing sugar and ash contents were found in Giza 80, Giza 70 and Giza 89, respectively. It is rather interesting to note

that, the values of total reducing sugar % for all the varieties were in normal range under 0.3 % (not sticky) which not case any processing problems.

Nevertheless, it is rather interesting to note that, on the average, the differences between the means of the fiber chemical constituents for both the extra- long staple (ELS) and the long staple (LS) cotton categories, were all statistically insignificant (table 1). Accordingly, it seems that the diversity in the contents of fiber chemical properties in Egyptian cotton does not follow a definite trend related to fiber length category to which any given variety belongs. Thus, it is generally concluded that, the varietal differences in fiber chemical constituents are well established indicating that the chemical characteristics of Egyptian cotton are in general genetically and environmentally controlled. It is clear from table (1) regarding the micronaire reading that in all varieties the decrease in micronaire reading was parallel with the decreased of lint grade and cellulose %. On the contrary parallel also with the increase in total reducing sugar %, wax % and ash %. This results, however indicate the importance of micronaire reading and fiber maturity in relation with chemical constituents of the cotton fibers.

In this respect, Goldthwait and Guthrie (1954) reported that the variation in cellulose content of raw cotton fiber is due to the variety of cotton and other factors which prematurely interrupt its growth. As regards wax content, Pandey and Iyengar (1970), pointed out that from the mean values of wax content for each botanical species, it was noted that for arboreum it was 0.47%, for herbaceum 0.43%, for hirsutum 0.64%, for barbadense, (Indian – grown) 0.66 % and for barbadense (foreign– grown) 0.87%. They further added that the Egyptian cotton variety Giza 68 gave an exceptionally high percent wax (1.19%) which was nearly twice as much wax as that of the other Egyptian variety Giza 45 (0.51%). Regarding sugar content, McCall and Jurgens (1951) stated that the amount of total sugars and reducing sugars present in different cottons were small, but significant variations were noted. On the other hand, Brushwood and Perkins (1994), indicated that the only varietal difference noted in ash content was with the SJ5 cotton variety where the potassium and magnesium contents of this variety were always higher than those of either the DPL 61 or GSA 71 varieties. They clarified, however, that there was a high positive correlation between cotton ash content and combined potassium and magnesium content. However, Mahmoud (1996) reported comparable values of total reducing sugar %, wax % and ash % in some Egyptian cotton varieties.

Table 1. Average percentages of cellulose, wax, total reducing sugar and ash and micronaire reading for different Egyptian cotton varieties and lint grades.

Cotton varieties	Lint Grades	Chemical constituents				
		Cellulose (%)	Wax (%)	Total reducing sugar (%)	Ash (%)	Micronaire reading
Giza 45	FG	93.5	0.78	0.13	0.94	3.1
	G	92.4	0.82	0.16	0.89	2.9
	FGF	92.3	0.85	0.18	1.16	2.8
	GF	86.4	1.37	0.21	1.72	2.6
Average		**91.15**	**0.955**	**0.170**	**1.178**	**2.9**
Giza 70	FG	94.3	0.67	0.11	0.78	4.1
	G	92.4	0.79	0.13	0.76	3.9
	FGF	91.3	1.10	0.16	1.02	3.7
	GF	90.9	1.50	0.17	1.34	3.4
Average		**92.22**	**1.015**	**0.142**	**0.975**	**3.8**
Giza 88	FG	93.2	0.45	0.13	0.95	4.1
	G	91.8	0.90	0.16	0.83	3.9
	FGF	90.0	0.92	0.21	0.87	3.7
	GF	88.7	1.30	0.25	1.20	3.3
Average		**90.92**	**0.892**	**0.187**	**0.962**	**3.8**
Giza 80	FG	93.9	0.90	0.12	0.95	4.6
	G	93.4	1.01	0.13	0.81	4.2
	FGF	87.5	1.16	0.16	1.46	3.6
	GF	86.1	1.17	0.18	1.77	3.3
Average		**90.22**	**1.060**	**0.148**	**1.248**	**3.9**
Giza 83	FG	92.4	0.67	0.15	0.70	4.6
	G	91.9	0.81	0.19	1.01	4.0
	FGF	90.1	0.86	0.20	1.34	3.5
	GF	89.1	1.02	0.24	1.43	3.2
Average		**90.88**	**0.840**	**0.195**	**1.120**	**3.8**
Giza 89	FG	93.9	0.61	0.12	0.85	4.3
	G	92.7	0.78	0.16	0.84	4.1
	FGF	92.2	1.01	0.17	0.94	3.4
	GF	92.0	1.46	0.21	1.14	3.1
Average		**92.70**	**0.965**	**0.165**	**0.942**	**3.7**
Mean of ELS varieties		91.43	0.95	0.166	1.04	-
Mean of LS varieties		91.27	0.96	0.169	1.10	-
L.S.D. 0.05		0.71	0.02	0.01	0.15	0.288

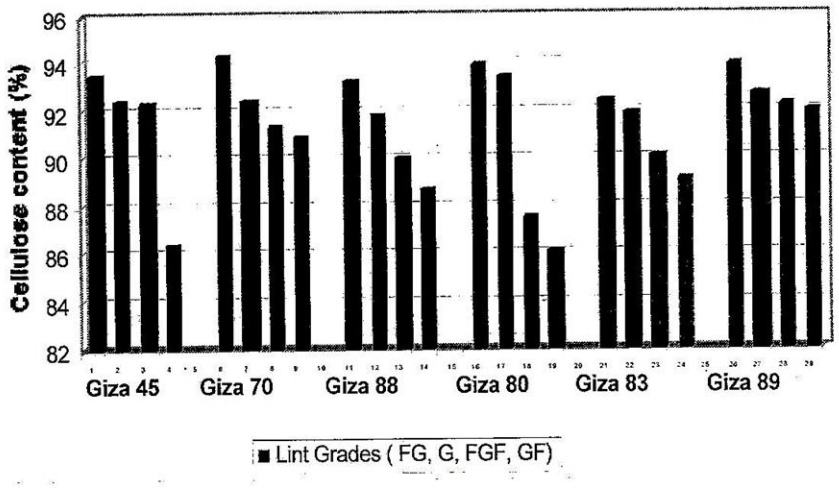

Fig. 1. The average values of cellulose content (%) for different Egyptian cotton varieties and lint grades.

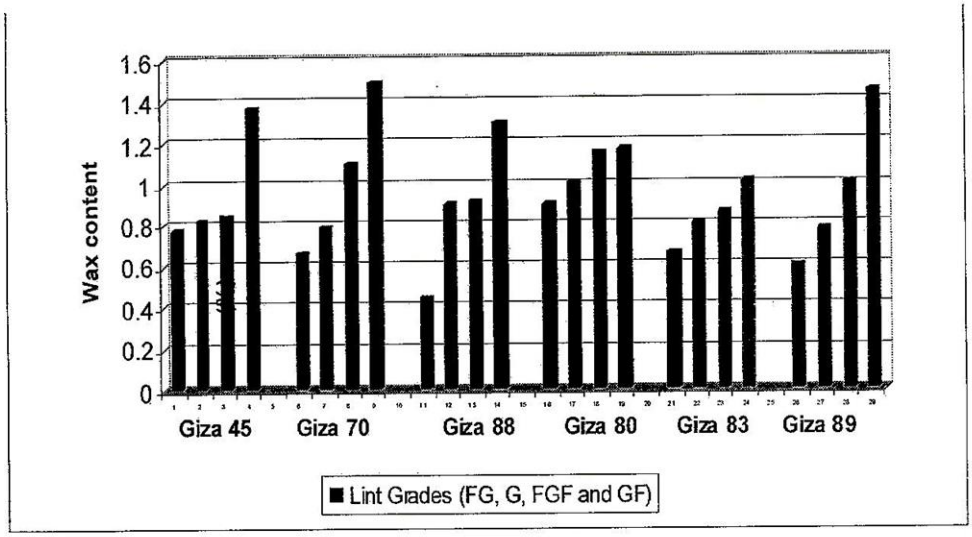

Fig. 2. The average values of wax content (%) for different Egyptian cotton varieties and lint grades.

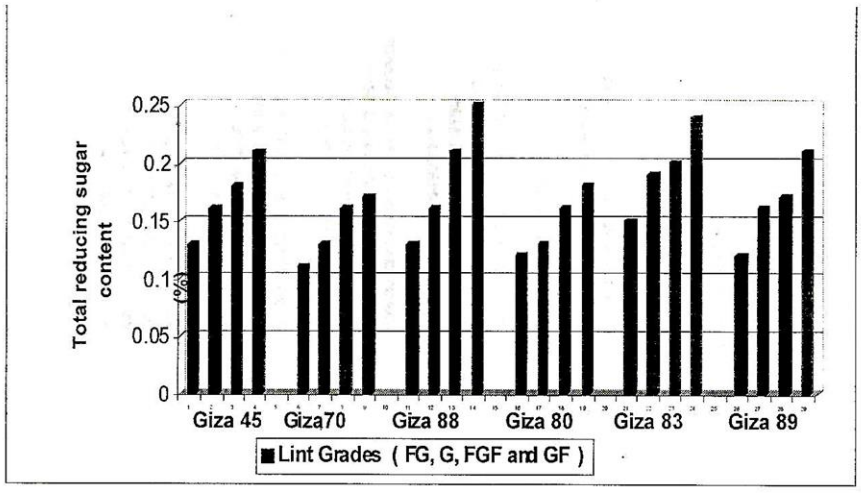

Fig. 3. The average values of total reducing sugar content (%) for different Egyptian cotton varieties and lint grades.

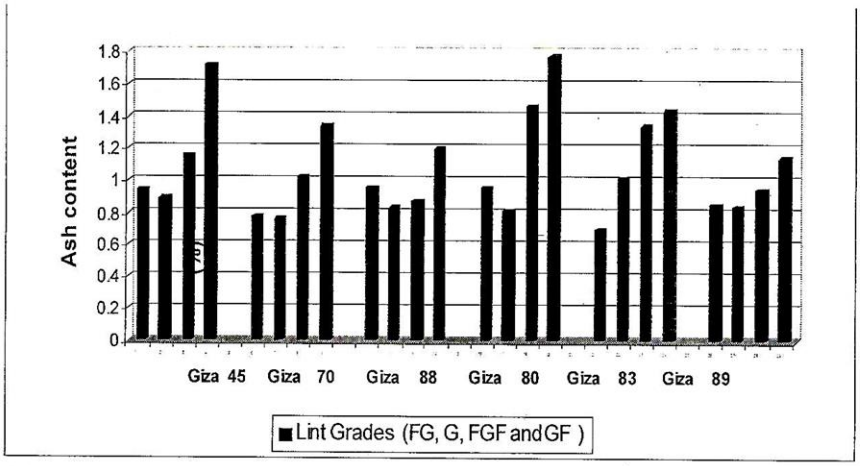

Fig. 4. The average values of total ash content (%) for different Egyptian cotton varieties and lint grades.

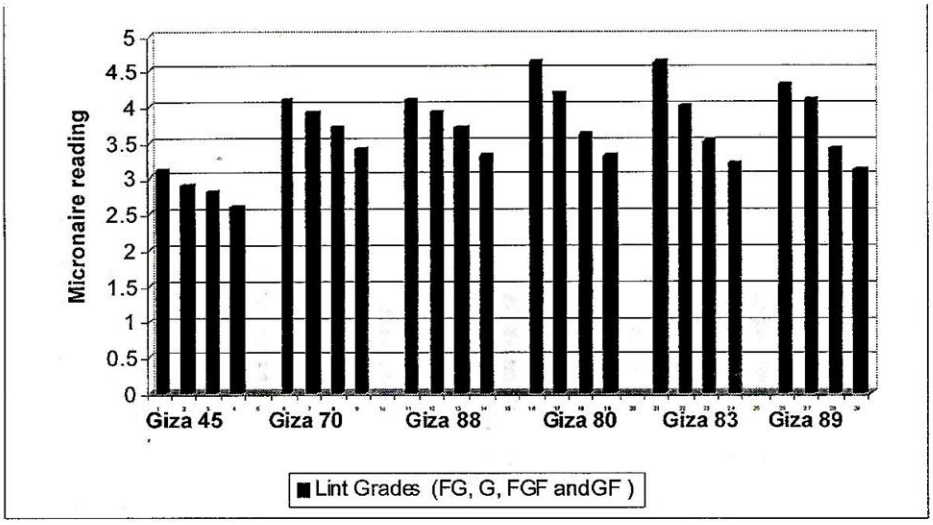

Fig. 5. The average values of micronaire reading for different Egyptian cotton varieties and lint grades.

2-Variation in fiber chemical constituents in accordance with the grade of cotton:

The data recorded in table 2 clearly reveal that the lowering of cotton grade was associated with a consistent pattern of decrease in cellulose content. Conversely, there was a general tendency of increase in wax, total reducing sugar and ash contents as the grade of cotton declined. These findings imply that generally the lowest grade would have the least amount of cellulose along with the highest amounts of non-cellulosic materials and vice versa in accordance with Al Ashwat (1974). These results are confirmed by the lower values of micronaire reading within varieties indicating lower fiber maturity with lower grades (table 1).

Table 2. Average values of the fiber chemical constituents of different lint cotton-grades of Egyptian varieties.

Lint Grades	Cellulose (%)	Wax (%)	Total reducing sugar (%)	Ash (%)	Micronaire reading
Fully Good	93.53	0.680	0.127	0.862	4.14
Good	92.43	0.852	0.155	0.857	3.73
Fully Good Fair	90.57	0.983	0.180	1.132	3.46
Good Fair	88.87	1.303	0.210	1.433	3.16
L.S.D. 0.05	0.288	0.010	0.003	0.060	0.18

It is rather interesting to mention that cellulose is deposited diurnally in the secondary wall of the cotton fiber, in the form of concentric layers. However, that deposition never proceeds to the point where the entire fiber is completely filled with cellulose, but there is always a central lumen left in the fiber. It is of particular concern to mention that the extent of the development of the secondary wall thickness determines cotton fiber maturity.

Lord (1981) reported that, it is well recognized that low grade cotton comprises a considerable proportion of dead and poorly-developed immature fibers. This conception is based on the fact that these immature fibers having thin cellulosic secondary walls are basically produced by late set bolls which are mostly infested with insects and diseases. Further, those late formed bolls develop and mature under unfavorable environmental conditions which usually prevail at the end of the growing season. Plant senility is another factor with the potential for contributing to the obvious reduction in cotton fiber maturity of late set bolls which constitute the majority of low grade cotton. Thereupon, those immature fibers in cotton of low grade, i.e. GF for instance, are expected to be of lower cellulose content. However, it is to be mentioned that for flowers produced later in the season, the development of the secondary wall starts somewhat later, then increases at a slower rate and finally terminates at a lower level resulting in immature fibers having lower degree of wall thickening. Immaturity is not caused by premature death of fibers, but it is a consequence of the poorer growth conditions including plant senescence .

Several workers referred to the increase of non-cellulosic material with the decrease of fiber maturity . Among them Goldthwait and Guthrie (1954) reported that low cellulose content usually indicates a high proportion of thin – walled immature fibers which contain a high proportion of non-cellulosic substances. Also , Guthrie (1955) pointed out that any condition that interrupts or hinders the process of development will result in the final fiber being thin – walled and high in pectin, nitrogen and sugar and low in cellulose. Al Ashwat (1974) studied the non-cellulosic materials content of different grades of Egyptian cotton varieties and came to same conclusion.

3-Interaction of cotton variety and grade:

Analysis of variance evidenced that generally the variation in the chemical characteristics considered in the present study, due to diversification of lint grade was markedly higher than that brought about by cotton varieties. The grades of cotton denote different levels of quality within a single variety. This variation in quality is as-

cribed to the varying environmental conditions, extent of care and efficiency of cultural practices applied and the nature of flowering and fruiting in cotton plant. For instance, unfavorable environmental conditions and application of inefficient cultural practices would produce poor quality, cotton characterized by inclusion of high proportion of poorly-developed immature fibers. Also late formed flowers and bolls would result in low quality immature cotton fibers. As it has been previously mentioned immature cotton fibers would have low cellulose content, and high content of non-cellulosic materials. Accordingly, it could be satisfactorily concluded that cotton grades representing different levels of quality within a variety, basically on account of varying environmental conditions, proved to have an impact on fiber chemical constituents which was obviously higher than that attributed to cotton varieties having different genotypes.

Furthermore, the analysis of variance indicated that a significant interaction between cotton varieties and lint grades, was found for all studied chemical properties. This finding implies that the effect of cotton grades as determinants of the chemical constituents of cotton fiber depends on the variety of cotton, i.e. it differs from one variety to another.

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إختلافات محتوى التيلة من المكونات الكيمائية الرئيسية تبعاً للصنف و الرتبة لبعض الأقطان المصرية

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معهد بحوث القطن – مركز البحوث الزراعية

تهدف هذه الدراسة الى تحديد دور كل من أصناف ورتب القطن المصرى عوامل محددة لمقادير بعض المكونات الكيماوية الرئيسية لتيلة القطن . وقد استخدم لهذا الغرض ثلاثاً من أصناف القطن المصرى الفائقة الطول أو الطويلة التيلة الممتازة وهى جيزة ٤٥, جيزة ٧٠ ، جيزة ٨٨ إضافة الى ثلاث من الأصناف الطويلة التيلة وهى جيزة ٨٠ وجيزة ٨٣ وجيزة ٨٩. ومن كل من الأصناف الستة سابقة الذكر إستخدام أربعة من راتب القطن الشعر تمثل مستويات مختلفة من الجودة فى داخل كل صنف وهذه الرتب حسب ترتيبها التنازلى هى فولى جود ، جود ، فولى جود فير ، جود فير .

وقد أوضحت نتائج هذه الدراسة وجود إختلافات صنفية واضحة فى المكونات الكيميائية لتيلة القطن حيث وجد أن الصنف جيزة ٨٣ أعطى أعلى قيمة للسكريات المختزلة الكلية بينما أعطى الصنف جيزة ٨٩ أعلى نسبة سليلوز. ومن ناحية أخرى الصنف جيزة ٨٠ أعلى قيم لكل من نسبة الشموع ونسبة الرماد وفيما يتعلق بأقل قيم للسليوز والشموع والسكريات المختزلة الكلية والرماد فقد كانت للأصناف جيزة ٨٠ وجيزة ٧٠ وجيزة ٨٩ على التوالى .

وقد أظهرت رتب القطن فى داخل كل صنف إتجاهاً واضحاً للإنخفاض فى محتوى السليلوز وقراءة الميكرونير بانخفاض الرتبة فى حين أنه كان هناك إتجاه واضح للزيادة فى محتوى الشموع والسكريات المختزلة الكلية والرماد بإنخفاض الرتبة أيضاً . ويرجع ذلك لانخفاض درجة نضج التيلة مع إنخفاض الرتبة داخل الصنف كما أتضح من إنخفاض قراءة الميكرونير ، وقد أوضح تحليل التباين أن الإختلاف فى محتوى المكونات الكيمائية لتيلة القطن الراجع الى إختلاف رتب القطن في داخل الصنف الواحد كان أكبر كثيراً عن ذلك الراجع إلى إختلاف الأصناف . ولذلك يمكن القول أن تأثير إختلاف رتب القطن الراجع أساساً إلي تباين ظروف البيئة على الصفات الكيميائية لتيلة القطن هو أكبر من الإختلافات الصنفية التى يحددها التركيب الوراثى لكل صنف . وقد وجد أيضاً أن التفاعل بين الصنف والرتبة فيما يتعلق بتأثيرهما على الصفات الكيميائية كان معنوياً مما يعنى أن إختلاف المكونات الكيميائية للتيلة بإختلاف الرتب لم يكن بنفس الكيفية بل إختلف من صنف لآخر .