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Comparative evaluation of photo-protective effect of *Aloe vera* Tourn. ex Linn. on UV damage in different Asian hair types

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When exposed to UV radiation, hair undergoes physical and chemical changes leading to several undesirable effects manifested as loss in shine and texture leading to roughness, loss in elasticity leading to breakage and loss in hair colour leading to fading of natural and artificial colour. These changes can be detected through several physical and chemical changes that occur in process. Amongst these amino acid degradation is an important parameter as hair is made of 18 amino acids which contribute to most characteristic properties of hair. There are different types of hair categorized on basis of region (Asian, African, European, etc.), hair colour (blonde, black, brown, etc.), hair thickness, chemical treatment, etc. In the present study, *Aloe vera* Tourn. ex Linn. which is a known skin care herb with multiple benefits was selected to evaluate its photo-protective effect on different Asian hair types through amino acid degradation studies.

Keywords: *Aloe vera*, Amino acids, Asian hair, Photo-protection, UV radiation.

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Introduction

Hair composed of two major morphological components, the outer cuticle and the middle cortex. The cuticle is made of 10-15% of hair shaft and is highly cross-linked with disulphide linkages[1]. The damage to the cuticle results in curving, breaking, or uprooting leading to dull, rough and dry hair which turns brittle[2]. The cortex lies below the cuticle and comprises of about 85-90% of the hair fibre. It contains pigment granules that give hair its colour derived from an amino acid tyrosine[1]. The cortex gives strength and elasticity to hair. The cortical cells control the smoothness and softness of hair[3,4].

The principle protein component of hair is cystine rich keratin which composed of 18 amino acids and contributes to most of the characteristic properties of hair[5]. These are present in cortex and to a lesser amount in cuticle. The cystine amino acid residues bind the protein chains of the cuticle into a network that is physically strong and chemically inert and protects inner regions of hair fibre[2]. These protein molecules are linked by intermolecular bonding i.e. the peptide bonds, salt linkages, disulphide linkages and hydrogen bonds. These bonds maintain the nature and form of hair[1].

UV radiation is absorbed by cystine, tyrosine, phenylalanine and tryptophan residues and possibly some peptide bonds which results in the formation of free radicals[6]. This is because sulphur containing amino acids are sensitive to oxidation[7]. These protein monomers are present in hair in the pure state and *in situ* are photolabile. They give rise to active oxygen species when irradiated which initiates:

(i) A chain reaction propagating free radicals such as singlet oxygen.
(ii) These reactive chemicals also cause chain scission by breaking amide linkage, or can reverse cross-linking by oxidizing disulphides to cysteic acid. The fission occurs at the –C-S-bond in UV-catalyzed cleavage.
(iii) Active oxygen species also react with dye molecules and depolymerise and decolourize melanin granules [8].

Amongst the above amino acids, Tryptophan (Trp.), which is present in cuticle and cortex and decomposes on exposure to UV radiation, is an early indicator of photo damage in human hair[9]. Photo-damage of hair can be controlled by using a UV protecting agent effective on hair fibres. There are

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several synthetic agents which have been investigated for sunscreen activity on hair. However, need for exploring an agent from natural source was thought to be important.

Aloe vera Tourn. ex Linn. (= *Aloe barbadensis* Mill*;* Family Liliaceae)[10] which is a known skin care ingredient was considered for this evaluation based on the reports that both Aloe extracts and aloin from this plant have spectro-photometric peaks at about 297 nm and hence can act as UV absorbers. The aloe extracts have maximum absorption around 294 nm[11]. It has also been reported that Aloin in extract blocks 20 to 30% of Sun's ultraviolet rays hence acts as a sunscreen[10].

The objective of the study was to determine the photo-protective activity of *A. vera* juice on Asian hair namely, Black, Grey and chemically coloured hair. The investigation was based on determining the photo-protecting efficacy as a function of Tryptophan content[9] of hair treated with *A. vera* juice before and after exposure to UV radiation. A comparative study was done using both freshly extracted and marketed juice based on the fact that freshly extracted *A. vera* juice is unstable and has a relatively short shelf-life[10]. Hence, a stabilized processed marketed juice was used as control.

Materials and Methods

Plant material and preparation of extract

The *Aloe vera* leaves were collected from an *Aloe vera* farm (Plate 1) near Nagpur in the month of September-October. The plant was identified and authenticated at the Botany Department, Nagpur University Campus, Nagpur with authentication number 9029 of the herbarium issued.

Leaves were cut transversely from the base and skin scraped off. Fresh juice (AI) was prepared by extracting the gel matrix from leaves and squeezing it to give clear juice. This was then preserved with 0.1% Sodium Benzoate, Citric acid 0.1% and Sodium sulphite 0.04%[(Ref. 11)]. Marketed juice (AII) 'Activaloe' was obtained from a local dealer. ('Activaloe' is a product of Aloecorp, UK.)

Plate 1 — *Aloe vera*

Selection of hair sample

The study was carried out on Asian hair. The hair types selected were Black Hair, Grey Hair treated with Henna and Hair dyed with branded synthetic hair colour. These samples were coded as: Black (virgin)-BH; Chemically coloured (treated with hair colour and washed)-CH; Grey (treated with henna and washed)-GH. The hair samples were collected from ladies between 25-40 years of age. The length of hair samples was about 15 cm and each bunch about 5 g in weight. These samples were pretreated with 10% SLS (Sodium lauryl sulphate) solution and air-dried.

Selection of UV source

Osram Ultra Vitalux 230V-E27/ES, 300W emitting both UVA (320-400 nm) and UVB (300-320 nm) radiation with a Quartz burner and a tungsten filament simulating UV light emitted from the sun during day time was selected as UV source for purpose of uniformity in radiation intensity. It was fixed in a fabricated UV chamber. The UV lamp was calibrated using digital Lux meter[12].

Test protocol

The pretreated hair samples of black, chemically coloured and grey hair were divided into four sets of each hair type and were treated with *Aloe vera* juice (fresh (AI) and marketed (AII) as above. Each set was then mounted on a glass slide. One set of each hair type was left unexposed throughout the entire length of study while another set was loaded in UV chamber for exposure at a distance of 20 cm[14] from the UV lamp.

The hair samples were coded as:

Treated with A I (Fresh Aloe vera juice): Black unexposed (BHU-AI), black exposed (BHE-AI); chemically coloured unexposed (CHU-AI), chemically coloured exposed (CHE-AI); grey unexposed(GHU-AI), grey exposed (GHE-AI).

Treated with A II (Mktd. Aloe vera juice): Black unexposed (BHU-AII), black exposed (BHE-AII); chemically coloured unexposed (CHU-AII), chemically coloured exposed (CHE-AII); grey unexposed (GHU-AII), grey exposed (GHE-AII).

Length of study

The exposure period to UV radiation was a total of 100 h in UV chamber with a daily dose of 4 h under standard humidity and temperature conditions[13]. Throughout the length of study, all the six hair samples were given 4 intermittent treatment applications with sample solutions of 10% SLS solution and *A. vera* juice[13,14].

Tryptophan estimation

The above samples of hair were then analyzed for Tryptophan degradation (content) as follows:

Samples solutions

Approximately 60 mg of hair of each hair type were taken in separate 50 ml volumetric flask respectively. 2ml of 18 N sulphuric acid solution, 1 ml of *p*-dimethylaminobenzaldehyde solution (reagent) in 10% sulphuric acid solution, and 11ml of an 18 N sulphuric acid solution was added to all flasks. The flasks were kept for 2 h at 70°C and after 2 h the hydrolysate was cooled for 2 min in an ice bath.

2 ml of a 0.01 M sodium nitrite solution was added and the flask were filled with 0.03 N sulphuric acid solution. The flasks were kept for another 2 h at 60°C and then cooled to room temp in an ice bath for 2 min. The solution was filtered and after 15 min absorbance was measured at 585 nm using a Shimadzu-UV 160 A photometer.

Control solutions

The results obtained were compared against those of the control solution (the reaction mixture without *p*-dimethylaminobenzaldehyde) taken in another 50 ml volumetric flask. The stability of the formed dyestuff was checked by measuring again after 30 and 45 min.

The Tryptophan content was calculated by using calibration curves obtained from solution of pure Tryptophan in 0.03 N sulphuric acid solution. The Solutions were filtered and after 15 min, the absorbance was measured at about 585 nm in UV spectrophotometer[7]. From the absorbance the amino acid content for BHU-AI, BHE-AI; CHU-AI, CHE-AI; GHU-AI, GHE-AI and BHU-AII, BHE-AII; CHU-AII, CHE-AII; GHU-AII, GHE-AII was determined (Table 1). The percent degradation was then plotted graphically and compared for each hair type.

Results and Discussion

The damage to hair due to UV radiation is both physical and chemical. Physical damage involves loss in mechanical properties and texture, chemical damage mainly leads to degradation of hair tissues (protein). This affects the quality and integrity of hair and in turn the quantity[15,16].

The damage by UV radiation is different for each hair type and is dependent on several factors like thickness of hair, colour and melanin content, etc. The different types of hair namely Black, Grey, chemically treated differ in the pigment content, for example melanin is present in large concentration in black hair where as in grey hair the pigment is almost lost. Hence, the degree of protection offered by a photo protecting agent will also vary[16].

The amino acid (Trptophan) content measurements revealed that hair which was untreated and exposed showed higher degree of chemical damage in terms of amino acid degradation while that treated with *A. vera* juice-both fresh and processed (AI and AII), offered protection from UV damage.

The degradation was minimum in chemically coloured hair i.e. CHE AI followed by CHE AII and maximum in black hair i.e. BHE AII followed by grey hair i.e. GHE AII indicating overall better protection by AI in all hair types (Figs 1 and 2). This

Table 1 — Tryptophan content for black, coloured and grey hair treated with AI and AII before and after exposure

Type of hair/treatment		Amino acid content (g)		% Degradation
		Unexposed	Exposed	
Black	AI	0.21857	0.17393	20.42366
	AII	0.16326	0.089	45.48572
Chemically coloured	AI	0.24073	0.22391	6.98708
	AII	0.21837	0.1737	20.4561
Grey	AI	0.20725	0.17826	13.98793
	AII	0.1626	0.12578	22.64452

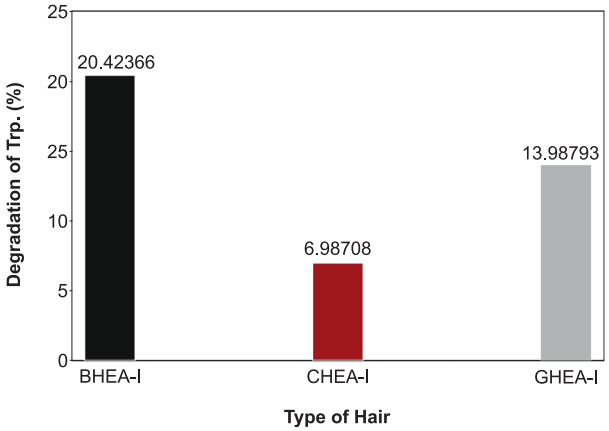

Fig. 1 — Tryptophan degradation of different types of hair treated with AI after exposure

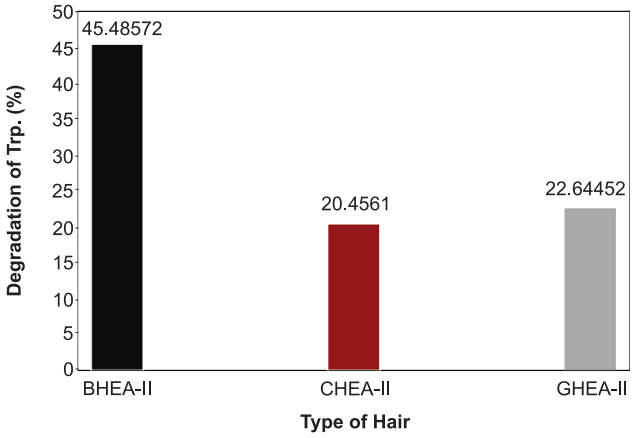

Fig. 2 — Tryptophan degradation of different types of hair treated with AII after exposure

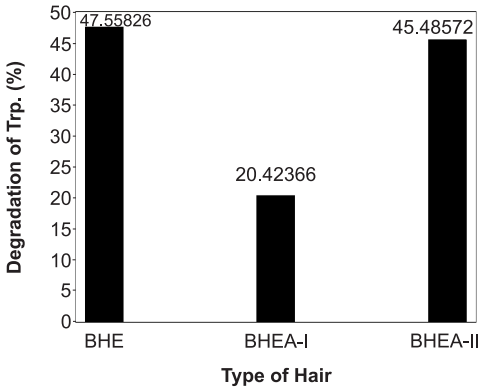

Fig. 3 — Comparative degradation in tryptophan in treated black hair after exposure

was attributed to the Aloin content in fresh juice which has sun blocking ability[10]. The overall better protection in coloured hair could be attributed to the deposition of dye pigments which in turn act as a screen and prevent penetration of radiation to inner layers of hair[9].

In black hair, the amino acid degradation was maximum in BHE AII (processed juice) and protection minimum. This could be attributed to absence of Aloin (which is a UV absorber)[10] in AII. In grey hair also, AI was a better protectant than AII for the same reason. In black hair, the degradation for untreated exposed hair and for that treated with AII was almost equivalent indicating very little protection offered by AII (Fig. 3). In grey hair, the degradation reduced with both AI and AII but was less with AI than with AII indicating better protection with AI (Fig. 4). In chemically coloured hair, the degradation was least compared to black and grey hair and protection offered with AI was better than with AII (Fig. 5).

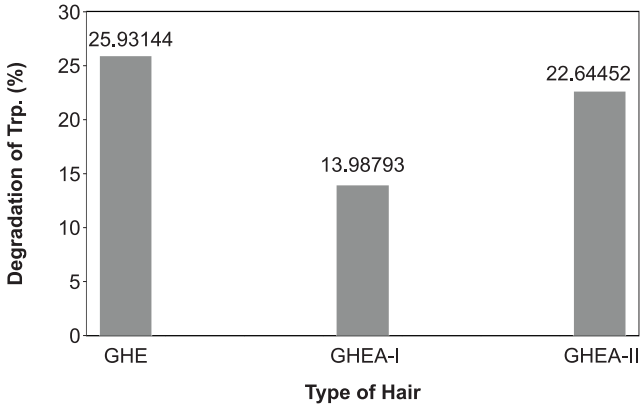

Fig. 4 — Comparative degradation in tryptophan in treated grey hair after exposure

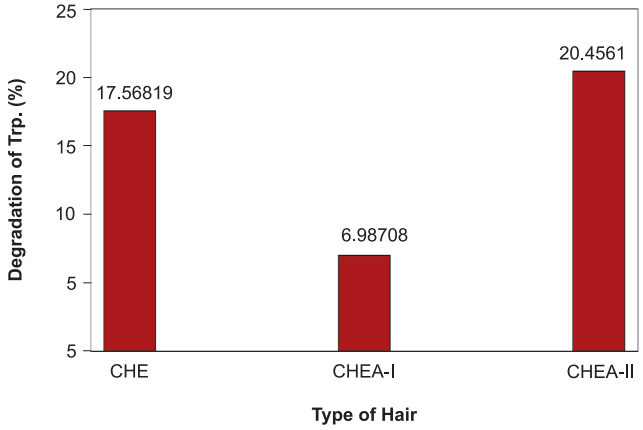

Fig. 5 — Comparative degradation in tryptophan in treated chemically coloured hair after exposure

Conclusion

The protection offered by *A. vera* juice selected for study as a photo protecting agent was satisfactory in all types of hair under consideration, but the degree of protection was different for each hair type.

Thus, it can be concluded that, hair undergoes chemical damage by exposure to UV radiation in terms of amino acid degradation. Both *A. vera* fresh juice and processed juice offer protection in all types of hair under study. The overall protection from damage is more with fresh juice than with processed juice. This may be due to the protective effects of components of fresh juice like resins and polysaccharides which 'condition' the hair along with Aloin in fresh juice which has sun screening properties. The protection offered is maximum in coloured hair followed by grey and black hair due to synergistic effect of hair dye with *A. vera* juice

wherein colour pigments get deposited and serve as a protective screen thus affecting strength and condition of hair.

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