Effect Of Hair Mask On Hair Mechanical And Biochemical Status Under Thermal, Chemical And Mechanical Stress

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DOI: 10.47750/pnr.2022.13.S07.971

Abstract

Hair is an item of our body, which provides beauty for both men and women. Human hair is subjected to air pollution and its own additive sebum. This makes it dirty and must be washed away. Hair drier and hot flat irons are used for drying and styling or texturing of hair. If the drying temperature is high, it may cause a thermal damage. Ultra Violet (UV) radiation of sun light may cause physical and chemical damage to hair structure. Due to mechanical process during styling, texturing and combing or tensions applied to hair during a normal day, hair structure may be damaged. Usually, hair mask is used to prevent or reduce these damages. Hair fibers were collected from a young woman, and divided into 2 parts. A hair mask was applied to one part of it. Thermal, UV, dead weight and detergent damages were applied to plain and masked hair fibers, and were tested. Max load and extension at max load from mechanical properties, and ROS and TAC from biochemical properties were measured. It was concluded from the test results that application of mask reduced thermal damage (ROS), dead weight damage (max load, extension at max load, ROS, and TAC) and detergent damage of the samples (ROS and TAC). Hair mask protected hair against thermal, chemical and mechanical stresses. Measurement of tensile properties, ROS and TAC of the hair samples gave good responses for evaluation of the induced damages.

Keywords: Hair mask, Hair treatment, Mechanical damage, Biochemical damage, Tensile

INTRODUCTION

Human hair is subjected to air pollution and its own additive sebum. This makes it dirty and must be washed away. Hair shampoos may cause physical and mechanical damage to hair structure. Natural pH of human hair is in acidic range (Dias et al., 2014). Dias MF et.al reported that, anionic shampoo with sodium lauryl sulfate may increase electrical negative charges on hair surface and increase its frizz and friction (Dias, 2015).

Hair drier and hot flat irons are used for drying and styling or texturing of hair. If the drying temperature is high, it may cause a thermal damage. Hot flat irons operate at temperatures over 200 °C, and they can cause significant damage to hair keratin. Zhou et al. (2011) reported that, thermally stressed hair causes an increase in hair breakage when subjected to combing. Polymeric pretreatments of hair provide thermal protection against thermal degradation of keratin in the cortex and hair surface. Morphology and smoothness of hair improves with polymeric pretreatment, and it plays an important role in their anti-breakage effect.

Ultra Violet (UV) radiation of sun light may cause physical and chemical damage to hair structure. Jeon SY et.al reported that photochemical damage of UV radiation mainly affects hair proteins and melanins. Biological changes in UVA-irradiated hairs are more than that of UVB and morphological damage in UVB-irradiated hairs is significantly more than UVA (Jeon et al., 2008).

Due to mechanical process during styling, texturing and combing or tensions applied to hair during a normal day, hair structure may be damaged. To resemble this type of damage, dead weight test was carried out.

Usually, hair mask is used to prevent or reduce these damages. It reduces the damage to some extent or repairs it. Hair masks are consisted of a fatty acid, amino acid and other additives for prevention or repair of the damage. A. Rele et.al reported that, coconut oil remarkably reduces protein loss for both undamaged and damaged hair in comparison to sunflower and mineral oils (India, 2003; Sisca V, et. al., 2019). Keis K et.al studied effect of oils on hair softness and concluded that, addition of oil may increase retention of water in hair cuticle and act as a moisturizing and softening agent (Keis et al., 2007). Yue Cao et.al reported that, loss of cystine content of photo damaged hairs was identified to be the main factor that physiologically contributed to the morphological changes of hair surface fibers and hence the variation of their multispectral reflectance spectra (Cao et al., 2017). Addition of cystine to hair mask may prevent these damages.

In this research, effect of a mask containing cystine and cysteine in avocado, coconut and jojoba oil on mechanical and biochemical damages of hair is investigated (Kanedi M, et. al., 2021).

MATERIAL AND METHODS

Materials

Hair Sample

Hair specimens were collected from an Iranian woman of 25 years old with no chemical process such as dyeing, bleaching, botaxing or keratination. The hairs were dry and curly. Figure 1 shows an image of this hair. All hair samples were taken from one individual person to prevent variation of mechanical and chemical properties due to genetics, age, nutrition, mental condition and geographical location (Yu et al., 2017).

Figure 1. Image of hair sample.

Detergents

Amphoteric and anionic detergents were used in this experiment. Amphoteric detergent was composed of Cocoamidopropyl Betaine and Anionic detergent was composed of Sodium Lauryl Ether Sulfate.

TAC and ROS assay kits

Hair Mask

This formulation contains cysteine and cysteine which are sulfur based. So for maximum efficacy resulted by amino acid structures, more sulfur groups were added. Antioxidant based by A and E vitamins, which are sold in Argan oil. Biphasic formulation was selected because of cortex and cuticle histology (Ahmadinik, 2021).

Laboratory Instruments

Elima yarn strength tester, Hot plate, Dead weight application gadget (The gadget was a 1m*1m U shaped (upside-down) wooden frame. At the bottom of U frame 5cm pins were placed at 5cm distances for hanging of hair samples) and Ultra Violet (UV) radiation box (UV box was composed of a 50cm*50cm*50cm cube of 1 cm thickness MDF wood, which had a 5-Watt UV bulb on top of the box. Hair samples for radiation were placed at bottom of the box).

Methods

Coding of samples

The samples were coded by two letters and a number. First letter was T for thermal, U for ultra violet, D for detergent and W for dead weight which shows type of damages. R was used for undamaged sample. Second letter was used for mask application. M was used for masked samples and N for samples without mask.

For thermal damaged samples the last number was 1, 5 and 9 which shows distances between sample and the hot plate. The number for UV damaged samples was 9, 18 and 36 which shows duration of UV radiation in hours. In case of detergent damages, the number was 1, 8, 16 and 24 which shows number of washing cycles. In coding of dead weight damage, no number were used, because amount of the dead weight and its application time were constant. For example, code UM18 indicates a sample which is masked and UV radiated for 18 hours. Table 1 shows coding of the samples.

Table 1. Coding of Samples.

No	Code	Description
1	RN	Raw, without mask
2	RM	Raw, with mask
3	TN1	Thermal damaged at 1 cm distance, without mask
4	TN5	Thermal damaged at 5 cm distance, without mask
5	TN9	Thermal damaged at 9 cm distance, without mask
6	TM1	Thermal damaged at 1 cm distance, with mask
7	TM5	Thermal damaged at 5 cm distance, with mask
8	TM9	Thermal damaged at 9 cm distance, with mask
9	UN9	UV damaged for 9 hours, without mask
10	UN18	UV damaged for 18 hours, without mask
11	UN36	UV damaged for 36 hours, without mask
12	UM9	UV damaged for 9 hours, with mask
13	UM18	UV damaged for 18 hours, with mask
14	UM36	UV damaged for 36 hours, with mask
15	DN1	Detergent damaged, 1 cycle, without mask
16	DN8	Detergent damaged, 8 cycle, without mask
17	DN16	Detergent damaged, 16 cycle, without mask
18	DN24	Detergent damaged, 24 cycle, without mask
19	DM1	Detergent damaged, 1 cycle, with mask
20	DM8	Detergent damaged, 8 cycle, with mask
21	DM16	Detergent damaged, 16 cycle, with mask
22	DM24	Detergent damaged, 24 cycle, with mask
23	WN	Dead weight damaged, without mask
24	WM	Dead weight damaged, with mask

Type of damage

Type of damages studied were thermal, UV radiation, detergent and dead weight. In thermal damage, samples placed at 1, 5 and 9 cm distances from the hot plate for 75 seconds. Temperature at 1cm distance from the hot plate was 130 °C.In UV radiation damage, samples were placed in radiation box for 9, 18 and 36 hours.In detergent damage, samples were washed for 1, 8, 16 and 24 cycles. In each washing cycle hair samples were processed for 3minutes. In case of repeated washing cycles for masked samples, hair samples were covered with mask material between cycles.

In dead weight damage, amount of load is important. If it is in the area of Hookian behavior of the sample, length of the hair will return to its initial value after removal of the weight. And if it is after yield point of the hair, it will cause a permanent or time dependent elongation. Since mechanical behavior of hairs collected from one person may vary for individual hairs, it is impossible to have a constant yield point for all hairs. Therefore, range of yield point for 15 samples of the raw hair were extracted from its load-elongation curve. This range for the raw hair was between 60 and 90 cN. Dead weight load was selected as 33% of the range, and it was 70 cN. Figure 2 shows load-elongation curve of the raw hair (Ahmadinik, 2021).

Conversion factor of cN to gram is 0.981, therefore, dead weight was rounded to 69 grams. Sand particles were poured into plastic bags to balance 69 g. The bags were tied to end of hairs and hanged from the stationary frame. Figure 3 shows set up for application of the dead weight.

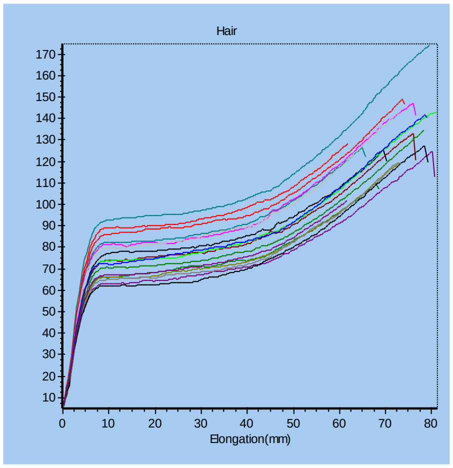

Figure 2. Load-Elongation curve of dead weight sample.

Figure 3. Image of set up for dead weight application.

Application of the mask to the samples with mask were prior to the damages. After damaging no more mask was applied. Then mechanical and biochemical tests were carried out on the samples.

Mechanical test

Sample length was 20cm, speed of the jaw was 1cm/min for first cm of the test and after that it was increased to 25cm/min. Separation speed of the jaws directly influences result of the test. For this reason, speed of the jaw was at a lower level in the beginning of the test. Number of the samples were 15 in each case.

Maximum (max) load and extension at maximum load were selected as important factors of the test. Time interval between damage to the hair and its examination may affect test results. For this reason, samples of thermal, dead weight and anionic detergent damage were tested shortly after the damage (Maximum 30 minutes). In case of UV application, the UV box were located in another lab and the delay time between damage and tensile test was maximum one hour.

Biochemical test

Reactive oxygen species (ROS) and Total antioxidant capacity (TAC) are two factors for measuring hair damage under different stresses. Prior to measurement of ROS and TAC, hair protein must be extracted. Then, ROS and TAC will be assayed in that protein. Hair protein was extracted according to the protocol described by Wong et al. (2016).

TAC assay

This test was performed by an ELISA device. 30 microliters of sample were added to each well. Saline phosphate buffer (PBS) was used as a blank and 30 microliters of it was added to the blank well. 150 µL of TAC working solution was added to each well. The plate was incubated at room temperature for 30 to 60 minutes. Then absorption of blank and the samples at a wavelength of 450 nm was read. Average absorption of the blank was subtracted from that of the samples. Their means and standard deviations were reported.

ROS assay

This test was performed by an ELISA device. All reagents, work standards and samples were prepared according to the kit instructions and were kept at room temperature for 20 minutes. 100 microliters of samplewere added to each well and incubated on shaker for 1 hour at 37 degrees. The plate should be emptied but not washed. 100 microliters of detection reagent A were added to each well and incubated for 1 hour at 37 degrees. The plate should be emptied and washed 3 times, each time with 400 µL of washing solution in the plate kit. 100 microliters of detection reagent B solution were added to each well and incubated at 37 ° C for 30 minutes. The plate should be emptied and washed 5 times, each time with 400 µL of washer solution. 90 µL of TMB substrate solution was added to each well and incubated for 20 minutes in the dark at 37 degrees. 50 microliters of stop solution were added to each well. Using the ELISA device, which is set to a wavelength of 450 nm, the light absorption of the sample in each well were read. Average absorption of the blank was subtracted from that of the samples. Their means and standard deviations were reported.

RESULTS AND DISCUSSION

Incomparison of results, if there were two groups with normal distributions, t-student method was used. Test of normality of distribution and Leven's for equality of variances were carried out for these groups. In comparison of more than two groups, Analysis of Variance (AnoVa) was used. In non-normal distributions, unequal variances transformed data was used. If there was a difference between the means, Tukey test was used for their ranking. In order to reduce number of Tables in the paper, if there was significant difference between the means, only Sig. value of AnoVa and Tukey Table of ranking are given.

Prior to discussion and comparison of test results, a test of normality of their distribution was carried out for all test results. It was found that, distribution of all test results were normal.

Mechanical test results

Raw (with no damage)

Tables 2 and 3 show group statistics and independent samples test of max load for raw samples. It can be seen that Sig. (2-tailed) value is 0.184, which is more than 0.05, and absolute value of t is 1.378, which is less than 1.96. Therefore, there is no SSD between max load means of RN and RM. Tables 4 and 5 show group statistics and independent samples test of extension at max load for raw samples. It can be seen that, Sig. (2-tailed) value is 0.681, which is more 0.05, and absolute value of t is 0.418, which is less than 1.96. Therefore, there is no SSD between extension at max load means of RN and RM.

Table 2. Group statistics of max load for raw samples.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Max load	RN	15	131.5400	11.43977	2.95374
	RM	15	121.7233	25.10313	6.48160

Table 3. Independent samples test of max load for raw samples.

	Levene's Test for Equality of Variances		t-test for Equality of Means					
	F	Sig.	t	df	Sig.	Mean	Std.	95% Confidence

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Interval of the Difference	
									Lower	Upper
Max load	Equal variances assumed	3.877	.059	1.378	28	.179	9.81667	7.12290	-4.77393	24.40727
	Equal variances not assumed			1.378	19.574	.184	9.81667	7.12290	-5.06218	24.69551

Table 4. Group statistics of extension at max load for raw samples.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Extension	RN	15	36.7980	2.83073	.73089
	RM	15	37.6087	6.95423	1.79558

Table 5. Independent samples test of extension at max load for raw samples.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Extension	Equal variances assumed	10.501	.003	-.418	28	.679	-.81067	1.93863	-4.78177	3.16044
	Equal variances not assumed			-.418	18.515	.681	-.81067	1.93863	-4.87547	3.25414

Thermal damaged

Table 6 shows AnoVa of max load for thermal damaged samples. It can be seen that Sig. value is 0.268, which is more than 0.05. Therefore, there is no SSD between means of TN and TM groups. Sig. value of AnoVa of extension at max load for thermal damaged samples was 0.001, which is less than 0.05. Therefore, there is SSD between their means. Table 7 shows results of Tukey test of ranking (TTR) for extension at max load of thermal damaged samples for TN and TM groups. It can be seen that extension of TN1, TN5 and TN9 are in one group and there is no SSD between them. Extension of TM1 and TM5 are in two different groups and there is SSD between them. Extension of TM9 is located jointly in TM1 and TM5 groups and there is no SSD between them. Finally, there was no SSD between extension of with and without mask samples at different distances from heat source.

Table 6. AnoVa of max load for thermal damaged samples.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2472.753	5	494.551	1.309	.268
Within Groups	31741.500	84	377.875		
Total	34214.253	89			

Table 7. Tukey test of ranking for extension at max load of thermal damaged samples.

Group	N	Subset for alpha = 0.05		
		1	2	3
TN1	15	28.9900		
TM1	15	29.4507	29.4507	
TN9	15	30.3607	30.3607	
TN5	15	32.7593	32.7593	32.7593
TM9	15		35.0973	35.0973
TM5	15			36.2380
Sig.		.423	.065	.515

UV damaged

Sig. value of AnoVa of max load for UV damaged samples was 0.016, which is less than 0.05. Therefore, there is SSD between means. Table 8 shows Tukey test of ranking for UV damaged samples. The Sig. value of ranking is 0.124, which is more than 0.05, and shows that there is no SSD between max load of UV damaged samples. Since results of Tukey overrides results of AnoVa, final decision will be, no SSD between the means for max load of UV damaged samples. Table 9 shows AnoVa of extension at max load for UV damaged samples. The Sig. value of extension at max load is 0.581, which is more than 0.05, and shows that there is no difference between their means.

Table 8. Tukey test of ranking for max load of UV damaged samples.

Group	N	Subset for alpha = 0.05
		1
UN18	15	116.5200
UN36	15	117.1700
Um36	15	117.5407
UN9	15	127.1733
Um9	15	131.0733
Um18	15	131.5267
Sig.		.124

Table 9. AnoVa of extension at max load for UV damaged samples.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	41.131	5	8.226	.761	.581
Within Groups	908.324	84	10.813		
Total	949.454	89			

Dead weight damaged

Tables 10 and 11 show group statistics and independent samples test of max load for dead weight samples. It can be seen that Sig. (2-tailed) value is 0.032, which is less than 0.05, and absolute value of t is 2.262, which is more than 1.96. Therefore, there is SSD between max load means of WN and WM. Tables 12 and 13 show group statistics and independent samples test of extension at max load for dead weight samples. It can be seen that, Sig. (2-tailed) value is 0.006, which is less than 0.05, and absolute value of t is 3.000, which is more than 1.96. Therefore, there is SSD between extension at max load means of WN and WM.

Table 10. Group statistics of max load for dead weight samples.

	Group	N	Mean	Std. Deviation	Std. Error Mean
max load	WN	15	133.1453	20.28683	5.23804
	WM	15	148.5267	16.79585	4.33667

Table 11. Independent samples test of max load for dead weight samples.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
max load	Equal variances assumed	.855	.363	-2.262	28	.032	-15.38133	6.80027	-29.31106	-1.45160
	Equal variances not assumed			-2.262	27.058	.032	-15.38133	6.80027	-29.33296	-1.42971

Table 12. Group statistics of extension at max load for dead weight samples.

	Group	N	Mean	Std. Deviation	Std. Error Mean
extension	WN	15	23.6613	7.35008	1.89778
	W	15	31.199	6.37811	1.64682

M	3

Table 13. Independent samples test of extension at max load for dead weight samples.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Extension	Equal variances assumed	1.358	.254	-3.000	28	.006	-7.53800	2.51269	-12.68501	-2.39099
	Equal variances not assumed			-3.000	27.455	.006	-7.53800	2.51269	-12.68962	-2.38638

Detergent damaged

Sig. value of AnoVa of max load for detergent damaged samples was 0.001, which is less than 0.05 and shows that there is SSD between their means. Table 14 shows results of Tukey test of ranking for max load of detergent damaged samples. Max load of the samples are classified into two subset groups. Max load of DN8 and DM24 samples are in subset group 1 and have SSD with DM16 in subset group 2. Rest of the samples are jointly in both groups of 1 and 2, and there is no SSD between them. Max load of similar DN and DM groups were statistically the same, which means that, application of hair musk didn't have significant effect on max load of the samples. Sig. value of AnoVa of extension at max load for detergent damaged samples was 0.027, which is less than 0.05 and shows that there is SSD between their means. Table 15 shows Tukey test of ranking for extension at max load of detergent damaged samples. The Sig. value is 0.147, which is more than 0.05, and means that there is no SSD between extensions of the samples. Since results of Tukey overrides results of AnoVa, final decision will be, no difference between the means for extension at max load of detergent damaged samples.

Table 14. Tukey test of ranking for max load of detergent damaged samples.

Group	N	Subset for alpha = 0.05	
		1	2
DM24	15	114.7400	
DN8	15	115.1267	
DN24	15	120.9400	120.9400
DN16	15	123.9993	123.9993
DM8	15	125.8267	125.8267
DN1	15	126.7133	126.7133
DM1	15	130.746	130.7467

		7	
DM16	15		137.5267
Sig.		.099	.077

Table 15. Tukey test of ranking for extension at max load of detergent damaged samples.

Group	N	Subset for alpha = 0.05
		1
DN16	15	34.4440
DM1	15	34.4900
DN8	15	34.8500
DM8	15	35.9753
DN1	15	36.7860
DM16	15	37.1433
DN24	15	37.2413
DM24	15	37.6800
Sig.		.147

Biochemical test results

Raw (with no damage)

Tables 16 and 17 show group statistics and independent samples test of ROS for raw samples. It can be seen that Sig. (2-tailed) value is 0.067, which is more than 0.05, and absolute value of t is 1.903, which is less than 1.96. Therefore, there is no SSD between ROS means of RN and RM. Tables 18 and 19 show group statistics and independent samples test of TAC for raw samples. It can be seen that, Sig. (2-tailed) value is 0.000, which is less than 0.05, and absolute value of t is 25.103, which is more than 1.96. Therefore, there is SSD between TAC means of RN and RM.

Table 16. Group statistics of ROS for raw samples.

	Group	N	Mean	Std. Deviation	Std. Error Mean
ROS	RN	15	21.5960	2.25073	.58114
	RM	15	20.2240	1.65158	.42644

Table 17. Independent samples test of ROS for raw samples.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
RO	Equal variances	1.41	.2	1.90	28	.06	1.372	.7208	-	2.84

S	assumed	0	45	3		7	00	1	.10451	851
	Equal variances not assumed			1.903	25.688	.068	1.37200	.72081	-.11052	2.85452

Table 18. Group statistics of TAC for raw samples.

	Group	N	Mean	Std. Deviation	Std. Error Mean
TAC	RN	15	61.2813	1.81677	.46909
	RM	15	44.7767	1.78422	.46068

Table 19. Independent samples test of TAC for raw samples.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
TAC	Equal variances assumed	.262	.613	25.103	28	.000	16.50467	.65747	15.15789	17.85144
	Equal variances not assumed			25.103	27.991	.000	16.50467	.65747	15.15787	17.85146

Thermal damaged

Sig. value of AnoVa of ROS for TN and TM groups was 0.000, which is less than 0.05. Therefore, there is SSD between their means. Table 20 shows Tukey test of ranking of ROS for thermal damaged samples. ROS of TM1 is more than that of TN1, and ROS of TM5 and TM9 are less than that of TN5 and TN9 respectively. Therefore, in two cases out of three tested cases, application of mask reduced thermal damage to the hair.

Sig. value of AnoVa of TAC for thermal damaged samples was 0.000, which is less than 0.05. Therefore, there is SSD between their means. Table 21 shows Tukey test of ranking of TAC for thermal damaged samples. TAC of TN1 and TM1 are located in one group. Therefore, there is no difference between them. However, TAC of TM5 and TM9 are less than that of TN5 and TN9 respectively. TAC of samples was less than that of without-mask ones in two cases out of three tested samples.

Table 20. Tukey test of ROS for thermal damaged samples.

Group	N	Subset for alpha = 0.05				
		1	2	3	4	5
TN1	15	52.4107				
TM9	15		64.0873			
TM1	15			76.7613		

TM5	15				106.9647	
TN9	15				107.1260	
TN5	15					130.1533
Sig.		1.000	1.000	1.000	1.000	1.000

Table 21. Tukey test of TAC for thermal damaged samples.

Group	N	Subset for alpha = 0.05		
		1	2	3
TM9	15	30.0460		
TM5	15	30.3333		
TN5	15		35.7940	
TM1	15			41.4100
TN1	15			41.9047
TN9	15			42.5153
Sig.		.995	1.000	.333

UV damaged

Sig. value of AnoVa of ROS for UV damaged samples was 0.000, which is less than 0.05. Therefore, there is SSD between their means. Table 22 shows Tukey test of ranking of ROS for UV damaged samples. ROS of with-mask samples for 9, 18 and 36 hours of radiation were more, less and more than that of without-mask samples respectively. Although, it was more than that of without-mask samples in two cases, but it didn't show a trend.

Sig. value of AnoVa of TAC for UV damaged samples was 0.00, which is less than 0.05. Therefore, there is SSD between their means. Table 23 shows Tukey test of ranking of TAC for UV damaged samples. TAC of with-mask samples for 9, 18 and 36 hours of radiation were less, more and less than that of without-mask samples respectively. Although, it was less than that of without-mask samples in two cases, but it didn't show a trend.

Table 22. Tukey test of ROS for UV damaged samples.

Group	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
UN36	15	73.5693					
UM36	15		82.4973				

UN 9	15			93.8060			
UM 18	15				99.2047		
UM 9	15					102.9220	
UN 18	15						130.5520
Sig.		1.000	1.000	1.000	1.000	1.000	1.000

Table 23. Tukey test of TAC for UV damaged samples.

Group	N	Subset for alpha = 0.05				
		1	2	3	4	5
UM 9	15	15.3360				
UN 9	15		20.3300			
UN 18	15			22.5920		
UM 36	15			23.9780		
UM 18	15				25.9000	
UN 36	15					30.1587
Sig.		1.000	1.000	.144	1.000	1.000

Dead weight damaged

Tables 24 and 25 show group statistics and independent samples test of ROS for dead weight samples. It can be seen that Sig. (2-tailed) value is 0.000, which is less than 0.05, and absolute value of t is 55.261, which is more than 1.96. Therefore, there is SSD between ROS means of WN and WM. Tables 26 and 27 show group statistics and independent samples test of TAC for dead weight samples. It can be seen that, Sig. (2-tailed) value is 0.000, which is less than 0.05, and absolute value of t is 12.127, which is more than 1.96. Therefore, there is SSD between TAC means of WN and WM.

Table 24. Group statistics of ROS for dead weight samples.

	Group	N	Mean	Std. Deviation	Std. Error Mean
ROS	WN	15	60.3127	1.48898	.38445
	WM	15	30.8713	1.42849	.36883

Table 25. Independent samples test of ROS for dead weight samples.

	Levene's	t-test for Equality of Means

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
ROS	Equal variances assumed	.017	.899	55.261	28	.000	29.44133	.53277	28.35000	30.53266
	Equal variances not assumed			55.261	27.952	.000	29.44133	.53277	28.34992	30.53275

Table 26. Group statistics of TAC for dead weight samples.

	Group	N	Mean	Std. Deviation	Std. Error Mean
TAC	WN	15	16.7887	1.02024	.26343
	WM	15	23.4253	1.85792	.47971

Table 27. Independent samples test of TAC for dead weight samples.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
TAC	Equal variances assumed	3.844	.060	-12.127	28	.000	-6.63667	.54728	-7.75772	-5.51561
	Equal variances not assumed			-12.127	21.740	.000	-6.63667	.54728	-7.77245	-5.50088

Detergent damaged

Sig. value of AnoVa of ROS for detergent damaged samples was 0.000, which is less than 0.05. Therefore, there is SSD between their means. Table 28 shows Tukey test of ranking of ROS for detergent damage samples. ROS of with-mask samples for 1 and 8 cycles were less than that of without-mask samples. It didn’t vary for 16 cycles, and increased for 24 cycles. Which means that mask has protected hair in most of the cases of washing cycles.

Sig. value of AnoVa of TAC for detergent damaged samples was 0.000, which is less than 0.05. Therefore, there is SSD between their means. Table 29 shows Tukey test of ranking of TAC for detergent damaged samples. TAC of with-mask samples for 8 cycles was more than that of without-mask samples. It didn't vary for 1 cycle, and increased for 16 and 24 cycles, which means that mask has protected hair up to 8 washing cycles.

Table 28. Tukey test of ROS for detergent damaged samples.

Group	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
DN24	15	54.5613					
DM24	15		58.2820				
DM16	15			64.3840			
DN16	15			66.3167			
DM8	15				68.5827		
DM1	15					76.7053	
DN8	15					76.8893	
DN1	15						91.5527
Sig.		1.000	1.000	.135	1.000	1.000	1.000

Table 29. Tukey test of TAC for detergent damaged samples.

Group	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
DM24	15	16.3293						
DN24	15		22.7467					
DM16	15			26.1707				
DN8	15				29.3460			
DN16	15					33.6500		
DM1	15						36.4327	
DN1	15						37.9567	37.9567
DM8	15							38.9707
Sig.		1.000	1.000	1.000	1.000	1.000	.537	.904

CONCLUSIONS

According to the test results, it may be concluded that:

1. Application of mask to raw samples didn't have significant effect on max load, extension at max load, and ROS of the samples. But it reduced TAC of the raw hair.
2. In case of thermal damage, application of mask didn't have any effect on max load and extension at max load, but it decreased ROS and TAC of the samples. The increase in ROS shows that, it protected hair from thermal damage.
3. In the case of UV damage, application of mask didn't have any effect on max load and extension at max load. But, regarding ROS and TAC results, it decreased UV damage in one case and increased it in two cases.
4. Application of mask to dead weight samples increased max load, extension at max load, and improved ROS, and TAC results of the samples. It means that, mask have positive effect on four measured parameters.
5. Application of mask didn't have significant effect on max load and extension at max load of detergent damaged samples, but it improved ROS and TAC results.
6. Finally, it may be concluded that, application of mask could protect hair from the mentioned damages.

REFERENCES

1. Ahmadinik S., 2021. The evaluation of cystine and cysteine amino acids effect on hair structural and biochemical status under thermal, chemical and mechanical stress. PharmD thesis, Islamic Azad University Medical Science.
2. Cao Y., Qu H., Xiong C., Liu C., Zheng L., 2017. A novel method for non-destructive determination of hair photo-induced damage based on multispectral imaging technology. Sci. Rep. 7(1): 1-8.
3. Dias MF., 2015. Hair cosmetics: an overview. Int. J. Trichology. 7(1): 2.
4. Dias MF., de Almeida AM., Cecato PM., Adriano AR., Pichler J., 2014. The shampoo pH can affect the hair: myth or reality? Int. J. Trichology. 6(3): 95.
5. India M., 2003. Effect of mineral oil, sunflower oil, and coconut oil on prevention of hair damage. J. Cosmet. Sci. 54: 175-192.
6. Jeon SY., Pi LQ., Lee WS., 2008. Comparison of hair shaft damage after UVA and UVB irradiation. J. Cosmet. Sci. 59(2): 151-156.
7. Kanedi M, Busman H, Sutyarso S, Farisi S, Mumtazah DF. Essential oil extracted from plant tuber of nutgrass "Cyperus rotundus" effectively decreased sperm quality of mice. J. Adv. Pharm. Educ. Res. 2021;11(2):66-70.
8. Keis K., Huemmer CL., Kamath YK., 2007. Effect of oil films on moisture vapor absorption on human hair. J. Cosmet. Sci. 58(2): 135-145.
9. Wong SY., Lee CC., Ashrafzadeh A., Junit SM., Abrahim N., Hashim OH., 2016. A high-yield two-hour protocol for extraction of human hair shaft proteins. PloS One. 11(10): e0164993.
10. Sisca V, Jamarun N. Biodiesel production from waste cooking oil using catalyst calcium oxide derived of limestone Lintau Buo. Arch. Pharm. Pract. 2019;11(3):8-14.
11. Yu Y., Yang W., Wang B., Meyers MA., 2017. Structure and mechanical behavior of human hair. Mater. Sci. Eng. C 73: 152-163.
12. Zhou Y., Rigoletto R., Koelmel D., Zhang G., Gillece TW., Foltis L., Moore DJ., Qu X., Sun C., 2011. The effect of various cosmetic pretreatments on protecting hair from thermal damage by hot flat ironing. J. Cosmet. Sci. 62(2): 265.