A PROJECT WORK

ON

"Waste to Wealth: Human Hair Perspective"

PAPER ZOO496B

SUBMITTED BY

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ROLL - PG/VUEGS08/ZOO-IVS, NO-0001

Registration no-1081630 (2018-19)

FOR PARTIAL FULFILLMENT OF M.SC, SEMESTER IV IN ZOOLOGY

EGRA SSB COLLEGE, VIDYASAGAR UNIVERSITY

UNDER THE SUPERVISION

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CERTIFICATE OF COMPLETION OF PROJECT WORK

This is to certify that Miss. Ananya Das a student of the MSc IV Semester Zoology program at Egra Sarada Shashi Bhusan College, has successfully completed her project work entitled "Waste to wealth: Human hair perspective" under my supervision.

During his MSc in Zoology program, Miss. Ananya Das displayed exemplary dedication, diligence, and passion for the subject matter. Throughout the duration of the project, she exhibited strong research skills, critical thinking abilities, and demonstrated a comprehensive understanding of the concepts and theories relevant to the field of Zoology.

Her project work showcased originality and intellectual curiosity, as she conducted an in-depth analysis of the subject matter. Miss. Ananya Das demonstrated exceptional competence in the design, execution, and data analysis of his research, highlighting his strong grasp of scientific methodologies.

Her commitment to the project was commendable, and she displayed exceptional time management and organizational skills in completing the project within the designated timeframe.

Based on her impressive performance, I have no doubt that Miss. Ananya Das will make significant contributions to the field of Zoology in the future.

I, therefore, recommend and endorse her project work for the fulfillment of her MSc in Zoology. I wish her all the best for her future endeavors.

Congratulations, Miss. Ananya Das on this remarkable achievement!

Sincerely,

Declaration

I hereby declare that this dissertation entitled "WASTE TO WEALTH: HUMAN HAIR PERSPECTIVE" was carried out by me for the degree of M.Sc in Zoology, under the supervisions of “Dr. Dipak kr. Tamili”, Hon’ble Pricipal; “Dr. Sudipta Kumar Ghorai”, Associate Professor, PG department of Zoology, “Dr. Nirmal Kr. Hazra” Associate Professor, Department of chemistry, Egra SSB College.

The interpretation put forth are based on my reading and understanding of the original texts and they are not published anywhere in the form of books, monographs or articles. The other books, articles and websites, which I have made use of are acknowledged at the respective place in the text for the present work, which I am submitting to the Egra SSB college under Vidyasagar University, no degree or diploma or distinction has been conferred on me before, either in this or in any other University/Institute.

Place: Egra

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Acknowledgement

I would like to express my deep and sincere gratitude to my supervisors, “Dr. Dipak kr. Tamili”, Hon’ble Pricipal; “Dr. Sudipta Kumar Ghorai”, Associate Professor, PG department of Zoology, “Dr. Nirmal Kr. Hazra” Associate Professor, Department of chemistry, Egra SSB College, for giving me the opportunity to do the project work and providing his invaluable guidance throughout the duration of my dissertation work. It was a great privilege and honor to study under his guidance.

I am extremely grateful for the opportunity and support provided to me by Dr. Dipak Kumar Tamili, Principal, Egra SSB College and Mr. Debajyoti Pradhan, Assistant Professor, PG Department of Zoology, Egra SSB College. No word can express my sense of gratitude to all teachers for their constant guidance, inspiration and support during my preparation.

Finally I would like to thanks my parents and my friends for generosity with which they have accepted to shoulder their burden of hectic schedule during the work and extended their best possible cooperation so that I could devote myself to the project work.

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ABSTRACT:

There are significant challenges associated with the management and disposal of waste materials. In a world with increasing environmental pollution, the concept of "waste to wealth" plays a crucial role in sustainable development. One such perspective is the conversion of waste into valuable resource such as cystine, creates opportunities for sustainable development. In this study, a particular emphasis is placed on the untapped potential of human hair as a resource that is transformed into wealth. Every day, lots of people visit the salon to get haircut to look manageable. Human hair is considered a waste material all over the world, and it is frequently discarded without considering its immense potential. Ultimately, those hairs accumulate in soil, pipelines, and drains and pollute the environment in several ways. This hair accumulates in the soil and prevents water from entering deep into the soil. It also doesn't allow sunlight to enter the soil properly. In this way, human hair reduces soil fertility and thus also affects agricultural yield. This discarded hair accumulates in the drain and creates obstacles in the water flow. Overflowing water from several drains results in flooding and thus causes environmental pollution. This hairs are thrown away in nature, where it slowly decomposes over several years. That's why the idea came across to convert this waste hair into valuable resource like L-cystine. Several uses for cysteine are found in the pharmaceutical industry, food industry, cosmetics, and many others. As the idea illustrates, "waste to wealth" has the potential to create employment and thus empower youth. The collection and processing of human hair can provide employment opportunities for youth. An economic, environmental, and social benefit can be generated by using this method. Through a sample study by visiting 13 hair salons, it was known that every year 3600 kilogram of human hair is discarded as trash, the price of which is approximately 216000. This shows the importance to manage the waste to keep environment pollution free and at the same time it also promotes economic growth. This makes us think to recognize human hair as a valuable resource rather than a waste. By adopting waste-to-wealth practices, we can unlock their potential for economic growth and environmental sustainability.

Key Words: Human hair, pollution, waste management, waste to wealth, cystine.

INTRODUCTION

Human hair is considered useless in most parts of the world and therefore is found in the municipal waste, streams in almost all over the world (Gupta, 2014). In rural areas with low population density, this hair is thrown away in nature where it slowly decomposes over years. In urban areas it often accumulates in streams and results in eutrophication and flooding (Gupta, 2014). Millions of tons of hair are discarded annually worldwide from every barber shops. Accumulation of this discarded hair in soil prevents the entry of sunlight and water, thus reduces soil fertility. Human hair, once discarded as trash from several barber shops, can be reused in several ways as it has its own unique characteristics. Hair has high tensile strength due to the presence of alpha keratin. Keratin is tough and fibrous protein being the main component of human hair, is the third most abundant polymer present in environment after cellulose and chitin polymers. The keratin present in hair is called hard keratin and composed of 16 amino acids (De et al., 2008). The type of keratin present in human hair is type 1 that is water resilient and acidic in nature (Duperray et al.,2022). In water it has low chemical reactivity but in presence of reducing agent and high heat its solubility increases. Approximately 91% of the hair is protein made up of amino acids, of which most abundant is cysteine (De et al., 2008). Keratin is stabilized by forming several disulfide bonds and is thus rich in a huge number of cystine. Cysteine is the only amino acid that can undergo oxidation to form cystine. Keratin was hydrolyzed to collect these cysteine amino acids by using HCl (Gortner and Hoffman, 2003). Cysteine is a polar, uncharged and non-essential amino acid that is synthesized in the body from the essential amino acid methionine (Clemente et al., 2018). Cysteine is used in medicine production and has several important roles in human body, food, cosmetics (Clemente et al., 2018). Cysteine is also produced from other sources including hog hair, duck feathers and wool (Giteru et al.,2023). Human hair is more effective at producing cysteine than other sources. The burning of this discarded hair is common in several parts of the world, but this process releases toxic gases like carbonyl sulfide, ammonia, hydrogen sulfide, sulfur dioxides, nitriles, phenols, and pyridine. These highly toxic gases gradually cause air pollution and also have harmful effects on human health. These harmful gases cause respiratory infections leads to difficulties in breathing. That's why proper management of those thrown hair is required to keep the environment pollution-free. The purpose of this project is to reduce the negative environmental impacts associated with human hair and by extracting cystine, it also promotes economic growth.

AIMS AND OBJECTIVES

The primary objectives of this project are:

1. Waste management and environmental sustainability to keep environment pollution free.
2. Provide employment and empower individuals by transforming human hair – a waste into profitable L-Cystine and its derivatives.
3. Raise awareness among youth society about reutilization of waste material – human hair to reduce pollution.
4. Extraction of L-Cystine from human hair - a waste material that can be used in a variety of applications, including foods, cosmetics, medicine, and pharmaceuticals.

REVIEW OF LITERATURE

In this study, cysteine was extracted using several processes: Keratin hydrolysate, Enzymatic bioconversion, and Fermentation to meet the requirements of legislation, especially in the pharmaceutical and food industries (Ismail et al., 2014).

The purpose of this research was to demonstrate how to extract L-cystine from human hair using acid treatment (HCl). Keratins are only common protein that has abundant cystine to serve as a source for this amino acid (Gortner and Hoffman,2003).

In this study, cystine was isolated from human hair using KOH and the crude extract was analyzed for effects on frog heart muscles and hepatoprotective activity in mice (De et al.,2008).

This project focused on quantitative estimation of cystine and cysteine by using amalgam-cyanide procedure in chromogenic value (Sullivan et al., 1942).

This research showed role of cysteine in neutrophil where glutathione (GSH) plays an important role in protecting neutrophils against ROS mediated oxidative injury (Sakakura et al., 2007).

This project focused on hydrolysis of sheep wool into edible keratin-making it an outstanding potential source of protein for food and biotechnological application. Sheep wool is an inexpensive and readily available resource containing 95%-98% protein (Giteru et al., 2023).

This study showed human hair is considered a waste material in most parts of the world and its accumulation in waste streams causes many environmental pollution. This study shows that human hair is a highly versatile material that can be used in agriculture, medical applications, construction materials, and pollution control (Gupta,2014).

This project showed a reliable method for complete isolation of L-Cystine from sheep wool by keratin hydrolysis. Sheep wool is rich in sulfur due to presence of keratin that contains several thiol group in the side chain of cystine (Toennies and Bennett, 1935).

This study focused on oral supplementation of L-Cystine associated with L-Glutathione that has a potential skin-lightening ingredient due to presence of anti-melanogenic properties (Duperray et al., 2022).

This project showed that in the presence of riboflavin a mixture of L-cysteine and L-cystine were exposed to sunlight for photolysis to develope the flavor of cooked rice (Obata and Tanka, 1965).

This project showed several usage of L-cysteine as a part of drug formulas, nutrition, cosmetics, antioxidant power, regulation of the mucolytic function, strengthening of the hair, induction of immune response, protection and detoxification of the live (Clemente et al.,2018).

This study showed a process of enzymatic reduction of L-cystine into L-cysteine by cell free extract of Clostridium thermoaceticum in the presence of hydrogen and methyl viologen (Nishio et al., 1991).

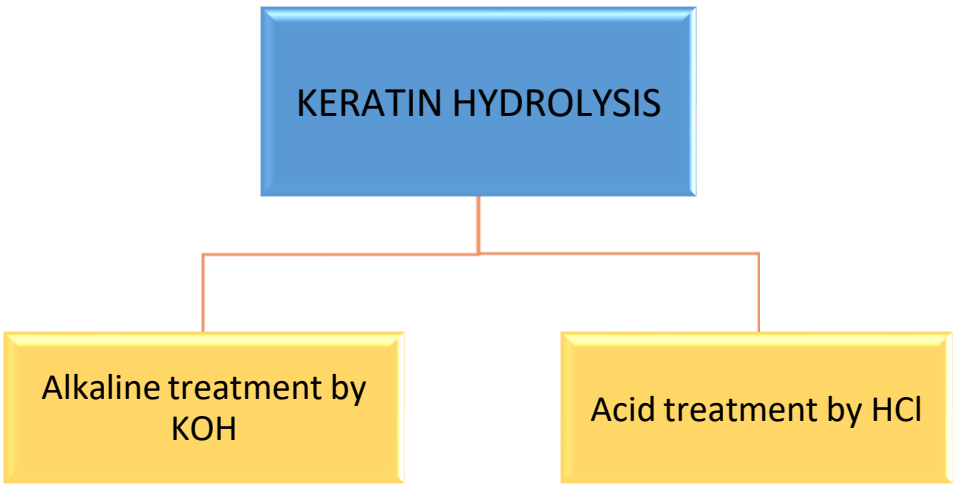
This research showed that easily available chopped human hair was used as fibers in the production of concrete to reduce the development of microcracks and pores and increases durability so that it can tolerate tension (Manjunatha et al., 2021).

METHODS AND MATE

METHODOLOGY

Extraction (Keratin hydrolysate):

Cystine was extracted by hydrolyzing alpha keratin structures of human hair. So there are two processes-



1. Hydrolysis by Alkaline Method:

In a round-bottom flask, 50 grams of dried, chopped human hair were added to 300 ml of 5% potassium hydroxide (KOH). Then the mixture was warmed for 5–10 minutes and left for 24 hours for keratin hydrolysis. During this time, all disulfide bonds were broken down into cysteine and cystine. The next day, the hydrolysate was treated with 7 grams of activated charcoal and then filtered with the help of a Buchner funnel. Then 1 N HCl was added dropwise with shaking to the filtrate until a white precipitate appeared. This precipitated compound was filtered, and the residues were washed with warm water followed by an ethanol and ether wash. Then the crude product was collected and kept in a vacuum (De et al., 2008).

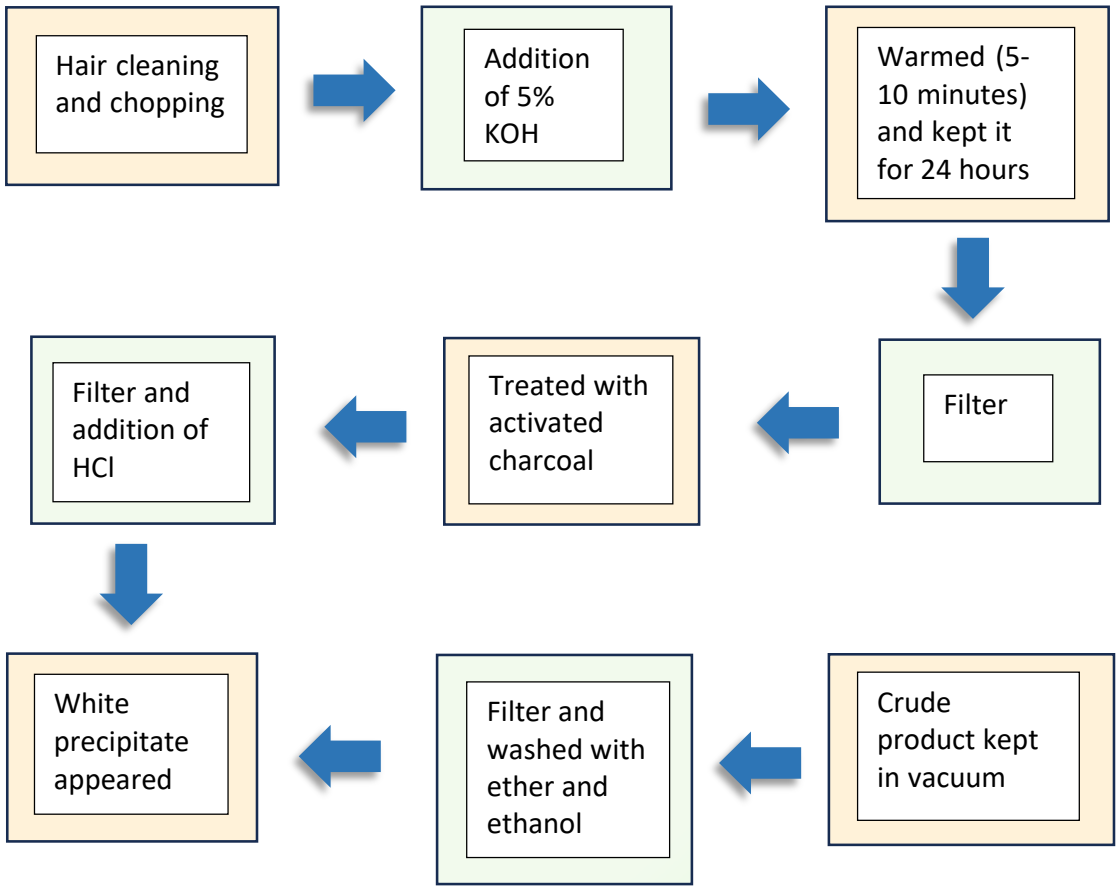


FIG 1: Flowchart of keratin hydrolysis by alkaline method

Demerits:

I obtained a polymerized product that has a rubber-like texture and is not transparent. The yield of cystine was absent in this process.

Fig 2: A: Filtration apparatus, B: Hair in KOH Solution, C: Polymerized Product

2. Hydrolysis by Acid Method (HCl):

Keratin was hydrolyzed by adding hydrochloric acid to a round-bottomed pyrex flask under high heat. Under the influence of a high heating process, extensive disulfide cross-linkages of keratin were first broken, which destabilized the intermediate filament (IF) structure. This destabilized structure easily undergo the denaturation process, where the peptide bonds were degraded. During the hydrolysis process, amino acids undergo partial or complete digestion. During the process of heating, amino acid polymers were broken down into several peptides (dipeptides, tripeptides, tetrapeptides, pentapeptides, hexapeptides, and heptapeptides). When amino acid residues were broken into free amino acids or dipeptides, this process liberated an abundant amount of cysteine in the reaction mixture that was isolated by several steps (Gortner and Hoffman, 2003).

Procedure

a. Sample cleaning:

100 grams of human hair was taken and then washed it properly with shampoo to remove dust, dirt, and oil from the hair. This process was repeated at least twice to remove all dirt, and then air dried in a newspaper bag for seven days in bright sunlight.

b. Chopping:

50 grams of dried human hair were taken from the sample with the help of a digital weighing machine. Then the hair was chopped finely in a paper bag with the help of a sharp scissor.

c. Treatment with HCl:

Chopped human hair was taken into a round-bottomed pyrex flask, and 150 ml of hydrochloric acid (HCl) (54 ml HCl + 46 ml H_20 = 100 ml) was added. An air-cooled reflux condenser containing a wide glass tube was attached to the flask.

d. Water bath:

The keratin of hair was hydrolyzed by heating it in a water bath for one hundred twenty to one hundred thirty hours. This process was time-consuming and hydrolyzed the keratin until the biuret reaction was completely negative (absence of copper-coordinated complex).

e. Hydrolysis and filter:

After the hydrolysis of alpha keratin into dipeptides (two amino acids joined by a single peptide bond) or single amino acids, the mixture was filtered with the help of a Buchner funnel. The Buchner funnel was used exclusively for vacuum filtration. The insoluble residue on the filter paper was washed with distilled water.

f. Neutralization with NaOH:

The total filtrate in the side-arm flask was taken into a beaker and was partially neutralized by adding 40% sodium hydroxide (NaOH). 100 ml of NaOH solution was added to the beaker and then the solution was well stirred with the help of a stir rod, and then the solution was cooled.

g. Saturation:

Then a saturated solution was made by adding 93.75 grams of crystallized sodium acetate in the beaker until the congo red test for mineral acid was entirely negative. Care was taken not to make the solution alkaline with sodium hydroxide.

h. Precipitation:

The beaker was covered with filter paper and then the entire solution was kept in a beaker at room temperature for three days (70–72 hours). After three days, the cystine was precipitated at the bottom of the beaker.

i. Decolourization:

The solution was filtered via a Buchner funnel, and all cystine-containing residue from filter paper was collected. The solution was kept in a beaker, and 7 grams of decolorizing carbon (activated charcoal) and 100 ml of distilled water were added.

j. Extraction of cystine:

Then the mixture was boiled for 7–10 minutes and filtered with the help of a Buchner funnel. Then the filtrate was kept overnight. The filtrate was clear after adding decolorizer. The cystine was precipitated from a clear solution. Through this process, the typical colourless hexagonal plates of cystine was obtained in powder form.

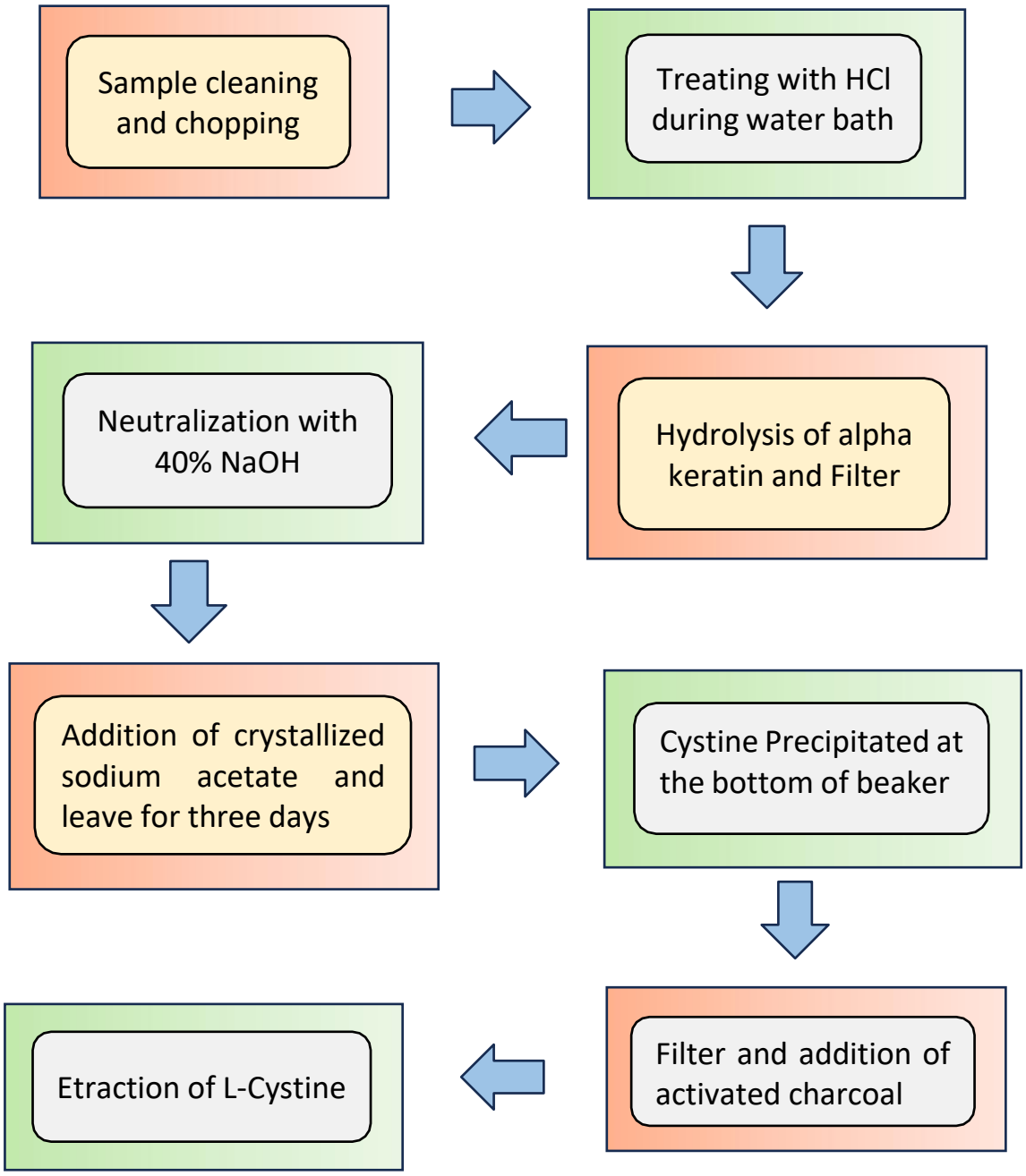


Fig 3: Flow chart of L-Cysteine extraction by HCl treatment

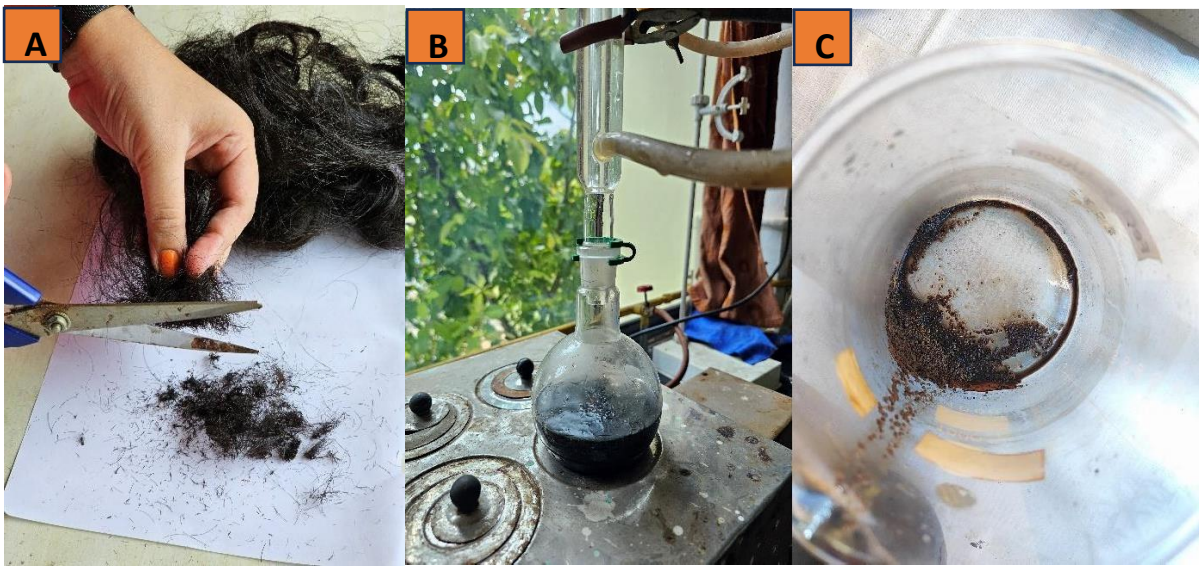


FIG 4: A: Chopped hair, B: Water bath process, C: Insoluble residues

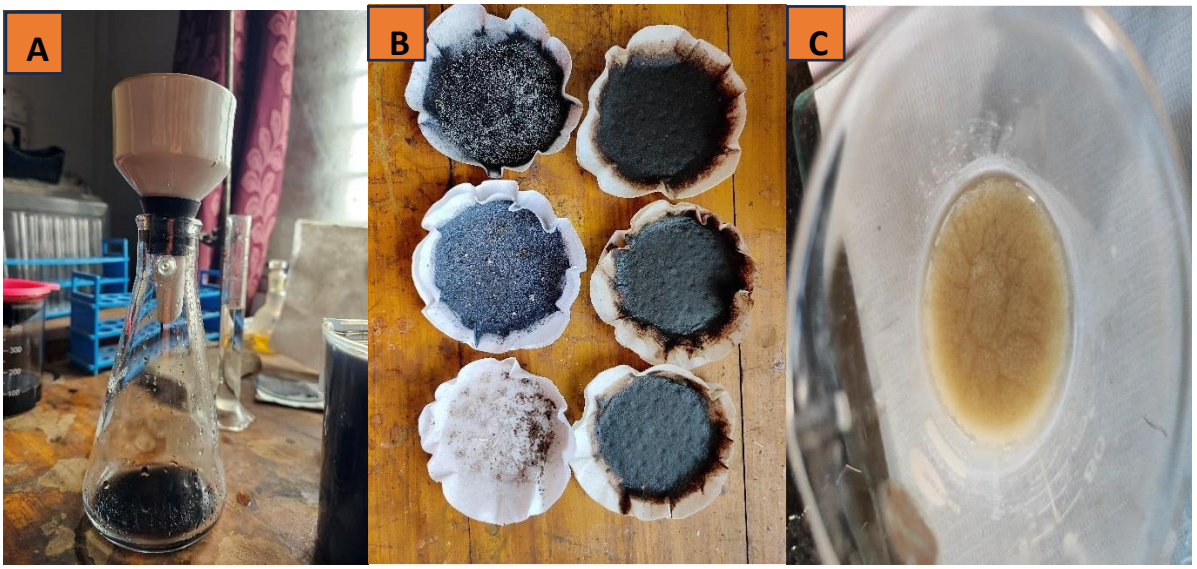


FIG 5: A: Buchner funnel, B: Cysteine on filter paper (Small crystal), C: Cysteine precipitated in clear solution.

MATERIALS OF ACID TREATMENT

Round bottom flask, Glass rod, Beaker, Steamer, Buchner funnel, Filter paper, Test tube, Vacuum apparatus, Digital weighing machine, HCL, NaOH, Sodium acetate, Activated charcoal, Distilled water.

Confirmation of structure:

1. **Determination of molecular mass of isolated product by Mass Spectrometry**

Mass spectrometry was used to determine the molecular mass of the isolated product. Mass spectrometry has three basic steps: ionization of sample, analysis of ions according to mass/charge (m/z) ratio and finally detection and generation of spectrum. Ionization process used here for ionization of sample was Electrospray Ionization (ESI). The type of mass analyzer used here is time -of -flight (TOF). So, this method is also called ESI-TOF.

Ionization of sample by using ESI

During the standard electrospray ionization, the analyte solution entered into ionization chamber for ionization and to gain charge, was pumped through a narrow capillary. A high voltage was applied to the tip of capillary and as a consequences the analyte emerging from the tip was highly charged droplets. By evaporation the charged droplets size was diminished. As the size of droplets decreases the charge density increases.

Mass analyzer TOF

Once the sample was ionized, the beam of ions was accelerated by an electric field and then entered into mass analyzer, where the ions were separated according to their mass to charge (m/z) ratio. The TOF mass analyzer measures the flight time of ions in this chamber. Smaller ion had high velocity (kinetic energy) as compared to the same charge of larger ion and thus reached the detector first. An ion with more charge reached the detector first as compared to same mass of less charged ions. The arrival time of an ion depends upon charge, mass, velocity and kinetic energy.

Process

The chemical constituents of the extracted materials were determined using ESI-MS. ESI-MS analysis was performed using HRMS (waters; Xebo-G2-xs-QTof). The HPLC was interfaced with a Q-TOF mass spectrometer fitted with an ESI source. Full scan mode from m/z 50 to 2000 was performed with a source temperature of 180 degree centigrade. Methanol solvent was used and delivered at a total flow rate of 5 micro liter/minute. The MS spectra were acquired in the positive ion mode. The temperature of the drying gas (N_2) was 350 degree centigrade, at a gas flow rate of 6 mL/min, and a nebulizing pressure (N_2) of 25 psi. About 0.5 g of sample extracts was diluted with methanol and filtered with 0.22 micro meter nylon filter

prior to analysis. The mass fragmentations were identified by using spectrum database for organic compounds in MASS Lynx 4.1 (waters).

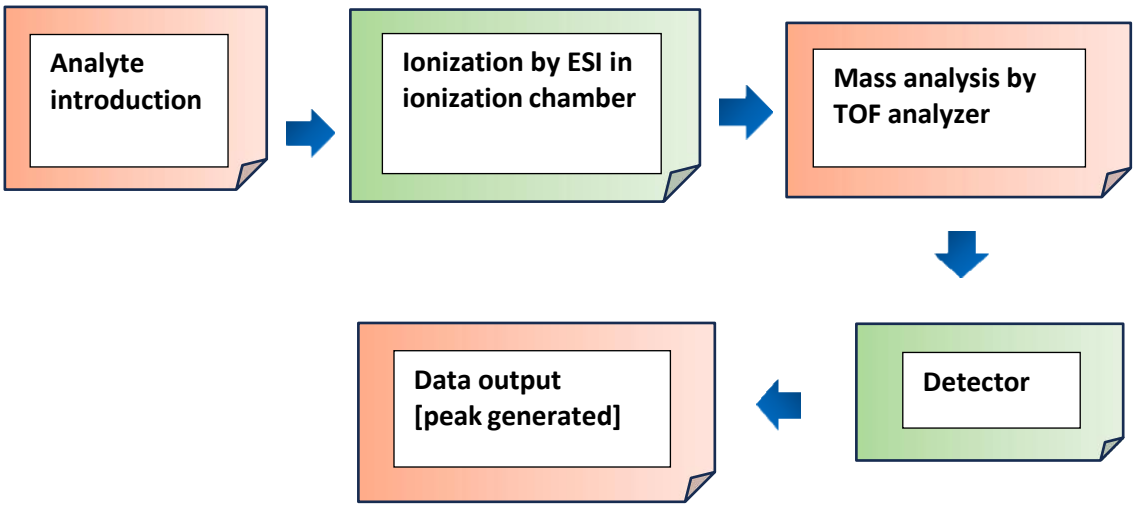


Fig 6: Flowchart of mass spectroscopy

2. ^{1}H NMR spectroscopy

Nuclear magnetic resonance is a spectroscopic technique that was used to determine the structure of isolated compound. This technique is based on magnetic property of nuclei that results from a property called nuclear spin. Here the energy used was radio wave to flip the nuclei from lower energy state to higher energy state. Alpha spin is called +1/2 as they aligned themselves parallel to external magnetic field and thus is lower energy state. Beta spin is called -1/2 as the aligned themselves antiparallel to the external magnetic field. In the presence of external magnetic field ^{1}H atomic nuclei of isolated product resonate between these two states to generate NMR peaks in respect to reference sample – Tetramethylsilane (TMS).

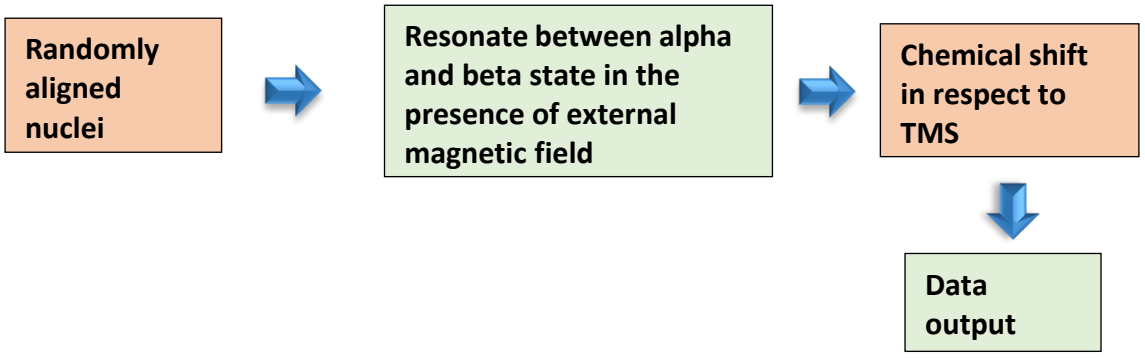


Fig 7: Flowchart of NMR spectrometry

RESULTS

Confirmation Test

1. **Result of ESI-MS:**

   ESI-MS generated two peaks-one peak was found at 121 that is the molecular weight of cysteine amino acid and another peak was found at 241 that is the molecular weight of cystine an oxidative derivative of cysteine amino acid. This measured mass matches with the mass reported in literature. So, ESI-MS confirmed that both cysteine amino acid and cystine are present in extracted product of acid treatment.

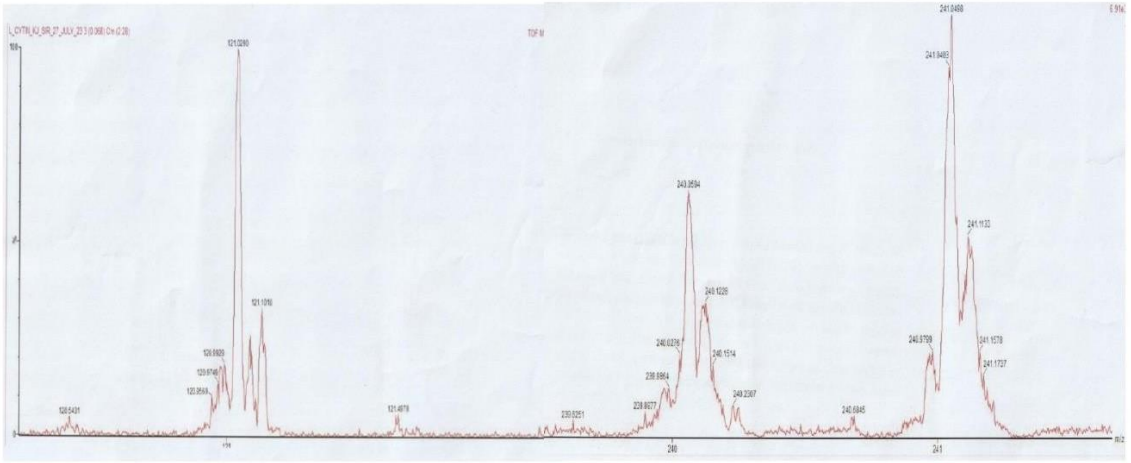


Fig 8: Mass Spectroscopic peaks of Cysteine and Cystine

2. **NMR spectroscopy:**

   The structure of extracted cystine through the acidic process was confirmed by H^1 NMR spectroscopic method. NMR spectroscopic method confirmed that sample contains both the structure of cysteine and cystine. NMR generated the peaks, matches with the peaks of cystine and cysteine reported in literature.

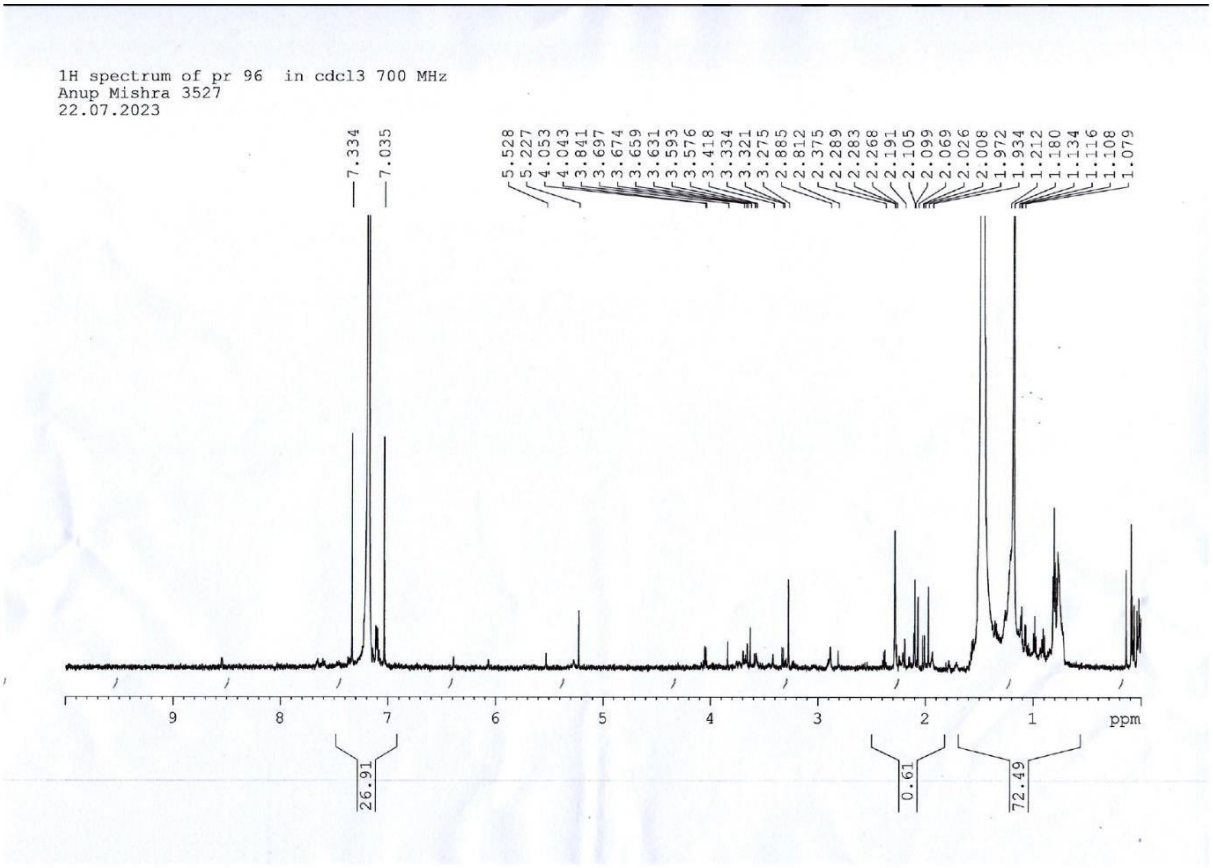


Fig 9: NMR spectroscopic peak of Cystine

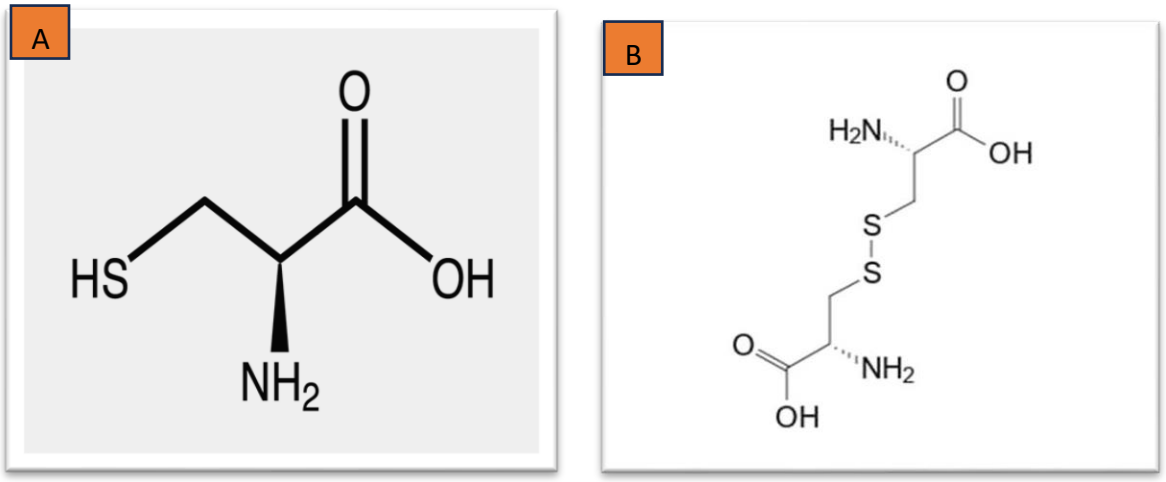


Fig 10: A: Cysteine, B: Cystine

3. Melting point:

I measured the melting point of extracted cystine with a melting point measuring apparatus. Obtained melting point is 238 degrees centigrade. Melting point of cystine reported in literature is 240 degrees centigrade. Obtained melting point is a bit lower than the reported value. So, there is a difference of 2 degrees centigrade between these two values (De et al., 2008).

Concern

In this process I obtained a mixture of both cysteine amino acid and its oxidative form- cystine. The thiol (SH) group of cysteine easily oxidized when it comes into contact with air and converted into cystine by forming disulfide cross-linkage (a covalent bond) between two atoms of sulfur. There is nothing serious to worry about, as cystine can easily be converted into two molecules of cysteine amino acid (Clemente et al., 2018). By treating them with a reducing agent Beta mercaptoethanol and dithiothreitol (the most widely used reducing agents) can be converted into cysteine amino acids. With the help of this reducing agent, we can isolate pure cysteine, which has a really good market value and is a valuable product for several usage.

In our area, a survey on human hair was carried out by visiting a number of hair salons to learn more about their establishments and the number of daily salon visitors for hair trimming. The information gathered from the sample survey is presented in a table below:

	SALON NAME	OWNER NAME	MOBILE NUMBER	WARD NUMBER	/DAY CUSTO-MER	/DAY HAIR (gm)	/MONTH HAIR (gm)	/YEAR HAIR (Kg)
1.	Glowsy Hair And Beauty Parlour	Narottam Barik	8967108401	6	45	3000	90000	1095
2.	Shreema Salon	Goutam Barik	9851088790	6	25	500	15000	182

3.	The Wave	Ranjan Barik	9046174710	6	10	250	7500	91
4.	Ma Gouri Salon	Nimai Barik	9002102243	1	10	150	4500	54
5.	Aparupa Ladies Beauty Parlour	Soma Roy	9732511290	7	13	300	9000	109
6.	Ma Basanti Family Salon	Jagannath Barik	8650556600	7	30	2000	60000	730
7.	Good Luck Salon	Sujit Barik	7318873470	1	15	150	4500	54
8.	Mukhashree Ladies Beauty Parlour	Tusi Maity	8250333800	1	20	155	4650	56
9.	Indian Gents Parlour	Rajkumar Barik	8001328824	1	35	2000	60000	730
10.	Khokon Saloon	Khokon Manna	9547917152	13	15	140	42	51

11.	New Gents Parlour	Raju Barik	9002204497	13	18	200	6000	73
12.	Chandan Saloon	Chandan Barik	6296808184	13	11	150	4500	54
13.	Moonlight Gents Parlour	Manik Mala	8972162224	13	15	150	4500	54

Table 1: List of 13 hair salons

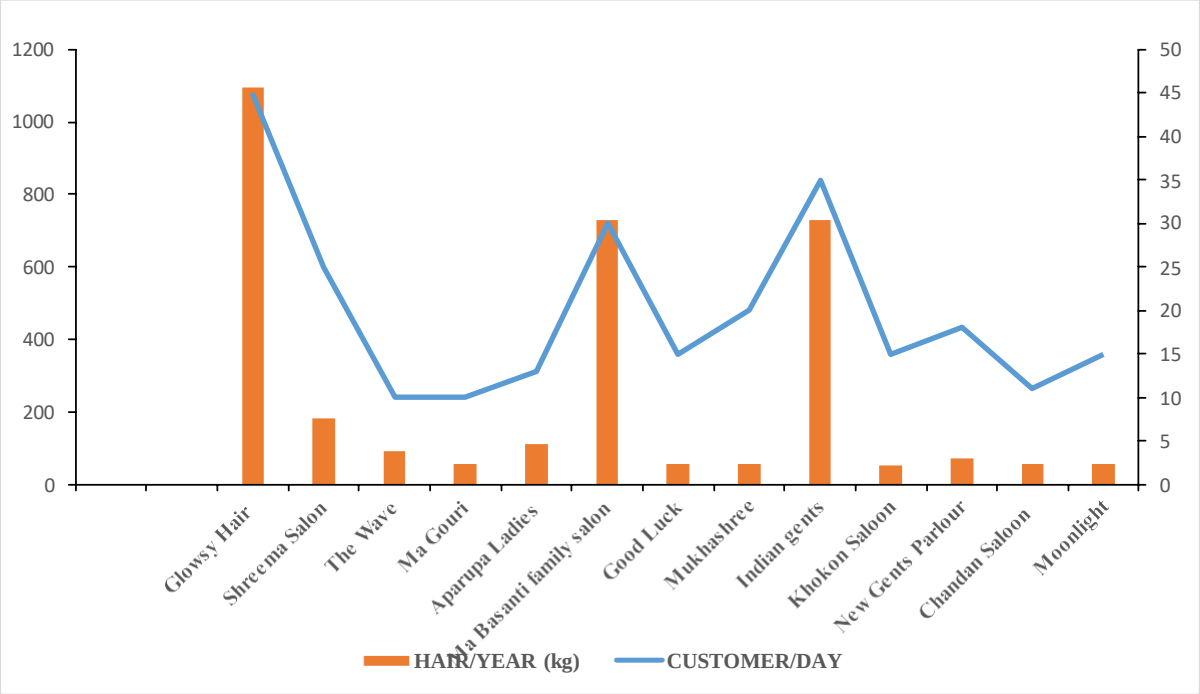


Fig 11: Survey results in chart form

According to this data, it appears that every day, close to 10 kg of human hair are discarded in the trash. 300 kg of human hair are thrown from salons each month. If we compute the annual loss of human hair, the result is roughly 3600 kg. This data was collected by visiting 13 hair salons. 50 grams of hair was taken as a sample and 1.97 g of cysteine obtained from this tiny sample. So, the yield of cysteine by this process is about 3.94 g/100 grams of hair.

From,

100 gm hair = 4 gm cysteine (Approximately)

10 Kg hair = 400 gm cysetine (Daily)

3600 Kg hair = 144000 gm/ 144 Kg cysteine (yearly)

Cost of 100 gm cysteine is = 150

	HAIR	HUMAN HAIR (kg)	CYSTEINE (gm)	COST
1.	HAIR/DAY	10	400	600
2.	HAIR/MONTH	300	12000	18,000
3.	HAIR/YEAR	3600	144000	216,000

Table 2: **List of amount of discarded hair, extracted cysteine and price**

Note Book: Hair/Year discarded from 13 hair salons is 3600 kilograms in a small area.

On an average, 400 gm cysteine can be extracted from 10 Kilograms hairs, which has a market value of around 600 rupees. Every month, 300 kilograms of hair is thrown away, with a market value of around 18,000 rupees. Each year, 3600 kilograms of hair are set aside as trash, which has a market value of approximately 216,000.

DISCUSSION

Data shows each year, 3500 kilograms of human hair are discarded from salons and society from small areas. These hairs accumulate in soil, drains, pipeline and agricultural field, thus pollutes environment. By wasting these hairs we are also wasting a lot of money. Instead of wasting, these hairs can be used to produce L-cystine. The extraction of cystine through this acid treatment from waste products—human hair—can be a good source of income for youth. One can dream of earning so much through this simple and easy process with minimal input. One can get maximum benefit from this process, as hair growth is a natural process that no one can prevent. Hair will grow day by day, and those people will come to the salon for their haircut. These trimmed hairs are the main raw material for this business; otherwise, those hairs would cause environmental pollution. In this way, we can attract the attention of youth towards

earning and thus reduce unemployment in our society. Thus, recycling those discarded hairs can be a useful process for the welfare of human beings, wild life, and the environment.

Composition of keratin

Keratin is a member of the large IF family. Keratin is divided into two types: Type I and Type II. Type I keratins are acidic, but Type II keratins are basic and neutral. In mammals, Type I alpha keratin is most commonly found in their nails, hairs, horns, and hooves. Two right-handed alpha helices twisted around each other to form a left-handed coiled coil dimer. Two such dimers associate with each other to form a protofilament, and two protofilaments combine to form a protofibril. Four such protofibrils further combine to form one intermediate filament, which has a diameter of 7 nm. All these structures are stabilized by extensive disulfide bonds that provide high tensile strength and stretchability to the human hair. Alpha helices are rich in glycine, cysteine, phenylalanine, and tyrosine.

Characteristics of L-Cysteine

Cystine is formed by the oxidation of two molecules of cysteine amino acid – a non-essential, polar, uncharged amino acid. Cysteine is the only amino acid that contains thiol (SH) group and can undergo oxidation to form di-sulfide bond between two cysteine amino acid. Cysteine is polar but its oxidized form-cystine is non polar (De et al., 2008). This di sulfide bond gives cystine its unique functional role. Cystine serves two main functions in proteins: one is a redox reaction site, and another is its involvement in the 3D structure of proteins (Clemente et al., 2018). Cysteine is an alpha amino acid that contains a carboxyl group (COOH), an alpha amino group (NH2) and a thiol group (SH) in its side chain. Cysteine contains only one chiral center. At neutral pH cysteine acts as zwitter ion. PK1(COOH) of cysteine is 1.96 and PK2 (NH2) is 10.28 and PKR (SH) value is 8.18. PI value of this amino acid is 5.07 (PK1 +PKR /PK2).

Functional properties

A. Antioxidant property:

As an antioxidant, cysteine is also beneficial. Cysteine is the only amino acid that can act as an oxidizing agent as it can donate its proton from the SH group and converted into cysteine amino acid. It can act as a scavenger for free radicals, which are highly reactive molecules that can damage cells and contribute to either cancer or liver diseases. By neutralizing free radicals, cystine helps to protect cells from oxidative damage (Clemente et al., 2018).

B. Use in medicine:

Cystine supplements can provide to those needy people who are in cystine deficient. Cystine is used as an antidot to counter acetaminophen toxicity in pharmaceutical field. In addition, it is also used to treat oral cavity infections such as gingivitis and glossitis (Ismail et al., 2014).

C. : Glutathione production:

Cysteine is an essential component of glutathione (GSH)- composed of three amino acids glutamate, cysteine and glycine. L-cystine is responsible to induce glutathione production to reduce oxidative stress.

D. Immune response:

Neutrophils kill a foreign particle by producing reactive oxygen species (ROS) that is harmful for themselves. Glutathione plays a vital role in protecting neutrophils against ROS mediated oxidative injury. Cystine/glutamate transporter plays an important role here by supplying cystine it maintains GSH level in cells (Sakakura et al., 2007).

E. Effects on dark spot and skin:

Glutathione has anti-melanogenic property that can induce the production of lighter pheomelanin instead of darker eumelanin. Oral consumption of L Cystine and glutathione significantly reduces the size of facial dark spot and also lightens the skin (Duperray et al., 2022).

F. Flavor of rice:

Both L-cystine and L-cysteine is used to develop flavor of rice by photolysis process in the presence of riboflavin. Hydrogen sulfide, ammonia and acetaldehyde are responsible for this flavor (Obata and Tank, 1965).

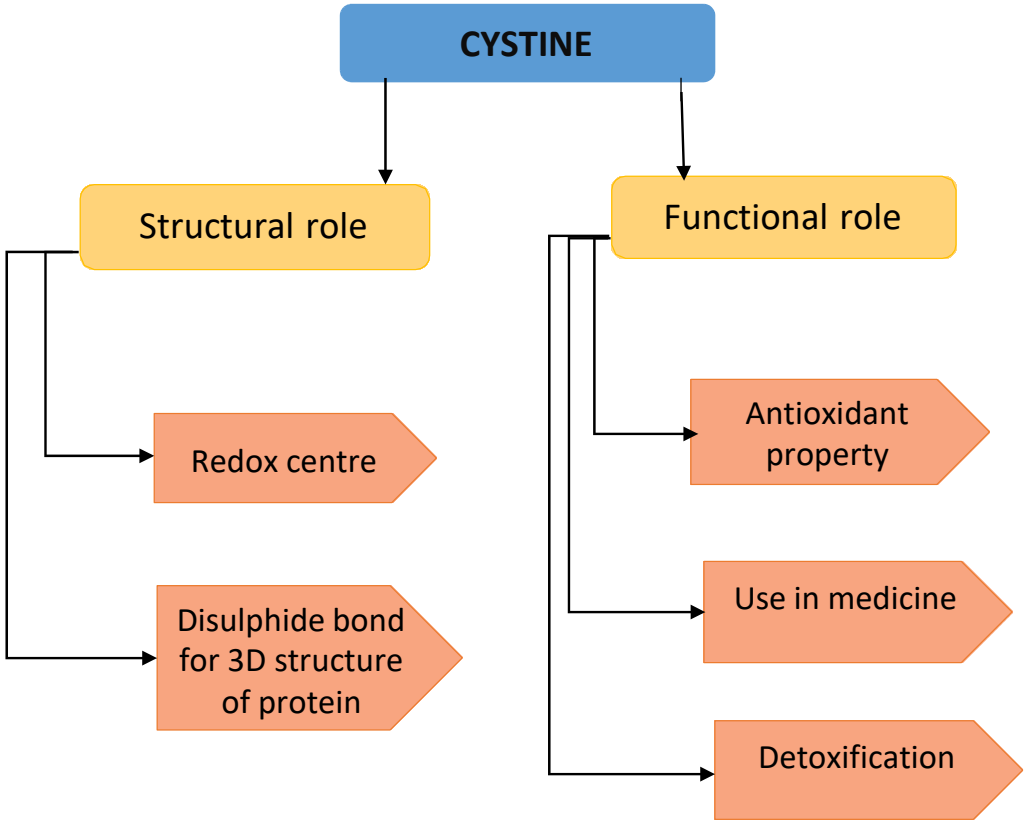


Fig 12: Role of cystine

Source of cysteine

Cysteine is a sulphur-containing amino acid that occurs naturally in many foods and can also be manufactured in the body from the amino acid methionine (another sulphur-containing non-polar, essential amino acid). Cystine is common in many foods- vegetables, fresh fruits, soyabean, sunflower seeds, legumes. The highest level of cysteine is in papaya (58 nM/g)(Ismail et al., 2014).

Natural amino acids like cysteine play an important role in the function and structure of proteins in living organisms. It is classified as a "non-essential amino acid" because the human body can synthesise it from the essential amino acid methionine (Ismail et al., 2014). Cysteine also provide stability to protein by forming several disulfide bonds.

CONCLUSION

1. Isolation, purification and characterization of cystine by spectroscopic means from easily available source that is human hair. Keratin hydrolysis by acid treatment does not promise to give huge yield as reported in some of the literature, but is convenient and gives consistent results. From 100 grams of human hair 3.9 grams of cystine was extracted.
2. In comparison to alkaline treatment, acid treatment is better for extracting cystine. Keratin hydrolysis by acid treatment is more promising to give result. I obtained cystine by this acid method only.
3. Production of L-cysteine from human hair generates employment and thus creates enthusiasm among the youth. This project also emphasized the importance of community engagement by providing employment opportunities for individuals involved in the collection of human hair from salons, fine chopping and extracting cystine, this will not only create economic benefits but also improve the livelihoods of those involved individuals
4. From a human-hair perspective, "waste to wealth" holds tremendous benefit for both sustainability and prosperity of environment. Recycling and reutilization of human hair can significantly contribute to waste reduction and promote a pollution-free environment
5. Instead of ending up with the problems related to this, human hair can be converted into valuable L-cystine, which has several beneficial roles in pharmaceutical, human body, food industry, medicine production and cosmetics. Cysteine is the only amino acid that contains a thiol group in its side chain. This thiol group can donate its proton easily and itself gets oxidized to form cystine. This unique property of cysteine can be used in cosmetic products as an essential component of anti-aging creams to neutralize reactive oxygen species produced in the body due to stress. It can be further used as an active component of hair serums. Vitamin E is widely used in foods, cosmetics because of its antioxidant property. In addition to using vitamin E, cysteine can also be used. Edible oils can also be enriched with cysteine amino acid along with vitamin E. These days cystine hair treatment is slowly being noticed along with keratin treatments. Cystine promotes proper growth of fingernail and thus can be used in nail care products.

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