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IMPACT OF GENETIC FACTORS ON KIDNEY STONE SUSCEPTIBILITY AND TREATMENT

Dr. Bhat Aasim Mohammad[1*], Dr. Mehak Ahsan[2], Dr. Bakhtawar Bashir[3], Samah Gaafar Hassan Alshyhi[4], Dr. Coenrad Adolph Groenewald[5], Dr. Elma Sibonghanoy Groenewald[6]

[1 *]MBBS, Poonch Medical College, Pakistan,
Email: bhatmohammad@gmail.com
[2] MBBS, University of health Sciences, Lahore, Pakistan,
Email: mehakahsan111@gmail.com
[3]MBBS, Medical Officer, University of health sciences Lahore Pakistan
Email: bakhtawarbashir08@gmail.com
[4]Department of Pharmacology, Nothern border University,
E.mail: samah.alshygi@nbu.edu.sa
[5]Consulting Director, SG Virtuosos International, Executive Department Cape Town, South Africa,
Email: dolfgroenewald@sgvirtuososinternational.com
ORCID: https://orcid.org/0000-0002-2394-6347
[6]Chief Executive Officer (CEO), SG Virtuosos International, Executive Department,1501-1502 Tran Phu Street, Loc Tho Ward, Nha Trang City, Khan Hoa Province, Vietnam, 650000
Email: elmasgroenewald@sgvirtuososinternational.com ORCID: https://orcid.org/0000-0001-7813-2773

***Corresponding Author**: Dr. Bhat Aasim Mohammad
*MBBS, Poonch Medical College, Pakistan,
Email: bhatmohammad@gmail.com

ABSTRACT:

Background: Kidney stone formation arises from the aggregation of crystals and organic materials within the urinary system, affecting approximately 13% of men and 7% of women globally, with a recurrence rate of up to fifty percent. The accurate detection of kidney stones through laboratory investigations has become pivotal in clinical practice due to its simplicity, speed, and safety, contributing significantly to patient prophylaxis.

Objective: This study aimed to conduct chemical and physical identification of two kidney stones to enhance understanding and diagnostic accuracy. The investigation utilized the Kamlet and Feigl methods, available in the Bioclin® laboratory reagent kit, structured into physical and chemical analysis phases.

Methods: The physical analysis delineated the kidney stone's physical characteristics, while the chemical analysis classified urinary crystals contributing to stone formation. Both samples underwent thorough examination to determine their composition and distinguish any distinct features.

Results: The results yielded satisfactory outcomes, with both samples displaying unique physical properties. Notably, despite physical distinctions, both samples contained calcium oxalate crystals. However, sample B exhibited the presence of uric acid, highlighting the methodology's significance in detecting specific crystal compositions crucial for accurate diagnosis.

Conclusion: The chemical and physical identification of kidney stones, facilitated by methodologies such as the Kamlet and Feigl methods, plays a crucial role in preventing disease relapse, enhancing patient quality of life, and enabling rapid and secure diagnosis. This study underscores the importance of robust laboratory investigations in managing kidney stone-related conditions effectively.

KEYWORDS: Urinary Crystals; Identification; Physicochemical; Kidney Stones.

INTRODUCTION:

Kidney stones are made when crystals and organic matter build up in the urine tract. At least 13% of men and 7% of women will get it at some point in their lives, and up to 50% of people who get it will get it again. The most common sign is severe pain in the back, sides, belly, or when you urinate. What makes the situation worse is the constant need to urinate and the need to do it so often that blood may be in the urine. It can lead to swelling, infection, blood in the urine, and worsening kidney function. It can also move into the bladder (González-Enguita, Garcia-Giménez, Garcia-Guinea, & Correcher, 2024a, 2024b).

Kidney stones happen because of issues with oxidative stress, inflammation, the urea cycle, the breakdown of purines, and the growth of blood vessels. The calculations show that saturation will lead to the concentration. Many things can cause kidney stones, such as age, climate, genes, job, sex, food, and metabolic diseases that make someone more likely to get them (Balamurugan & Rathina, 2024; Menon et al., 2024).

The process of kidney stones forming depends on people drinking less water, which is necessary to raise the mineral levels in the urine to the point where crystals form in the urine. Problems with biochemical processes like oxidative stress, inflammation, purine metabolism, the urea cycle, and angiogenesis can lead to kidney stones. Increasing the saturation will raise the level of salts in the urine, which will help the formation of stones. Once the crystals start to stick together, a process called aggregation will happen, which is when the crystals finally join together and form large particles that make up the calculation (Mammate, Belchkar, Ssouni, el Mouhri, & Houssaini, 2024; Raj et al., 2024).

To keep water in the body, the kidneys have to get rid of things that don't dissolve easily. Usually, urinary stones happen when there is an imbalance between two physical qualities that are at odds with each other: the solubility and precipitation of salts. The body keeps these two different physical traits in balance by using normal physiological processes and some substances that stop urine from crystallizing (He, Li, Li, & Fu, 2024; Q. Zhang, Wei, & Huang, 2024).

But some things, like what you eat, the weather, and how much you exercise, can make this function less useful. Stones form in a complicated process that includes many steps. For example, crystals form in urine that is too concentrated because the molecules that make up the stones are being flushed out more quickly or there is less urine in the body. The crystals then start to stick together, which continues until a clinical stone forms (Raj et al.; Shahzadi et al., 2024).

Most of the time, calcium salts, uric acid, cysteine, and struvite make up kidney stones. Kidney stones come in four different types: struvite stones, calcium stones, cystine stones, and uric acid stones. Nearly 80% of stones are made of calcium oxalate and calcium phosphate. Uric acid (5–10%), struvite (5%), and cysteine (1%), on the other hand, are less common. The presence of stones in a patient's urinary tract is a sign of a diseased process that causes chemical compounds to precipitate and form deposits (Kanlaya, Kuljiratansiri, Peerapen, & Thongboonkerd, 2024; Ouhammou, Hiadr, Mourak, Alahyane, & Mahrouz, 2024).

For this reason, it is very important to diagnose all stones, whether they were passed naturally or surgically removed. By accurately figuring out the structure and chemical makeup of stones, you can figure out why they formed, pick the best treatment method, and change the patient's diet to stop them from happening again (Mancuso et al., 2024a).

Medications may be used to ease the pain and get rid of the stone, but if it doesn't pass, other procedures are needed, like an endoscopic procedure or ureteroscopy, which entails putting a tube through the urethra and into the kidney, where the stones are broken up mechanically or with a laser to get rid of them. Lithotripsy is another treatment that uses shock waves to break up stones so that they are easier to pass when you urinate (Bi, Li, Lv, Shi, & Jiang, 2024).

Based on what Gomes et al. How well kidney stones are treated rests on figuring out exactly what caused them to form in the first place. The disease can be stopped from happening again once the underlying cause of kidney stones has been identified. These can be metabolic, structural, idiopathic, or dietary. Figuring out these risk factors will help with prevention and treatment (Cao et al., 2024; Robinson, Marom, Ghani, Roberts, & Matzger, 2024).

Because doctors don't always follow the right steps, clinical analysis labs don't use this method very often to find crystals in kidney stones. Two well-known ways in the literature can be used to figure out what parts of a kidney stone are present. Like Kamlet and Feigl's methods, these both use colourimetric reactions to find urinary crystals that have formed a certain stone. These reactions can show whether certain crystals like calcium oxalate, acid uric acid, phosphate, cystine, and others are present or absent. These crystals often show up in the urine and may be a sign of stone disease (Lapsina, Stirn, Hofmann-Lehmann, Schoster, & Riond, 2024).

Identifying kidney stones has evolved into an important part of lab investigations. These usually involve several biochemical tests that are used together to give clues about the type of stone and where it came from. These tests are based on a method created by Kamlet and Feigl and are now available in pre-made reagent kits that can correctly and accurately figure out what kind of material kidney stones are made of (Pereira Amado et al., 2024).

A method that isn't used very often is studied in this work because it is easy to use, quick, and safe. It can help prevent problems in patients. The point of this article is to show how easy it is to figure out what causes renal lithiasis so that doctors can try to stop the disease from happening again and cut down on the number of people who have to go to the hospital by studying the physics and chemistry of these crystals in the urine (Bose, Sulthana, Narendhar, & Phanideepika, 2024).

Table 1: Factors Contributing to Kidney Stone Formation

Factors	**References**
Oxidative stress	(Balamurugan & Rathina, 2024)
Inflammation	(Mammate et al., 2024; He et al., 2024)
Urea cycle	(Balamurugan & Rathina, 2024)
Purine breakdown	(Raj et al., 2024; Q. Zhang et al., 2024)
Angiogenesis	(Mammate et al., 2024)
Age	(Balamurugan & Rathina, 2024)
Climate	(Menon et al., 2024)
Genetic predisposition	(Balamurugan & Rathina, 2024)
Occupation	(Menon et al., 2024)
Gender	(Balamurugan & Rathina, 2024)
Dietary habits	(He et al., 2024)
Metabolic diseases	(Raj et al., 2024)
Fluid intake	(Balamurugan & Rathina, 2024)
Physical activity	(Raj et al., 2024)

Table 2: Composition of Kidney Stones

Stone Type	Composition	References
Struvite stones	Magnesium ammonium phosphate	(Ouhammou et al., 2024)
Calcium stones	Calcium oxalate, calcium phosphate	(Mammate et al., 2024)
Cystine stones	Cystine	(Kanlaya et al., 2024)
Uric acid stones	Uric acid	(Ouhammou et al., 2024)

Table 3: Treatment Options for Kidney Stones

Treatment Option	Description	References
Medications	Pain relief and stone dissolution medication	(Bi et al., 2024)
Endoscopic procedures	Insertion of a tube through the urethra to mechanically or laser-break stones	(Bi et al., 2024)
Lithotripsy	Use of shock waves to break up stones for easier passage during urination	(Bi et al., 2024)
Prevention strategies	Identification of underlying causes and dietary modifications to prevent recurrence	(Cao et al., 2024; Robinson et al., 2024)

Table 4: Methods for Identifying Kidney Stones

Method	Description	References
Colourimetric reactions	Detection of urinary crystals using colourimetric reactions to identify stone components	(Lapsina et al., 2024)
Biochemical tests	Utilization of biochemical tests, including Kamlet and Feigl methods, to determine stone composition	(Pereira Amado et al., 2024; Bose et al., 2024)

Note: References are cited for each respective table item.

MATERIALS AND METHODS:

This is a study that is qualitative, and experimental and explains things. Two donated samples from two patients at a private urology clinic in the city of Imperatriz, MA, are part of the study universe. Both samples come from kidney "stones" that were removed during surgery (Amado et al., 2024).

The patients were both male and female and were identified with kidney lithiasis. The stones had to be removed by surgery because they wouldn't go away on their own (through the urethra). Patients agreed to give samples by signing the informed consent document (TCLE). Since the FACIMP Ethics Board for Scientific Research agreed with the study, it was made public through protocol 1290830 (Pathan, Mulla, & Gajendragadkar, 2025).

The Kamlet and Feigl method was used to change this study. This method tries to find out directly whether kidney stone-forming crystals are present or not. The kits with chemicals were made using the standard method, which was split into two steps: physical analysis and chemistry analysis. The kit makes it easy, quick, and safe to find Carbonate, Oxalate, Ammonium, Phosphate, Calcium, Magnesium, Urate, and Cystine (Mancuso et al., 2024b; Singh & Dash, 2024).

The two samples (A and B) were each looked at separately to see how their chemistry and physical properties changed. The kit used is the KIDNEY STONE Kit from Bioclin®, with reference number K008 and lot number 0072. It has 14 chemicals and one standard, which is enough for 10 full analyses. A precision analytical balance was used to weigh the numbers. Next, each sample was ground up in a porcelain bowl and put in its bowl so that it could be used in the analysis chemist (Naranjo-Ruiz et al., 2024).

Once the stone was broken up, a small amount of each of samples A and B was put into a different tube and labelled (P.A.) and (P.B.). Certain parts of the positive control sample that came with the reagent kit have been named (P.C.). Each test tube got 10 drops of solution no. Five to ten drops of distilled water should be mixed and put in a bain-marie that has already been cooked to 56°C. After spinning each test tube three times for five minutes, the centrifuge was turned up to 3000 rpm for three minutes (Rath et al., 2024).
The sample was then centrifuged with the help of a pipette, and the supernatant was carefully moved into three other test tubes labelled (S.A.), (S.B.), and (S.C). We sorted the precipitate and supernatant from the samples and the control (Liu et al., 2024).

The first thing we did was look for carbonate, oxalate, calcium, and magnesium in the precipitate, as we will explain below:

Carbonate: Ten drops of reagent no. 1 were put into the three test tubes labelled as precipitates (P.A.), (P.B.), and (P.C.). Then, the bottom of each tube was watched to see if gas was leaving, which would mean that the carbonate was positive. Finally, 10 drops of water that had been distilled were added, mixed well, and put under the alcohol lamp's light with the help of a Bunsen flame. The tube was taken out and set away to cool as soon as it started to boil. Three tubes were used for the whole process. This helped break up the sample that was stuck at the bottom of the testing tube, which could then be used as a sample for more studies (Karantas, Miliotou, & Siafaka, 2024).

Oxalate: 0.1 ml of the hot solution above plus 3 drops of reagent no. 2. The presence of oxalate is shown by the creation of intense turbidity or white precipitate.

Calcium: 5 drops of reagent no. 1 mixed with 0.1 ml of the hot sample. 6. The fact that the white powder forms shows that calcium is present.

Magnesium: 0.02 ml of the heated sample was put into an Erlenmeyer flask, and 20 ml of distilled water that had been weighed out into a beaker was then added. One drop of reagent number was added after it was mixed well. 5 to water down the sample. A test tube got 7 drops of solution no. 7 drops of reagent no. 8 were mixed in and 0.05 ml of the diluted sample was added to the Erlenmeyer jar while it was being stirred. When the colour purple shows up, it means that magnesium is present (Ida & Yamane, 2024).

The last step was to look at the residue and see if Urates, Cystine, Ammonium, and Phosphate were present or not, as explained below:

Urates: After spinning in a tube, 0.1 ml of the supernatant was moved to be separated and set aside. Five drops of reagent number 10 and five drops of reagent number 11 were added to this. Urates are present because of their strong blue colour (Punzi et al., 2024).

Cystine: A drop of reagent number 12 and a drop of reagent number 13 were added to the tube along with 0.1 ml of the supernatant. After five minutes, add two drops of reagent number 14. Cystine is present as soon as the strong red colour shows up. "The whole procedure had to be done under a fume hood because reagent no. 13 contained NaCN, which is against the law according to RDC 306/2004 ANVISA;" (Matejić et al., 2024).

Ammonium: A test tube was filled with 0.1 ml of residue, 10 drops of homogenized distilled water, and 5 drops of reagent no. 9. The presence of a yellow residue shows that ammonium is present.
Phosphates: To make phosphonates, 0.1 ml of supernatant, 1 ml of pure water, and 1 drop of reagent N° 1 were mixed. Then, 2 drops of reagent N° 3 were added, and the mixture was mixed again to add

2 drops of reagent N° 4. After two minutes of rest, add two drops of reagent no. 5. The fact that the blue colour shows up means that phosphate is present (Raghav, Raj, Tiwari, & Kandwal, 2024).

Excavations	Reagents	Reaction
1st	1 drop of NaCO3 solution and 2 drops of uric acid reagent.	Immediate intense blue staining indicates uric acid and urates
2nd	3 drops of HCl, let it cool and add 1 pinch of MnO2	Small bubbles released from the bottom reveal oxalates
3rd	5 drops of molybdate solution and heating over a flame	Clear yellow precipitate means phosphates
4th	1 drop of ammonia + 1 drop of NaCN, wait 5 min and add 3 drops of Na nitroprusside	Beetroot-red colour indicates cysteine
5th	Add 10 drops of HCl Divide this acid extract into two parts, distribute them into two excavations (A and B) and add:	Frothy fizz indicates carbonates
a.	3 drops of NaOH solution and 3 drops of Nessler's reagent	Yellow or orange precipitate indicates ammonia Light, white precipitate means calcium oxalate
b.	3 drops of NaOH solution	Thick precipitate, calcium phosphate

***Chart 1**: Simplified identification of kidney stones*

RESULTS AND DISCUSSIONS:

The steps suggested by the methodology were used to report the findings, which were broken down into both chemistry and physics for each sample. The stone that was physically analyzed (sample A) has an uneven shape, and the surface looks like it has holes in it. The colours on the surface vary from dark yellow to light brown. The second stone that was physically analyzed (sample B) is very different from the first stone. It has a smooth, oval shape, and only one colour that changes shades of yellow. It is also the biggest of the two samples, which means it is the biggest in how GOOD is (Medjoubi et al., 2024).

Variables	Sample A	Sample B
Weight	0.184g	0.223g
Form	Irregular	Oval
Colour	Dark brown	faded yellow
Surface	Porous	Lisa
Consistency	Petrea	Petrea
Dimensions	0.8cm x 0.7cm	0.9cm x 0.7cm
Appearance after sectioned	Presence of grey powder with irregular colouring	Uniform colouring

***Table 1 –** Physical analysis - Sample A and B*

Larger than a microscope, the two samples are physically different. The stones' weight and shape are two important features that make them unique. These features vary from individual to individual and are directly linked to the metabolic condition of the person where the stone is found. You can get kidney stones because of how much water you drink and other important factors. It's important to note that the same patient can form distinct physical stones at different times. This doesn't mean that they can't also form parts of various kinds of stones (Kumari, Dhankhar, Abrol, & Yadav, 2024).

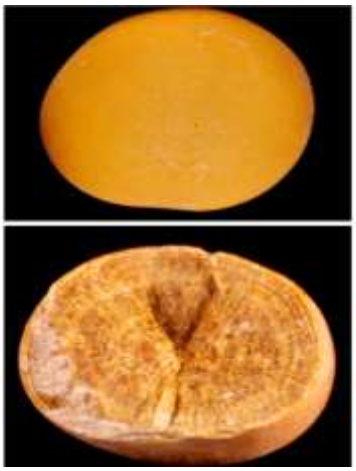

***Figure 1** – Samples A and B respectively*

The chemical analysis constitutes the second and most important phase of the methodology, where it will be possible to qualitatively diagnose the presence or absence of some urinary crystals in samples A and B (Budiman et al., 2024).

VARIABLES	SAMPLE A	SAMPLE B
CARBONATE	-	-
OXALATE	+	+
PHOSPHATE	-	-
CALCIUM	+	+
MAGNESIUM	-	+
AMMONIUM	-	-
URATES	-	+
CYSTINE	-	-

***Table 2-** Chemical analysis for the search for crystals in sample A*

The OXALATE test showed that sample A was positive, with a white precipitate and a lot of cloudiness. The CALCIUM test also showed that sample A was positive, with a white deposit on the bottom of the tube being tested, which was shown by the positive outcome of the method (Jing & Xiaoke).

This proves that the thing that was looked at does contain calcium oxalate.

Different kinds of urine crystals were found in Sample B. The first crystal found was OXALATE, which had a lot of cloudiness in the part that was being tested and a light white precipitate that confirmed its presence with the beneficial control of the method (Duque-Sanchez, Qu, Voelcker, & Thissen, 2024).

It was also proven that the sample had CALCIUM by finding a white residue that looked like the positive control. Additionally, a purple colour was seen when it tested positive for MAGNESIUM, and a strong blue colour was seen when it tested positive for URATES. As expected, Calcium Oxalate, Magnesium, and Urates (Uric Acid) were found in all of the sample B material that was tested (Kalashgrani et al., 2024).

Nath et al. did a physicochemical study of kidney stone fragments and got similar results to these. The samples showed that they contained calcium carbonate, calcium, and magnesium. Most kidney stones are made up of calcium salts, uric acid, and cystine. Magnesium and phosphates are next on the list. A study by Ansari et al. looked at 1050 kidney stones from people in North Delhi. They found that 93.04% of the stones were calcium oxalate, 0.95% were uric acid, and 2.76% had a mixed pattern (Ayyamperumal et al., 2024).

Similarly, Rao et al. looked at 51 stones and found that 96% of them were calcium oxalate stones. Nevertheless, urate, carbonate, phosphate, and ammonium could not be seen in samples A and B.

Only magnesium and urate were present in sample B. This is because the sample size was not as large as those of Nath et al., where all compounds were found. However, all compounds were found because they were present in some samples and not in others (M. Zhang, Zhang, Du, Chen, & Zhang, 2024).

Kidney stones come in four different types: struvite stones, calcium stones, cystine stones, and uric acid stones. That made of calcium is the most common. That made of cystine shows up in people with cystinuria. That made of struvite grows the fastest and can block parts of the urine system. And that made of uric acid is more common in men. This study looks at two types of stones: sample A is made of calcium oxalate and sample B is made of calcium oxalate and uric acid (Marchetti et al., 2024).

CONCLUSIONS:

Based on the findings, it is essential to facilitate the diagnosis of kidney stones based on the physico-chemical analysis of the crystals. Through the methodological application used, the doctor will be able to carry out the diagnosis more simply and assertively, also providing for the prevention of future kidney stones.

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