NEW INSIGHTS INTO KONJAC GLUCOMANNAN AS A BARRIER AGENT AGAINST AROMATIC AMINES IN HAIR DYES: EVALUATION OF ITS PROTECTIVE MECHANISMS AND EFFICACY IN REDUCING SCALP IRRITATION AND SENSITIVITY

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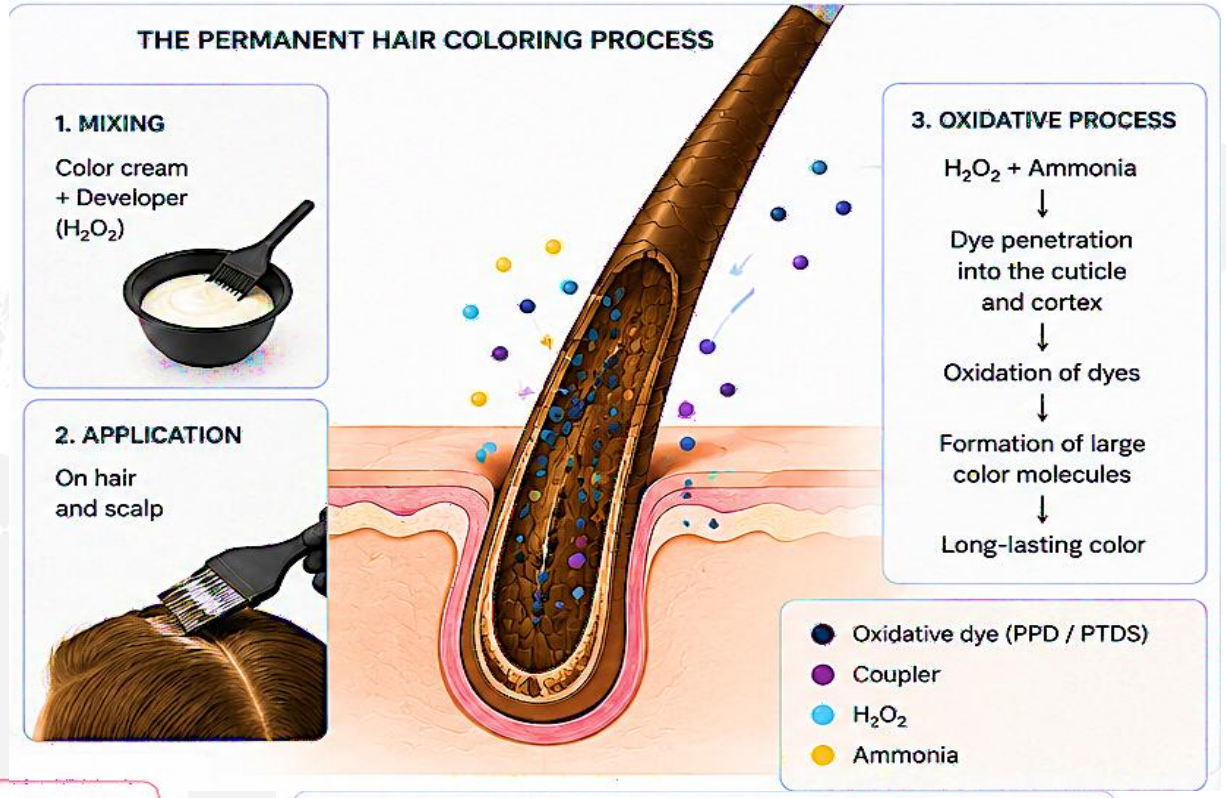
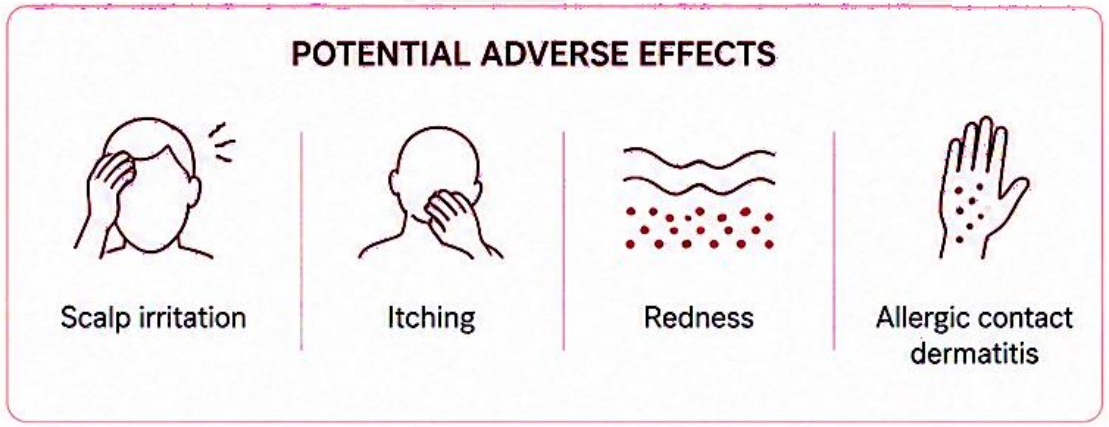
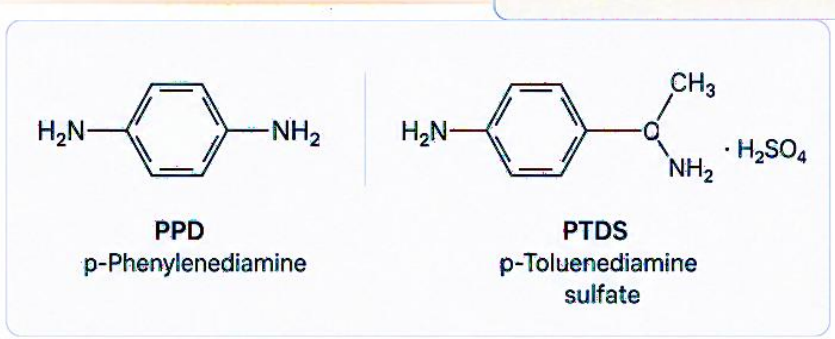
Permanent Hair Dyes:
Benefits and Challenges

- ✓ Long-lasting coloration
- ✓ Effective grey hair coverage
- ✓ Based on oxidative chemistry
- ✓ Contain aromatic amines such as PPD and PTDS







WHY KONJAC GLUCOMANNAN?

Konjac Glucomannan (KG) is a natural polysaccharide with unique structural and functional properties.

✓ **NATURAL POLYSACCHARIDE**
Biodegradable, non-toxic, and biocompatible.

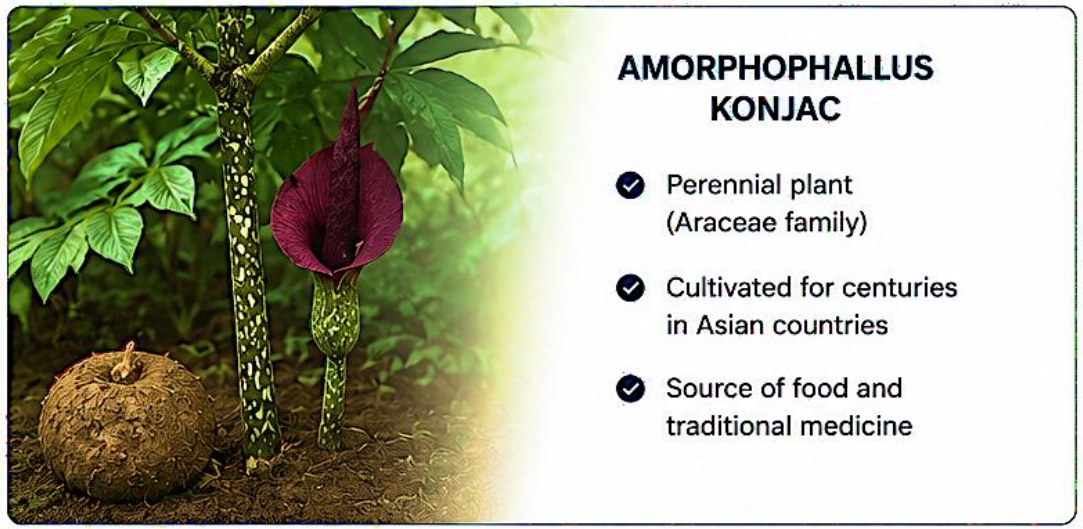
✓ **DERIVED FROM AMORPHOPHALLUS KONJAC**
Extracted from the tubers of the konjac plant, widely cultivated in Asia.

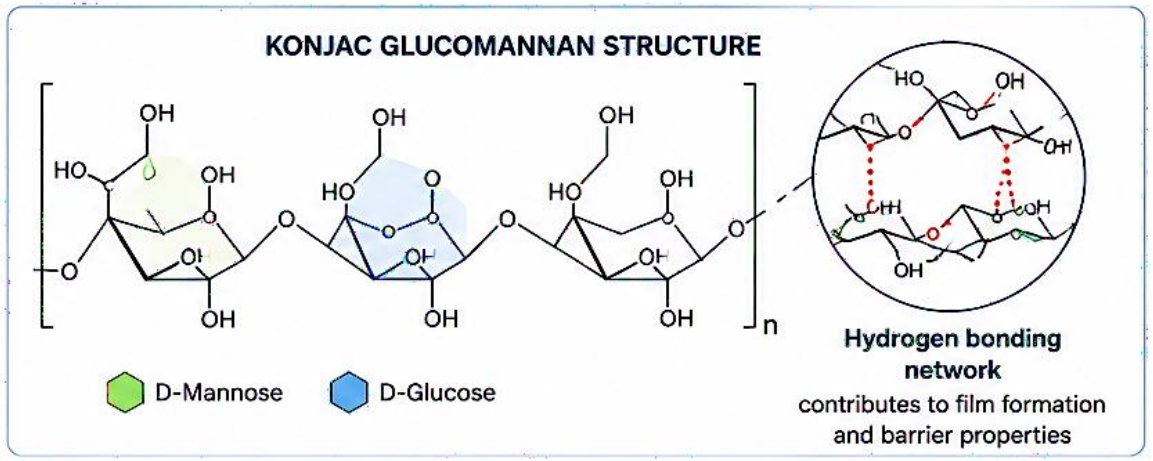
✓ **RICH IN HYDROXYL AND CARBONYL GROUPS**
Abundant functional groups enable strong interactions with water and other molecules.

✓ **EXCELLENT FILM-FORMING PROPERTIES**
Forms coherent, flexible and transparent films on surfaces.

✓ **ABILITY TO CREATE HYDROGEN BONDS**
Forms extensive hydrogen-bond networks with water and macromolecules.

✓ **POTENTIAL PROTECTIVE BARRIER EFFECT**
May reduce the permeation of aromatic amines and help protect the scalp.





Thanks to its structure and film-forming ability, Konjac Glucomannan is a promising candidate for reducing scalp irritation during hair coloring

AIM OF THE STUDY

Objectives

To evaluate the efficacy of Konjac Glucomannan in hair dye formulations for:

- ✓ Reducing aromatic amine permeation
- ✓ Mitigating scalp irritation
- ✓ Improving skin comfort
- ✓ Preserving hair color performance

MATERIALS & METHODS

I. HAIR COLOR FORMULATION

- Base formulation**:** Water, Cetearyl Alcohol (emulsifier), Cocamide MEA (thickener), Decyl Oleate (oil phase).
- *Cetearyl Alcohol and Cocamide MEA were used in different ratio (3:1; 2:1;* ***1:1****; 1.5:1; 1:1,5; 1:2) in order to obtain a good structure*
- *Decyl Oleate was included to increase hydration and tested in different ratios from 1:1:1/2 to 1:1:1*
- Four oxidative hair color were developed using primary intermediates and couplers: *Black, Brown, Red, Blonde*
- For each shade, three different formulas were developed by varying the percentages of the hair dyes.
- Konjac Glucomannan was added to each shade formulation at concentration of 0.25% or 0.5%.

I. FORMULATION DEVELOPMENT

Oxidative Hair Color Emulsion – Formulation

INCI Name	% w/w	Function
Water	q.s. to 100	Solvent
Cetearyl Alcohol	5.0 – 15.0	Emulsifier / structurant
Cocamide MEA	7.5 – 15.0	Thickening agent / co-emulsifier
Decyl Oleate	5.0 – 10.0	Emollient
Propylene Glycol	5.0	Solubilizer / humectant
Ammonium Hydroxide (30%)	5.0	Alkalizing agent
Oxidative Hair Dyes (primary intermediates + couplers)	0.5 – 5.0	Colorant agents
Ascorbic Acid	0.2	Antioxidant
Sodium Hydrosulfite	0.3	Antioxidant / reducing agent
Konjac Glucomannan	0.25 – 0.5	Film-forming / conditioning agent

I. FORMULATION DEVELOPMENT

Composition of Oxidative Dye Precursors (Primary Intermediates & Couplers)

Shade	Sub-shade	PPD	RES	2MR	MAP	HPS
Black	1	1.0	1.0	–	–	–
Black	2	0.5	1.0	–	–	–
Black	3	1.5	1.0	–	–	–
Brown	1	0.75	–	0.75	–	–
Brown	2	0.5	–	0.75	–	–
Brown	3	1.0	–	0.75	–	–
Red	1	–	–	–	0.75	0.25
Red	2	–	–	–	0.5	0.25
Red	3	–	–	–	1.0	0.25
Blond	1	–	0.3	–	–	0.3
Blond	2	–	0.15	–	–	0.3
Blond	3	–	0.45	–	–	0.3

Application test:

Hair color + H_2O_2 (20 vol)
Mixing ratio: 1:1
Hair type: yak
Development time: 30’

Legenda:

PPD = p-Phenylened
RES = Resorcinol
2MR = 2-Methylresorcinol
MAP = m-Aminophenol
HPS = 1-Hydroxyethyl-4,5-Diamino Pyrazole Sulfate

II. IN VITRO PERMEATION STUDY

EXPERIMENTAL SETUP

- **Franz diffusion cells** (Microette Plus, 6 cells)
- Diffusion area: 1.77 cm2
- Membrane: synthetic lipophilic
- Receptor medium: T80 1% (w/w) in water

TEST FORMULATIONS

- **Reference oxidative dye formulation (aromatic amines)**
- **Same formulation + 0.5% Konjac Glucomannan**

PROTOCOL

- Sample amount: **~200 mg per cell**
- Receptor volume: 7 mL
- Temperature: 32 ± 1 °C
- Stirring: 600 rpm
- Experiments performed in triplicate (n = 3)

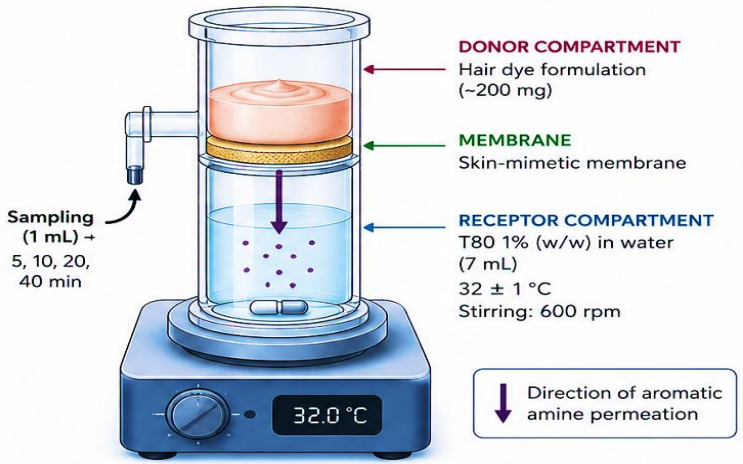
SAMPLING

- Aliquots of 1 mL withdrawn at predetermined times: **5, 10, 20 and 40 minutes**
- Replaced with the same volume of receptor medium to maintain sink conditions

ANALYTICAL METHOD

- Aromatic amines in receptor fluid quantified by HPLC with UV detection at 262 nm
- Cumulative permeation expressed as % of applied dose

***Endpoint*: Reduction in skin permeation of aromatic amines comparing reference formulation vs. formulation + 0.5% KG**



III. IN VIVO STUDIES

Scalp irritation and discomfort evaluation

- Scalp irritation and discomfort (itching, burning) were evaluated
- Assessments were performed during and after application
- In vivo study conducted on **26 models**
- A total of **54 applications** were performed
- **12 different shades** were tested
- All formulations contained **0.5% KG**

RESULTS

I. FORMULATION DEVELOPMENT

- Increasing the percentage of primarily hair dyes (PPD, PMS, HPS) the color resulted more intensive. And increasing the percentage of secondarily hair dyes (RES, 2MR, MAP) the nuance of the color changed.

Figure 1. Four hair color shades (Black, Brown, Red, and Blonde) formulations using primary intermediates (P-Phenylenediamine, 4-Methylaminophenol Sulfate, 1-Hydroxyethyl-4,5-Diamino Pyrazole Sulfate) and couplers (Resorcinol, 2-Methylresorcinol, m-Aminophenol) by varying dye percentages (without Konjac Glucomannan). Parameters: dilution 1:1, 20 volume, temp 30°C for 30 minutes on yak hair.

RESULTS

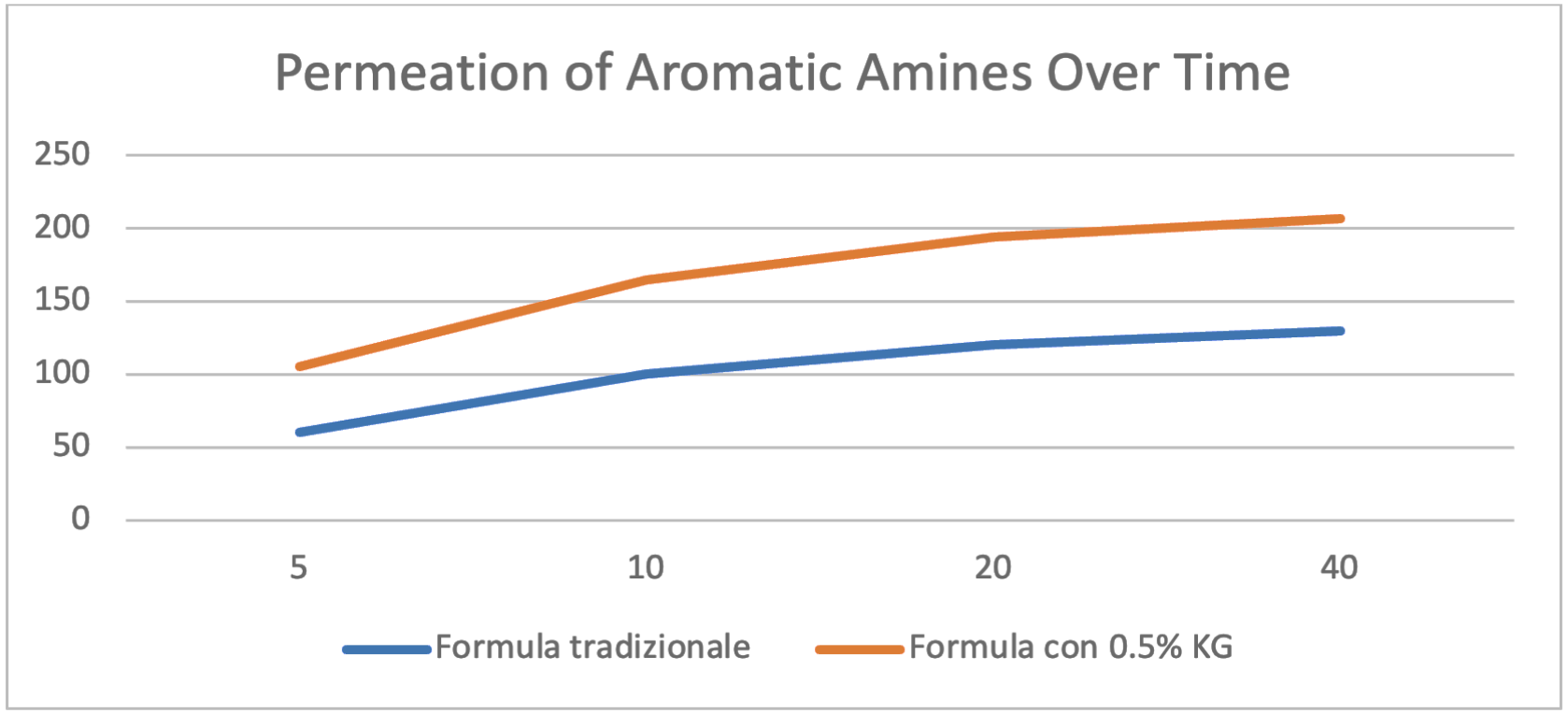
I. FORMULATION DEVELOPMENT

- Using 0.5% of active KG didn't affect the color or nuance.
- Konjac Glucomannan at 0.5% preserved color integrity and enhanced luminosity, with 0.25% showing no additional benefits.

➡ *It's recommended to use Konjac Glucomannan at a concentration of 0.5%.*

Figure 2. The tests using different percentage of KG so 0.25% and 0,5%.

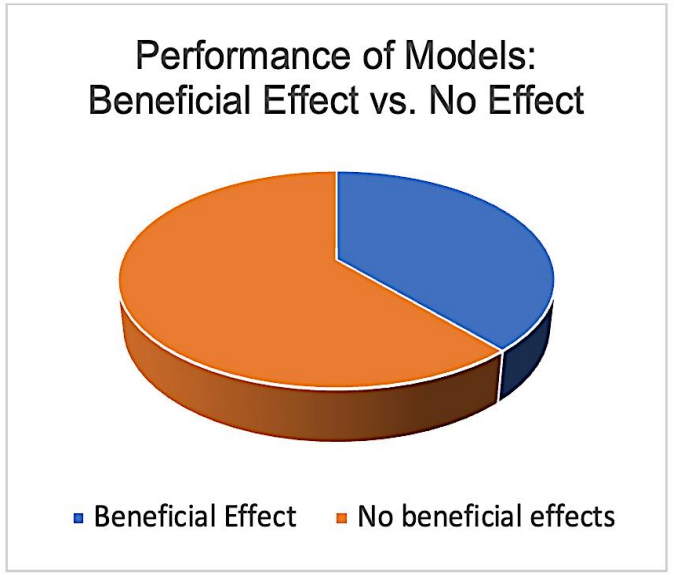
II. IN VITRO PERMEATION STUDY

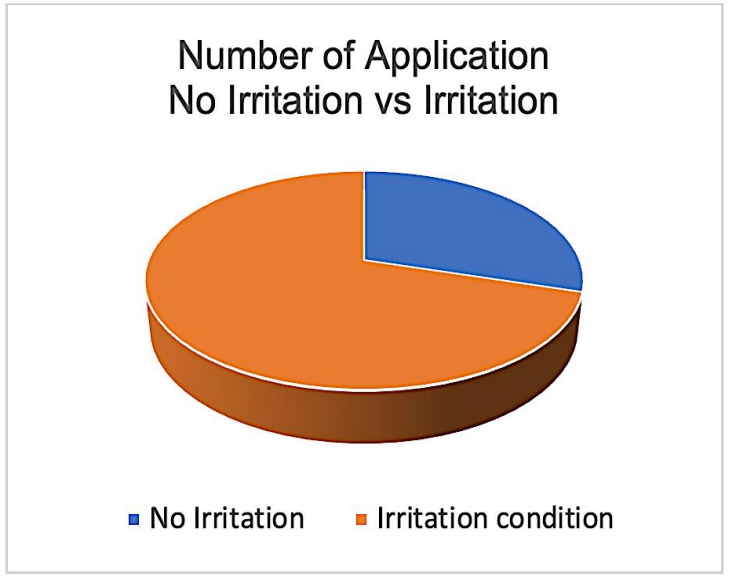


In vitro test showed that 0.5% KG reduced skin permeation of aromatic amines, in particular p-phenylenediamine, by more than 40% compared to the standard formulation.

III. IN VIVO STUDIES

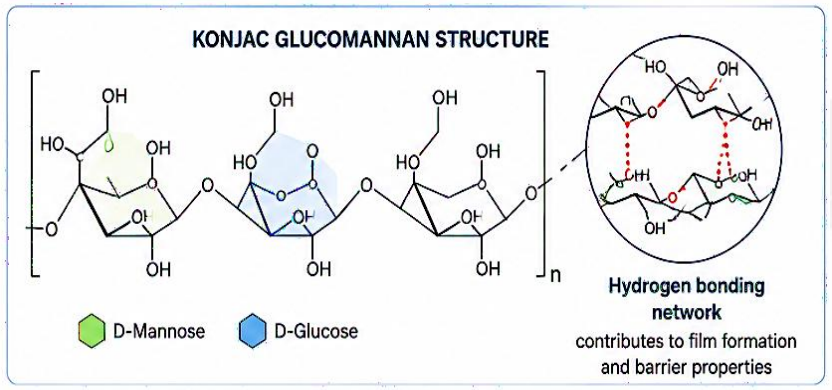
- *A reduction in scalp irritation and discomfort associated with hair dye application.*
- *Formulations containing 0.5% KG showed good tolerability in 40% of the models.*
- *30% of the models reported improvements in scalp irritation and discomfort during application.*





DISCUSSION

- ✓ The reduction of aromatic amine penetration by KG is likely related to its chemical structure.
- ✓ KG consists of randomly linked β-1,4 α-mannose and α-glucose units, which may form a barrier on the hair keratin structure.
- ✓ The high content of hydroxyl and carbonyl groups enables hydrogen bonding and van der Waals interactions.
- ✓ These interactions occur with amino and carboxylic groups in keratin, promoting barrier formation.
- ✓ The resulting barrier may limit aromatic amine penetration into the hair fiber.



Konjac Glucomannan (KG)
β-1,4 Mannose & α- Glucose Units
Hydroxyl & Carbonyl Groups
↓
(Hydrogen Bonding+ v. d. Waals Interactions)
↓
Interaction with Keratin
(Amino and Carboxylic Groups)
↓
Protective Barrier
↓
Reduced Aromatic Amine Penetration

CONCLUSIONS

- ✓ Konjac Glucomannan (KG) is a promising natural ingredient for reducing aromatic amine penetration.
- ✓ It provides a sustainable approach to safer hair dye formulations while maintaining high coloring performance.
- ✓ The use of **0.5% KG** preserves color integrity and enhances hair luminosity.
- ✓ **0.25% KG** showed no additional benefits.
- ✓ Further studies could investigate additional polysaccharide-based protective mechanisms and broader applications in hair care formulations.

THANK YOU FOR YOUR ATTENTION

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CEO & Founder

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