



Comparative Performance Evaluation of Bleaching of Egyptian Cotton Fibers Using Different Bleaching Agents



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THE main objective of this study was to evaluate the potential of sodium percarbonate and sodium perborate utilization in cotton fiber bleaching instead of Hydrogen Peroxide and to compare the influence of these bleaching agents on performance of some Egyptian cotton varieties (G88, G90, G95, and G96).

Bleaching efficiency is evaluated by the degree of whiteness, yellowness, micronaire value, Length, fiber strength and elongation percent. This research was conducted with bleaching using Oxygen bleaches comparable to the conventional bleaching agents such as Hydrogen Peroxide.

Results showed that the bleaching with sodium Percarbonate (SPC) and sodium perborate (SPB) using three different concentrations brought an overall improvement in cotton fibers whiteness without decreasing the qualities of cotton fibers in comparison to hydrogen peroxide. This implies that these oxygen bleaches can replace the hydrogen peroxide. Moreover, oxygen bleaches are considered as good alternatives for other bleaches because of their economic and environmental impact as they are more stable and can be stored in a solid form. Besides, they can be active at lower temperatures.

Keywords: Egyptian cotton varieties, Bleaching, Hydrogen Peroxide, Oxygen bleaches, Sodium percarbonate and Sodium perborate.

Introduction

Egyptian cotton is the world's finest cotton because it has some noble characteristics which set it apart from other natural fibers [1]. In Egypt, more than one million families work in cotton production, over 850 thousand individuals participate in cotton manufacturing and trading and more than 1 million persons serve indirectly in the cotton sector. Egypt seeks to face the challenges of cotton value chain and put intelligent and sustainable solutions for its cultivation, manufacturing and trading. So, it is necessary to work on developing the textile industries and find smart and sustainable solutions in this field. One of them is using the latest technologies in preparation systems. This is accomplished by the expansion in utilizing the latest technologies in preparation, dyeing and

apparel industry to comply with the customer desires. [2]

Over the last few years, great changes occurred in the bleach compounds used all over the world. Several types of chemicals are used as bleaching agents, and their selection depends upon the material of fabrics as well as their intended use. Hydrogen peroxide is the most useful bleaching agent for cotton fibers and cotton blends [3, 4], as the chlorine containing bleach compounds such as sodium hypochlorite and sodium chlorite have been withdrawn for the market and their usage was gradually limited because of its disadvantages; a) all protein impurities must be completely removed before bleaching otherwise the fabric may turn yellowish. b) Residual chlorine must be removed because it has a bad effect on fibers, c) can produce

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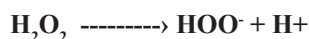
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more toxic chlorinated organic byproducts that can cause environmental pollution. On the other hand, bleaching with peroxide has many advantages; a) can be used for bleaching cotton, wool, silk, jute..etc. b) it shows less degradation of cotton as compared to hypochlorite bleaching [5-7].

Promising results have been reported by Glucose Oxidase enzyme that converts glucose to hydrogen peroxide and gluconic acid used for bleaching purpose [8]. Hydrogen peroxide contains an atom of loosely combined oxygen, so, it has powerful oxidizing properties and used in bleaching of textile materials. In a neutral aqueous solution, hydrogen peroxide is ionized in to perhydroxyl and hydrogen ions. These hydrogen ions have a tendering effect on cellulose due to its acidic nature. In acidic or neutral pH tendering effect of H⁺ ions is more than the bleaching effect of the HOO⁻ ions. This will impart yellowness to the cotton fibers. So it is not recommended to carry out bleaching in acidic conditions.



On the other hand, in alkaline condition following equilibrium exists:



Due to this in alkaline pH we get more bleaching effect and less tendering of cotton, but although the damage to cotton fiber is less, the stability of peroxide itself is also decreased. In absence of stabilizer, hydrogen peroxide in hot alkaline medium will get decomposed in less than 10 min. So it is necessary to use a stabilizing agent such as sodium Silicate to stabilize the peroxide solutions, It takes about 54min. for peroxide to decompose to extent of 50% in presence of silicate[5].

The major alternatives currently employed are oxygen-based chemicals [9,10]. Oxygen bleaches effectively remove stains and improve the degree

of whiteness. These compounds can be active at lower temperatures (<60 °C) than hydrogen peroxide. The consumption of Oxygen bleaches in 2002 was approximately 105,000 tones [11]. Sodium percarbonate or sodium perborate usage is safer to use than hydrogen peroxide and easily stored when compared with peroxide [12].

There are three types of oxygen bleaches sold in the consumer market, hydrogen peroxide, sodium percarbonate and sodium perborate. While hydrogen peroxide is a liquid, sodium percarbonate and sodium perborate are powders. Pure sodium percarbonate contains about 13-14% oxygen and sodium perborate contains about 10-15% oxygen [13]. Sodium percarbonate breaks down into oxygen, water, and soda ash. Percarbonate releases oxygen at a lower temperature, and is effective as laundry bleach. Sodium perborate has been used in laundering as bleach for many years and acts as hydrogen peroxide bleach because it releases oxygen at elevated temperatures [14].

Sodium percarbonate naturally decomposes, very slowly, to form sodium carbonate and hydrogen peroxide. The hydrogen peroxide may further decompose to form water and oxygen and liberate some heat. The decomposition proceeds according to the reaction in figure 1[15].

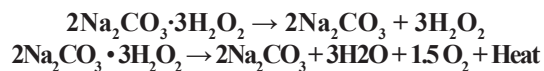


Fig.1. Mechanism of hydrogen peroxide release from sodium percarbonate

Sodium perborate contains the peroxyborate anion that has been shown to have the cyclic peroxide structure shown in Figure 2 [16]

Sodium perborate (SPB) is a convenient source of such H₂O₂. The borate helping somewhat to buffer, stabilize against decomposition, and activate towards nucleophilic oxidations, through associated species such as [B(OH)₃(OOH)]⁻ [17].

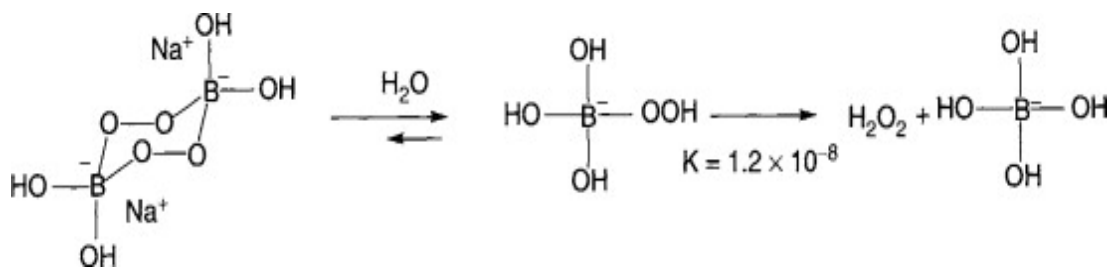


Fig.2. Mechanism of hydrogen peroxide release from sodium perborate.

Oxygen Bleaches have been developed to allow effective bleaching at lower temperatures. The demand for energy saving, as well as the availability of modern washing agents, has led to that almost 70% of all washings in Germany are carried out at temperatures below 40°C-60°C. Based on its better efficiency and environmental considerations, sodium percarbonate has replaced sodium perborate in modern washing agents [18].

When sodium percarbonate is combined with water, it is broken down into sodium carbonate (Na_2CO_3) and hydrogen peroxide (H_2O_2). The released hydrogen peroxide then becomes the active oxidizing agent, which breaking down the colored section of the chromophores. It is a polar molecule and water soluble due to the hydrogen bonding between hydrogen and oxygen [19,20]. Most sodium percarbonate is used in eco-friendly bleach products, including home and industrial laundry detergents and in other fields like its use in toothpastes [15].

The main difference between these two oxygen bleach compounds; sodium percarbonate and sodium perborate is in the amount of freely available hydrogen peroxide. Sodium perborate releases only one molecule H_2O_2 while sodium percarbonate releases three of them. The amount of sodium perborate to sodium percarbonate was set at 1:0.67, which means that instead of 1g/l perborate only 0.67 g/l percarbonate was used [18].

Sodium perborate has much greater stability and selectivity than sodium hypochlorite, and therefore it can be widely formulated in detergents. However, in the last 10 years sodium perborate gradually was replaced by sodium percarbonate. Since percarbonate has a greater rate of dissolution, has a more environment-friendly profile and has the advantage of generating hydrogen peroxide and of liberating carbonate, which gives a higher pH than borate. Currently, percarbonate is the form of choice in most European detergents [16].

While the purchase price of hydrogen peroxide products are cheaper than the powdered versions you must consider that much of the hydrogen peroxide. On an oxygen equivalency basis the costs are similar [13]. While hydrogen peroxide solutions have the advantage over powdered products of being sold ready to use, powdered bleaches are easier to handle, have better storage stability and do not need any added chemicals to

enhance stability [13]. Sodium perborate is more expensive than hydrogen peroxide because of the use of peroxide during perborate production. On the other hand sodium perborate includes extra alkaline, and consequently it needs less alkaline charge than hydrogen peroxide for oxygen bleaching. In this respect, the cost of for bleaching process can be decreased by using sodium perborate or sodium percarbonate [9]. Moreover, Oxygen bleaches are a good alternative for peroxide because it is more stable and can be stored in a solid form. In addition to their environmental impact as they are Non-toxic to animals, plants and humans and environmentally friendly as they break down into natural soda ash after the oxygen is released.

Because of the wide availability of sodium percarbonate and sodium perborate at reasonable prices and the ease at which they can be formulated into a range of effective and safe consumer products, the future for these products is bright. Oxygen based bleach products will continue to provide consumers with naturally derived safe and effective alternatives to toxic household cleaners [13].

Because of the importance of the oxygen-based bleaching agents and the current lack of studies describing the effects of these bleaching agents in Egyptian cotton varieties, therefore we planned to evaluate the influence of oxygen bleaches as novel alternatives for hydrogen peroxide.

For this purpose, we used multiple concentrations of sodium percarbonate and sodium perborate compared to hydrogen peroxide in different Egyptian cotton varieties; Giza 88, Giza 90, Giza 95, and Giza 96.

Experimental

Material

Four commercial varieties representing in two categories of Egyptian cotton (G. barbadense) were used, namely: (Giza 88 and Giza 96) as extra-long staple length (ELS cotton in Lower Egypt) and Giza 95 and Giza 90 as long staple length (LS cotton in Upper Egypt) are used for research at the cotton Research institute where research has been carried out, along with all the equipment supporting the research.

Sodium hydroxide, sodium silicate, Hydrogen peroxide, Sodium percarbonate (SPC), Sodium Perborate (SPB) and triton x-100 as a wetting agent,

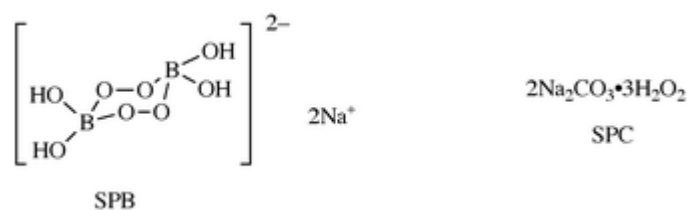


Fig. 3. Chemical structure of sodium percarbonate (SPC) and sodium perborate (SPB).

Methodology

Alkali Scouring Process

Conventionally, scouring is done in a hot aqueous solution of 3% NaOH to remove hydrophobic components from the primary wall (e.g. pectin, protein and organic acids) and the cuticle (waxes and fats) at temperature 95-100°C for 60 minutes, after scouring rinse twice with hot and cold water. [5,21]

Bleaching Process

Conventional bleaching was done using H₂O₂ depending on weight of the cotton fiber samples. The scoured samples were bleached for 60 min at temperature 60-70 °C into the bleaching baths prepared according to the recipes bellow: [3]

Liquor ratio	1:20
Auxiliaries	Sodium silicate (1g/l)
wetting agent	Triton x-100 (1ml/l)
Sodium percarbonate SPC	3 g/l , 6 g/l , 9 g/l
Sodium perborate SPB	3 g/l , 6 g/l , 9 g/l

Bleaching Evaluation

All testing samples was carried out in laboratories where standard atmospheric conditions at 65 ± 2% relative humidity and 21 ± 2°C temperature were maintained.

Cotton Classifying System: CCS- version 5 is a fiber laboratory instrument used to determine almost all the cotton fiber characteristics such as; Micronaire value, fiber length, tensile strength, elongation, degrees of whiteness and yellowness, according to ASTM standards for assessing the bleaching performance.

Weight Loss

The weight loss percentage was calculated by the following formula:

$$\text{Percentage of weight loss} = \frac{W_0 - W_1}{W_0} \times 100$$

Where, W₀= weight of fabric before treatment and W₁= weight of fabric after treatment

Fiber Whiteness and Yellowness degree

In the present research the cotton treated fibers each sample size was diameter 22 mm, were measured on CCS-FIBROCOLOUR Station for the determination of whiteness and yellowness degrees according to (ASTM E313- ASTM D 1925), using spectrophotometer LUCI 120

Fiber length UHM, fiber Strength and Elongation

The breaking strength of the cotton fibers were measured on CCS-FIBROTEST-Station - Automatic measurement of fiber length distribution, fiber bundle force and elongation at short stable fibers by using an advanced laser system and line camera for superior accuracy of length measurement and short fiber content; - Force measuring range up to 500 N, length measurement range up to 60 mm; - Automatically operated pneumatic clamps for absolute measurement of tenacity by automatic determination of sample mass -UHM, E(%), (g/tex) according to (ASTM D-5034) [22]

Fiber Micronaire value

To determine the Micronaire value of cotton treated fibers the **CCS-MICRONARE Station**, equipped with Micronaire tester, vacuum pump and balance, works according to ASTM D3813-ASTM D1448.

Statistical analysis

The effects of SPC and SPB on various bleached Egyptian cotton properties were compared using paired student t-test with the WinPepi statistical software package. P values less than 0.05 were considered significant.

Results and Discussion

Weight Loss

Weight loss of the cotton bleached fibers showed the highly effects of bleaching agents and concentrations on weight loss. The weight loss is due to the removal of impurities from the cotton fibers.

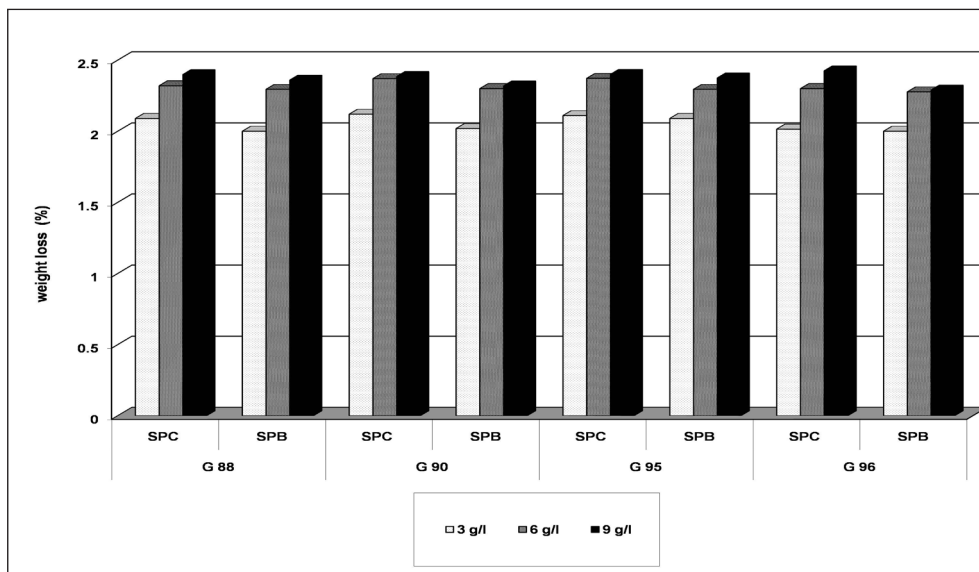


Fig. 4. Effect of the concentration of bleaching agents on the weight loss % of the Egyptian cotton fibers.

The effect of the concentration of bleaching agents on the weight loss % of the cotton fibers is shown in figure 4. The maximum weight loss was recorded for (9 g/l) with the mean value 2.4 % followed by (6 g/l) and (3 g/l) with their mean values 2.3% and 2 % respectively. There was no significant difference between the SPC and SPB effects on weight loss in each Egyptian cotton variety. The results show that weight loss was increased by increasing the concentration of bleaching agents. This is in agreement with Al Wasif and Indi (2010) and Shad et. al. (2000) [23,24].

The maximum weight loss was recorded for (H_2O_2) with mean value 2.5 % followed by (SPC) and (SPB) with mean values 2.1 % at lowest concentration (3g/l) and 2.4 % at highest concentration (9 g/l).

These results revealed that bleaching cotton fibers reduced their weight and this may be due to removing the impurities of cotton fibers.

Fabric Tensile Strength and Elongation

Effect of bleaching type and concentration on fiber tensile strength and elongation is respectively high. The comparison of tensile strength for different bleaching agents using multiple concentrations show the difference between using (SPC) and (SPB), as well as difference response of Egyptian cotton variety as shown in figure 5.

From figure 5 we can deduce that the strength of all cotton fibers is decreased after different treatments. It was found that Giza 96 and Giza 88

recorded maximum tensile strength followed by Giza90 and Giza 95 when treated with all bleaches. This is maybe due to their genetic structure and because they are considered as extra-long staple length in Egyptian cotton classification.

The strength loss percentages of bleached cotton fibers were referenced to the scoured samples for each cotton variety using different bleaching treatments as illustrated in Table 2. The maximum strength loss was recorded for Egyptian cotton varieties Giza 96 and Giza 88, with strength loss percent of 16.3 % and 13.7 %, respectively at the highest concentration of SPC (9g/l) followed by conventional bleaching with H_2O_2 with strength loss percent of 13.4 % with Giza 96 variety. The results show that tensile strength was decreased by increasing the concentration of bleaching agents. These results confirm the results reported by Tzanov et al. 2011, that the decrease in tensile strength is due to decrease in the degree of polymerization of cellulose because of oxidation [25]. While bleaching treatments improve whiteness by removing the impurities, coloring matters and non cellulosic constituents which on the other hand reduce the fiber strength [26].

As summarized in Table 2, there was also a significant difference between the SPC and SPB effects on tensile strength value in Egyptian cotton varieties Giza 90 and Giza 95, while Giza 88 and Giza 96 showed no significant difference. Overall there was a tendency of SPC to show more loss in tensile strength (%).

TABLE 1. Effect of the concentration of bleaching agents on the weight loss % of the cotton fibers.

Conc.	G 88		G 90		G 95		G 96	
	SPC*	SPB**	SPC	SPB	SPC	SPB	SPC	SPB
3 g/l	2.09	2	2.12	2.019	2.11	2.09	2.015	2
6 g/l	2.32	2.295	2.37	2.3	2.372	2.295	2.3	2.277
9 g/l	2.399	2.36	2.385	2.319	2.4	2.375	2.425	2.29
P value	0.74		0.575		0.762		0.727	

*Sodium percarbonate (SPC), **Sodium Perborate (SPB).

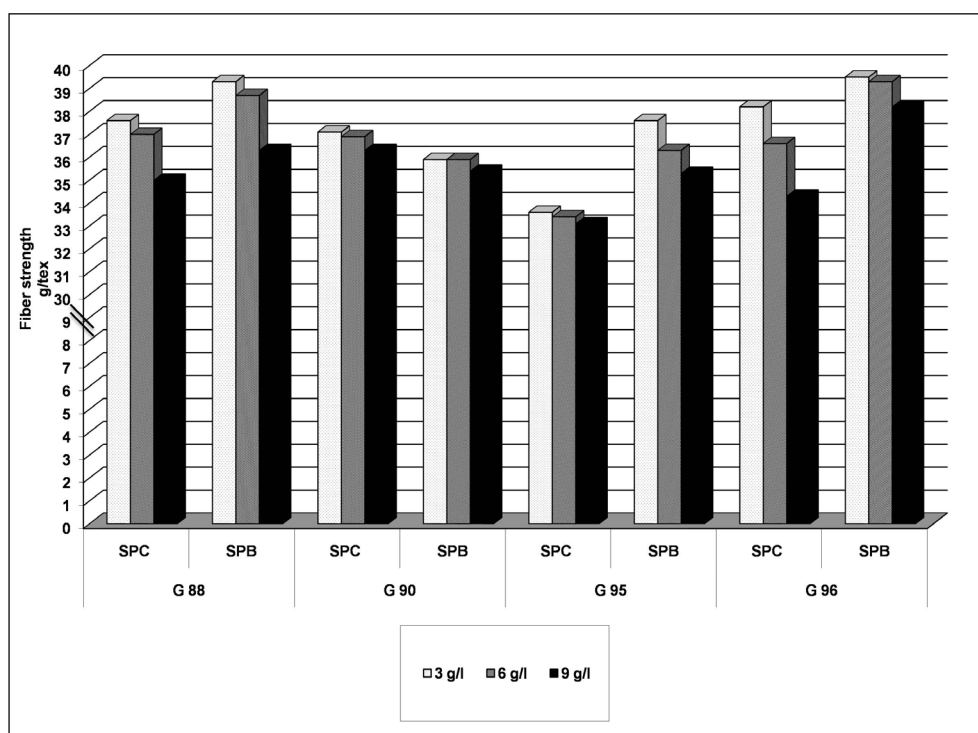


Fig. 5. Effect of the concentration of bleaching agents on the tensile strength of the Egyptian cotton fibers.

The mechanical and chemical damage caused during bleaching increased with the rise in concentration, which may be due to the drop in carboxyl group content with increase in bleaching agent. However the rate of increase in the extent of damage with increase in concentration seems to be the least for SPB followed by SPC in comparison of hydrogen peroxide in that order.

The comparison of elongation (%) for different bleaching agents using multiple concentrations

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was illustrated in figure 6, which shows the difference between using (SPC) and (SPB), as well as difference response of Egyptian cotton variety. It is clear that G90 and G95 showed higher elongation than G96 and G88. As shown in Table 2, only G95 variety showed a significant difference between the SPC and SPB treatments regarding elongation percentage, while the other three varieties were not significant.

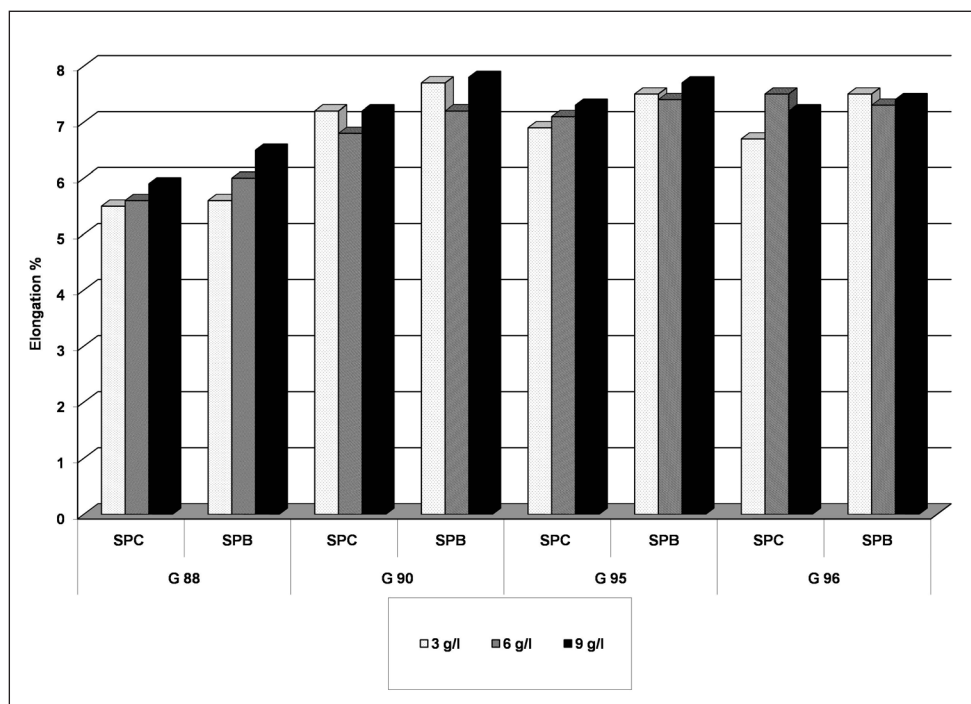


Fig. 6. Effect of the concentration of bleaching agents on the elongation % of the Egyptian cotton fibers.

Whiteness and Yellowness

Figures 7 and 8 showed that Rd% value which indicates the whiteness and brightness of the fibers rises with increasing the concentration of SPC or SPB between the 3-9 g/l. As the reactive oxygen content in the solution increases, more pigment of cotton fiber surface is oxidized thus the whiteness of the fibers becomes higher and the yellowness becomes lower, this suggests that cotton has higher adsorption capacity to active oxygen [6].

The cotton variety Giza 96 recorded the highest reflectance degree (Rd %) while, variety Giza 90 recorded the highest yellowness degree (+b %). Both Giza 90 and Giza 95 showed a significant difference in yellowness degree between SPC and SPB. Overall SPC was more effective bleaching agent showing less yellowness and more whiteness; however, the color brightness (Rd%) was not significantly different between SPC and SPB for any Egyptian cotton variety.

Upper half-mean length and Micronaire

Cotton fiber characteristics, such as upper half mean length (UHML) in mm and micronaire were affected by cotton varieties as well as chemical treatment. Table (2) compares the properties of fibers bleached with sodium perborate (SPB), sodium percarbonate (SPC) and hydrogen peroxide

The highest mean values of upper half mean length UHML (mm) was recorded by the cotton variety Giza 96 and Giza 88 compared to cotton varieties Giza 90 and Giza 95. From statistical analysis in Table 2, there was no significant difference between the SPC and SPB effects on upper half mean length in Giza 88, Giza 95 and Giza 96 Egyptian cotton varieties, but Giza 90 recorded a significantly higher UHML when using SPC compared to SPB.

Concerning micronaire value, there are different values that were recorded according to cotton variety and bleaching agent concentration. The results are summarized in Table 2. There was no significant difference between the SPC and SPB effects on micronaire value in all treated Egyptian cotton varieties (Giza 88, Giza 90 and Giza 96), except Giza 95 which recorded a significant difference effect on the micronaire value when using SPC compared to SPB.

Overall micronaire values have been reduced after scouring and bleaching, which may be due to the removal of impurities particularly in the outer surface layer (the cuticle) as most of wax and non-cellulosic materials are present in the outer layers of cotton fiber [27].

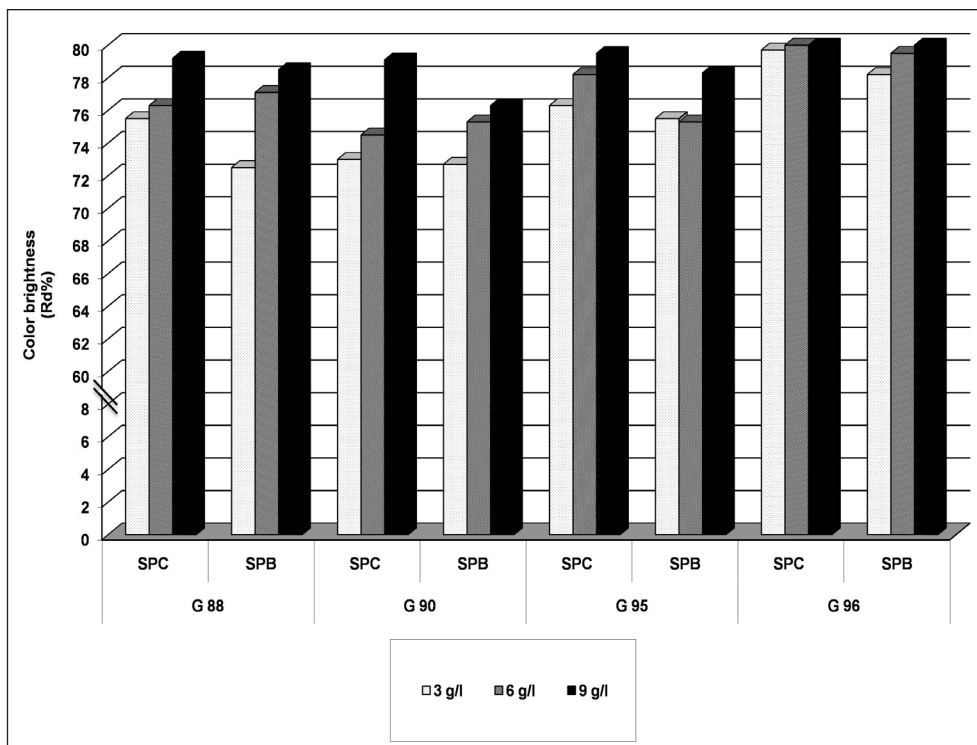


Fig. 7. Effect of the concentration of bleaching agents on the brightness (Rd %) of the Egyptian cotton fibers.

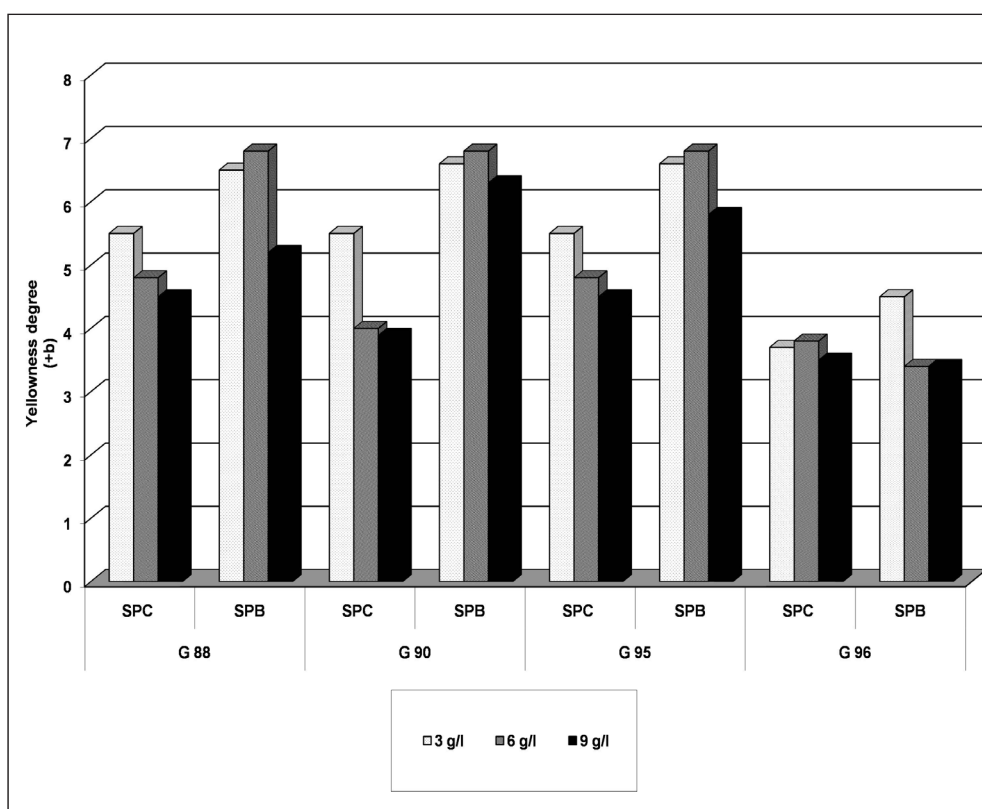


Fig. 8. Effect of the concentration of bleaching agents on the yellowness (+b) of the Egyptian cotton fibers.

TABLE 2. Comparison of bleached Egyptian cotton fiber properties with hydrogen peroxide, sodium perborate and sodium percarbonate.

	Treatment	Fiber strength (g/tex)	Strength Loss (%)	Elongation (%)	Yellowness degree (+b)	Color brightness (Rd%)	Fiber length UHML (mm)	Micronaire value
Giza 88	Raw	44.7		6.2	11.3	68.5	36.2	3.8
	Scoured	40.6		6.5	10.8	69.2	35.6	3.65
	H2O2	36.8	9.3	5.8	5.1	78.2	35.4	3.47
	SPB - 3 g/l	39.3	3.2	5.6	6.5	72.5	35.3	3.65
	SPB - 6 g/l	38.7	4.6	6	6.8	77.1	35.2	3.6
	SPB - 9 g/l	36.3	10.5	6.5	5.2	78.5	35.2	3.54
	SPC - 3 g/l	37.6	7.3	5.5	5.5	75.5	35	3.57
	SPC - 6 g/l	37	8.8	5.6	4.8	76.3	34.8	3.5
	SPC - 9 g/l	35	13.7	5.9	4.5	79.2	34.3	3.44
	P value	0.264	0.264	0.298	0.098	0.674	0.065	0.131
Giza 90	Raw	37.8		8.1	12.03	64.7	30.5	4.07
	Scoured	37.5		7.9	10.6	68.5	30.3	3.72
	H2O2	35.7	4.8	6.6	6.1	78.5	30.3	3.7
	SPB - 3 g/l	35.9	4.23	7.7	6.6	72.7	30	3.74
	SPB - 6 g/l	35.9	4.23	7.2	6.8	75.3	29.6	3.6
	SPB - 9 g/l	35.4	5.6	7.8	6.3	76.3	29.4	3.51
	SPC - 3 g/l	37.1	1.06	7.2	5.5	73	30.8	3.7
	SPC - 6 g/l	36.9	1.6	6.8	4	74.5	30.5	3.54
	SPC - 9 g/l	36.3	3.2	7.2	3.89	79.1	30.3	3.35
	P value	0.026*	0.026*	0.094	0.018*	0.737	0.019*	0.514
Giza 95	Raw	37.8		8	11.8	61.3	30.5	4.3
	Scoured	36.2		8.3	10.7	62.1	29.7	4.2
	H2O2	35.3	2.4	7.8	5.3	72.2	29.5	4
	SPB - 3 g/l	37.6	3.8	7.5	6.6	75.5	30.5	4.15
	SPB - 6 g/l	36.3	0.6	7.4	6.8	75.3	30.1	4.03
	SPB - 9 g/l	35.3	2.4	7.7	5.8	78.3	28.3	3.88
	SPC - 3 g/l	33.6	7.1	6.9	5.5	76.3	28.5	3.83
	SPC - 6 g/l	33.4	7.7	7.1	4.8	78.2	28.3	3.75
	SPC - 9 g/l	33.1	8.5	7.3	4.5	79.5	28.25	3.7
	P value	0.011*	0.011*	0.041*	0.026*	0.29	0.133	0.04*
Giza 96	Raw	44.5		7.5	8.7	76.8	37	4.04
	Scoured	41		7.6	8.2	75.6	36.5	3.63
	H2O2	35.5	13.4	7.2	3.6	88.8	35.5	3.6
	SPB - 3 g/l	39.5	3.6	7.5	4.5	78.2	35.5	3.5
	SPB - 6 g/l	39.3	4.1	7.3	3.4	79.5	35.2	3.27
	SPB - 9 g/l	38.2	6.8	7.4	3.4	80	35	3.16
	SPC - 3 g/l	38.2	6.8	6.7	3.7	79.7	35.1	3.51
	SPC - 6 g/l	36.6	10.7	7.5	3.8	80.2	34	3.45
	SPC - 9 g/l	34.3	16.3	7.2	3.5	85.5	33.5	3.2
	P value	0.094	0.094	0.329	0.804	0.255	0.105	0.608

SPB, Sodium Perborate; SPC, Sodium percarbonate; * P value < 0.05; UHML, upper half mean length.

Conclusion

It can be observed from this research that the quality and properties of cotton fibers bleached with sodium perborate, sodium percarbonate are mostly better than those bleached with hydrogen peroxide especially in degree of whiteness and tensile strength. In general, the quality of cotton fibers bleached with sodium percarbonate is superior to that of hydrogen peroxide and perborate. The most suitable conditions for the bleaching process are concentration of sodium percarbonate 6 g/L, bleaching temperature 60C for 60 min.

Also the study demonstrated that there is no much difference between the quality of fabrics bleached with SPB, SPC and hydrogen peroxide, meaning that these oxygen bleaches can replace hydrogen peroxide, especially that they are more environmentally friendly.

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تقييم الأداء المقارن لتبييض ألياف القطن المصرية باستخدام مواد التبييض المختلفة

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يختلف لون شعيرات القطن ما بين الأبيض والأبيض المائل للاصفرار ويرجع لونه إلى وجود الصبغات الطبيعيه الموجودة في الألياف, والتي يمكن إزالتها إزالة تامة بعملية التبييض ومما لاشك فيه أن لون القطن من اهم خواص جوده الألياف.

يهدف البحث الى تسليط الضوء على أهمية عملية التبييض بالاضافة إلى دراسة تأثير المواد المستخدمة في عملية تبييض الألياف القطنية باستخدام مواد التبييض يعتمد على دور الأكسجين . حيث تقوم الدراسة بتقييم إمكانية استخدام بيروكربونات الصوديوم و بيروورات الصوديوم في تبييض ألياف القطن بتركيزات مختلفة (٣, ٦, ٩) جم /لتر كبديل عن بيروكسيد الهيدروجين ومقارنة تأثير عوامل التبييض على تحسن في أداء التبييض لبعض أصناف القطن المصري (جيزة ٨٨ ، جيزة ٩٠) فائق الطول، (جيزة ٩٥ ، جيزة ٩٦)طويل.

ويتم تقييم بعض الصفات من خلال درجة البياض ، والاصفرار ، و الميرونير ، وقوة ومثانة الألياف واستطالتها والطول.

اظهرت نتائج هذا البحث كفاءة استخدام مركبات الاكسجين بما يماثل عوامل التبييض التقليدية مثل بيروكسيد الهيدروجين، وأن التبييض باستخدام بيروكربونات الصوديوم وبيروورات الصوديوم اظهرت تحسنا عاما في خصائص ألياف القطن مقارنة ببيروكسيد الهيدروجين ، وإنها كبديل جيد لبيروكسيد الهيدروجين حيث أنها أكثر ثباتاً كما يمكن تخزينها في صورة صلبة.

ومن مزايا التبييض بمركبات الأكسجين:

- أفضل استقرار على المدى الطويل من منتجات فوق اكسيد الهيدروجين السائل
- تعمل كمطهر ضد البكتيريا والفيروسات
- يمكن خلط أو تبييض الأكسجين مع المنظفات المنزلية الأخرى
- غير سامة للحيوانات والنباتات والبشر.
- صديقة للبيئة لأنها تتحلل إلى الصودا بعد إطلاق الأكسجين.
- تقليل التكلفة الاقتصادية.

ويعتبر الاتجاه المستقبلي للتبييض بالأكسجين ، فمع التوافر الواسع لبيروكربونات الصوديوم وبيروورات الصوديوم بأسعار معقولة وسهولة اضافتها في مجموعة من المنتجات الاستهلاكية الفعالة والأمنة ، فإن مستقبل هذه المنتجات مشرقا. حيث ان مركبات التبييض التي تعتمد على الأكسجين تلقى رواجاً واقبالاً من المستهلكين وتعتبر بدائل آمنة وفعالة مقارنة بغيرها.