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# Recombinant Human Hair Keratin for Improving Hair Health

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Short Communication

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## ABSTRACT

Conventional chemical hair care products used for treatment of damaged hair and hair straightening are toxic for both human health and environment. Excessive use of chemical hair treatments can produce irreversible damage to hair texture and can lead to hair loss. Keratin is fibrous structural protein, a major building block of hair covering 90% of total hair mass and provides mechanical strength. Keratin treatment has been a growing trend to restore the natural characteristics and youthfulness of hair. Keratin is used in a wide range of hair care formulations, perform many functions, including conditioning, permanent hair straightening, and recovering the health and smoothness of the damaged hair.

## INTRODUCTION

There are several well-known keratin based hair care products in the market for different hair treatments. Industrially, keratin are extracted from various natural sources such as chicken feathers, wools, horns and hooves either in intact or hydrolyzed form for devising commercial hair care products. However, for hair cosmetic application, chicken feathers is considered a preferred keratin extraction source, due to its abundance and economical cost. Due to the toughness of the keratin sources, highly robust chemical methods are used to extract the keratin. These methods include either strong alkali or acid treatments at high temperatures. Alkali treatment has a drastic impact on structural integrity and amino acid composition of the extracted keratin. The keratin from chicken feathers has 15% homology with human hair keratin, while intact keratin from hairs, wools or horns obtained through chemically robust methods have defects in its structural integrity and amino acid composition, which all makes it less favorable to hair binding [1].

## DESCRIPTIVE

The keratin isolated through chemical methods usually exists in the form of peptides rather than intact protein. Various studies have shown that the intact keratin isolated showed improved mechanical strength of the damaged hair as compared to the keratin hydrolysate. Solubility of the keratin is a major concern in isolation and its inclusion in personal care products. Conventionally, the keratin is hydrolyzed into peptides through enzymatic hydrolysis or alkaline treatment. However, the peptides when applied on hair may not provide efficient stability after binding

.Therefore, using the intact keratin in its native form would be ideal to recover damaged profile of the hair protein and provide mechanical strength to the hair. Several studies have reported the application of intact keratin, isolated from keratin sources, in hair cosmetics. These proteins are terms as functional keratin, with compact amino acid composition. However, the flaw in using the intact keratin is its extraction methods that either use formaldehyde or other hazardous chemicals which need extensive refining for their removal, making the product more expensive or put the human health on risk. These chemicals have potential side effects on human health. Formaldehyde is a cancerous compound and also causes allergic reaction on contact with skin [2].

Several hair care products containing keratin was banned in U.S by Oregon OSHA due to excessive formaldehyde levels in the product. Many keratin-based products contain formaldehyde. Due to its chemical nature in the product, manufacturers might list alternative names (methylene glycol, methylene oxide, formalin, methanal, paraform, formic aldehyde, oxymethylene, oxomethane, or CAS Number 50-00-0) for formaldehyde and claim that the product is formaldehyde free, to deceive the consumers.

Keratin are extracted by using reducing or oxidative agent such as thiols and peroxides, respectively, that decreases the stability of keratin fibers and solublize the protein. These chemical agents are toxic to human health, difficult to handle and cannot be recycled. Keratin are also extracted through physiochemical methods by heating keratin source materials (horns, hooves, hairs and feather etc.) with organic solvents such as Dimethylformamide (DMF) and Dimethyl Sulfoxide (DMSO). The proteins are then precipitated with acetone followed by distillation to remove the solvent.Both chemical and physical extraction methods of keratin requires extensive energy investment to remove this hazardous chemicals from the keratin solution [3].

Taken together, we attributed that the keratin isolated from chicken feathers, show less homology with human hair protein, while keratin isolated from other animal sources uses hazardous chemicals which may be toxic for health if not completely removed. The keratin produced through chemical methods are expensive, with health risk and due to less homology with human hair keratin, they may not effectively bind and fill the gaps of the lost keratin from the damaged hair protein profile. The effective way to fill the gaps produced by loss of keratin in damaged hair is by replacing it with the same human keratin lost. A recent study has shown that a human keratin peptides synthesized commercially showed significant recovery of the mechanical properties of severely damaged hair.

Keratin peptides extracted through chemical methods from keratin sources are most commonly used in hair care formulations.Though these peptides easily penetrate through the cuticle of the damages hair and bind the protein building blocks, however, due to non-specificity; they may not fill the gaps completely produced by the loss of intact protein. The nonspecific nature of the peptide may not allow all the peptides in solution to bind with damaged hair, hence increasing the quantity required in the formulation during hair treatment [4].

The non-specific nature of keratin peptides, high production cost and health risks associated with the keratin isolated through physiochemical methods urge the community for alternative methods of keratin production. Recombinant production of human hair keratin would be an ideal method for hair care formulations. The method does not involve any hazardous chemicals and the proteins also retain their amino acid composition and their native structure. This allows the keratin to fill the gaps produced by the intact protein lost during hair damage. The specific nature of the protein, increase the chances of applied protein binding with hair, hence decreasing the required quantity in formulation [5].

## CONCLUSION

Intact human hair keratin K31 in *E. coli*. The gene of K31 was cloned and expressed in *E. coli.* Though the protein expressed in insoluble form but interestingly the yield of expressed keratin K31 was almost 40% of the total *E. coli* protein. Approximately 1.2 g keratin K31 was obtained from 1 liter bacterial culture after 12 hour incubation. The production yield can be enhanced in large scale fermenter. Interestingly, the keratin K31 when refolded, were almost >85% purified, which does not need additional purification steps. This also reduced the overall cost of its production. The k31 when applied on damaged hair showed significant improvement in hair thickness, hair tensile strength as well as surface smoothness. The K31 would integrate into the hair intermediate filament protein by making disulfide bonds with the damaged keratin, filling the gaps and rebuilding the damaged hair protein profile, resulting in increased mechanical strength and recovery of the damaged hair properties. This was the first time recombinantly produced human hair keratin applied on damaged hair and showed damaged hair health improvements. The protein K31 was selected based on the previous study, conducted on proteome analysis of the damaged hair, where K31 was found as mainly lost from damaged hair. Keratin k31 has > 95% identity with other human hair keratin types. Homology of k31 with other hair keratin can compensate the loss of other keratin, making it more effective in hair improvement.

We concluded that recombinant production of human keratin is economical, nonhazardous and highly efficient for hair care formulations due to its specificity and native state. It will be interesting to produce other human hair keratin i.e. acidic keratin K34-39 and basic keratin K81-86 in *E. coli* and analyze their combine effect when applied on damaged hair. The cocktail of such recombinant keratin can add more improvement to hair health.

## CONFLICT OF INTEREST

The authors state no conflict of interest.

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