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Preliminary Phytochemical Profiling of Extracts from Unidentified Cactus Species

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Abstract: ***The phytochemical composition and extraction efficiency of an unidentified cactus species were investigated using eleven solvents with varying polarities. The study demonstrates that both the yield and the profile of extracted bioactive compounds are strongly dependent on solvent choice. Highest yields were achieved with benzene (2.98%) for moderately polar compounds and methanol (2.79%) for high-polarity compounds, while less polar solvents like chloroform (1.73%) and hexane (1.77%) were less effective. Extraction kinetics also showed variation, with benzene and petroleum ether providing the shortest extraction times, highlighting a trade-off between speed and final yield. Qualitative analysis revealed a diverse range of secondary metabolites. Alkaloids and glycosides were consistently present in all organic extracts but absent in the aqueous extract, indicating their nonpolar to moderately polar nature. Conversely, reducing sugars were universally present across all solvent types, while protein detection was selective, observed only in acetone and petroleum ether extracts. Flavonoids, phenolic compounds, terpenoids, and triterpenoids were widely detected, with varied solubility patterns. Confirmed presence of coumarins, quinones, saponins, resins, and oils further underscores the species' rich chemical diversity. These findings confirm that selective solvent extraction is a critical factor for isolating specific bioactive constituents and provide a foundation for future pharmacological and characterization studies.***

Keywords: Phytochemical analysis, cactus extract, secondary metabolites, conventional extraction.

I. INTRODUCTION

The Cactaceae family is a large group of perennial succulent plants known for their morphological adaptations to arid and semi-arid environments [1]. Beyond their ecological resilience, many cactus species are traditionally utilized in folk medicine across various cultures for their purported health benefits. Scientific inquiry into the therapeutic potential of medicinal plants begins with phytochemical analysis, a crucial step for identifying the chemical constituents responsible for biological activity [2]. While phytochemical investigations have been conducted on a number of well-documented cactus species, significant gaps remain regarding the composition of many lesser-known members of this family [3].

Secondary metabolites, such as phenolic compounds, flavonoids, alkaloids, and saponins, are known to possess a wide spectrum of pharmacological activities, including antioxidant, antimicrobial, and anti-inflammatory properties [4]. The therapeutic potential of a plant extract is directly linked to the synergistic effects of its chemical profile [5]. A comprehensive preliminary screening is therefore an essential step towards unlocking the medicinal properties of unexplored flora [6].

This study aims to conduct a systematic preliminary phytochemical profiling of extracts from unidentified cactus species collected from a specific arid region. The objective is to identify the major classes of secondary metabolites present in the extracts using conventional and established screening assays. The results are intended to provide foundational data for subsequent targeted research, focusing on the isolation, quantification, and bioassay-guided fractionation of the most promising bioactive compounds.

II. MATERIALS AND METHODS

A. Collection of Plant material

Unidentified cactus species were collected from Green Paradise Nursery, Kalimpong, West Bengal, India, and were raised in the green house at Department of Biotechnology, Gulbarga University, Kalaburagi [7].

B. Sample Preparation

Fresh cactus stem sample was thoroughly washed, air-dried in the shade at room temperature to preserve heat-sensitive compounds. The dried material was then ground into a fine powder using a mechanical grinder, sieved to ensure uniform particle size, and stored in an airtight container [8].

C. Chemicals and Reagent

Analytical-grade Methanol (MeOH), Acetonitrile (ACN), Ethanol (EtOH), Acetone (Ace), Petroleum Ether (pet ether), Hexane, Benzene (Bz), Toluene, Ethyl acetate (EtOAc) and Chloroform ($CHCl_3$) were procured from Sigma Aldrich Hyd. The Center for Biological Research, Kalaburagi where the Milli Q Water (H_2O) was obtained.

D. Preparation of Plant Extracts

The dried powdered 25 g sample of unknown cactus stem was filled in a thimble, made up of Whatman No. 1 filter paper and was subjected to Soxhlet extraction with 150 ml of solvents with rising polarity index such as petroleum ether, hexane, toluene, benzene, chloroform, ethyl acetate, acetone, methanol, ethanol, acetonitrile and water in the ratio of 1:6 w/v in at 45-50^oC until the extract was clear or colourless. Extraction was carried out in controlled conditions of temperatures to prevent the loss of heat sensitive phytochemicals. The resulting extracts were concentrated in a rotary evaporator under reduced pressure at 40^oC. Dried extracts were weighed in an analytical balance. The extracted materials were stored at 4^oC for further testing [9]. The stem extract was used to analysis the different phytochemical preliminary tests.

E. Determination of Extraction Yields ($Y_{Extract}$)

The extraction yields were determined using Equation (1) and presented as dry weight (d.w.) [10].

$$Yield_{Extract} = \text{Weight of extract from sample (g)} / \text{Weight of dried plant powder (g)} \times 100\%$$

F. Preliminary Phytochemical Analysis (Table I)

Preliminary tests were analyzed for both primary metabolites and secondary metabolites such as Protein, Carbohydrates, Flavonoids, Glycosides, Alkaloids, Tannins, Saponins, Phenolic compound using the procedure followed has been previously described [11, 12]

Table I
Preliminary Phytochemicals screening

Test	Procedure	Observation (Indicating Positive test)
Detection of alkaloids		
Wagner's test	Few ml filtrate + 1-2 drops of *Wagner's reagent* (Along the sides of test tube)	A brown/reddish precipitate
Detection of Carbohydrates		
Molish's test	2ml filtrate + 2 drops of alcoholic α–naphthol + 1ml conc. H_2SO_4 (along the sides of test tube)	A violet ring
Detection of Reducing sugars		
Fehling's test	1ml each of Fehling's solution A & B + 1ml filtrate + boiled in water bath	A red precipitate
Detection of Glycosides		
Salkowski's test	Crude extract was mixed with 2ml of chloroform. Then 2ml of conc. H_2SO_4 was added carefully and shaken gently	A reddish brown colour
Detection of Cardiac Glycosides		
Keller-Killani test	1ml filtrate + 1.5ml glacial acetic acid + 1 drop of 5% ferric chloride + conc. H_2SO_4 (along the side of test tube)	A blue coloured solution (in acetic acid layer)
Detection of Proteins and Amino acids		
Xanthoproteic test	Plant extract + Few drops of conc. Nitric acid	A yellow-coloured sol.
Ninhydrin test	2ml filtrate + 2 drops of Ninhydrin soln (10mg ninhydrin + 200ml acetone)	A purple-coloured sol. {Amino acids}

Detection of Flavonoids		
Ferric chloride test	Extract aqueous solution + few drops 10% ferric chloride solution	A green precipitate
Conc. H_2SO_4 test	Plant extract + conc. H_2SO_4	An orange colour
Alkaline reagent test	Plant extract + 10% ammonium hydroxide sol.	A yellow fluorescence
Lead acetate test	1ml plant extract + few drops of 10% lead acetate solution	A yellow precipitate
Detection of Phenolic compounds		
Lead acetate test	Plant extract is dissolved in 5ml distilled water + 3ml of 10% lead acetate sol.	A white precipitate
Ellagic Acid Test	Plant extract aqueous solution + 5% glacial acetic acid + 5% sodium nitrite solution	Solution turns muddy / Niger brown precipitate
Ferric chloride test	Extract aqueous solution + few drops 5% ferric chloride sol.	Dark green/bluish black colour
Gelatin test	Plant extract is dissolved in 5ml distilled water + 1% gelatin solution + 10% NaCl	A white precipitate
Detection of Tannins		
10% NaOH test	0.4ml plant extract + 4ml 10% NaOH + shaken well	Formation of emulsion {Hydrolysable tannins}
Gelatin test	Plant extract is dissolved in 5ml distilled water + 1% gelatin solution + 10% NaCl	A white precipitate
Detection of Carboxylic acid		
Effervescence test	1ml plant extract + 1ml sodium bicarbonate solution	Appearance of Effervescence
Detection of Saponins		
$NaHCO_3$ test	Plant extract + few ml sodium bicarbonate solution + distilled water (vigorously shaken)	Stable honeycomb like froth
Detection of Phytosterols		
Hesse's response	5ml aq. extract + 2ml chloroform + 2ml conc. H_2SO_4	Pink ring / Red colour (in lower chloroform layer)
Acetic anhydride test	0.5ml plant extract + 2ml of acetic anhydride + 2ml conc. H_2SO_4	Change in colour from violet to blue/green
Detection of Cholesterol		
Cholesterol test	2ml extract + 2ml chloroform + 10 drops of acetic anhydride + 2-3 drops of conc. H_2SO_4	A red-rose colour
Detection of Terpinoides		
Terpinoides test	2ml chloroform + 5ml plant extract, (evaporated on water bath) + 3ml conc. H_2SO_4 (boiled on water bath)	A grey coloured solution
Detection of Triterpinoides		
Salkowski's test	Filtratef + few drops of conc. H_2SO_4 (Shaken well and allowed to stand)	Golden yellow layer (at the bottom)
Detection of Lignins		
Labat test	Extract solution + gallic acid	An olive-green colour
Detection of Quinones		
Conc. HCl test	Plant extract + conc. HCl	A green colour
Alcoholic KOH test	1ml plant extract + few ml alcoholic potassium hydroxide	Red to blue colour
Detection of Coumarins		
NaOH test	Plant extract + 10% NaOH + Chloroform	A yellow colour
Detection of Resins		

Acetic anhydride test	1ml plant extract + Acetic anhydride solution + 1ml conc. H_2SO_4	Orange to yellow
Detection of Fixed Oils and Fat		
Spot test/ Stain test	Little quantity of plant extract is pressed in between to filter papers	Oil stain on the paper

III. RESULTS

The investigation systematically assessed the efficiency and kinetics of solid-liquid extraction from a specific sample matrix across a panel of eleven solvents, maintaining a constant solvent-to-solid ratio of 1:6. The results, summarized in Table II, reveal a significant dependency of both the final percentage yield and the required extraction time on the intrinsic polarity and specific chemical properties of the solvent.

A. Solvent-dependent Extraction Yield

The extraction yield varied substantially among the different solvents. The highest yields were obtained with Benzene (2.98%), Methanol (2.79%), and Ethyl Acetate (2.57%). This pattern suggests that compounds of moderate polarity are highly abundant in the sample and exhibit high solubility in these particular solvents. Benzene, a nonpolar aromatic solvent, demonstrates a particularly strong affinity for specific lipophilic and moderately polar constituents. Similarly, the high yield achieved with methanol, a highly polar protic solvent, points to a substantial presence of polar phytochemicals, such as phenolic compounds and certain glycosides, within the plant material. The lowest extraction yields were observed with Chloroform (1.73%), Hexane (1.77%), and Toluene (1.80%). The low efficiency of these nonpolar solvents indicates a low concentration of highly nonpolar components in the sample extractable under these conditions. This highlights the selectivity of solvent-based extraction, where the nature of the solvent directly dictates the classes of compounds retrieved.

B. Extraction Kinetics and Efficiency

Extraction kinetics also differed markedly. The shortest extraction times were achieved with Benzene (369 min) and Petroleum Ether (370 min), which correlate with high extraction yields for these specific solvents. The rapid extraction suggests an efficient mass transfer of the targeted compounds from the solid matrix into the solvent phase. This can occur due to either a high concentration of readily accessible compounds or favourable solvent-solute interactions that promote rapid partitioning. Conversely, highly polar solvents such as Methanol (450 min), Water (445 min), and Ethanol (440 min) required significantly longer extraction times to reach equilibrium. This may be attributed to a slower diffusion process, where the solvent must penetrate the complex polysaccharide and protein matrix of the plant material to access and solubilize the more polar, and often more tightly bound, phytochemicals.

Table II
Effect of solvent type on percentage yield and extraction time

Solvents	Solvent Ratio	Percentage yield %	Extraction Time (min)
Methanol (MeOH)	1:6	2.79	450
Acetonitrile (ACN)	1:6	2.28	430
Ethanol (EtOH)	1:6	2.29	440
Acetone (Ace)	1:6	2.17	438
Petroleum Ether (pet ether)	1:6	2.54	370
Hexane	1:6	1.77	390
Benzene (Bz)	1:6	2.98	369
Toluene	1:6	1.80	380
Ethyl Acetate (EtOAc)	1:6	2.57	420
Chloroform ($CHCl_3$)	1:6	1.73	387
Water (H_2O)	1:6	2.18	445

C. Phytochemical Screening

Qualitative phytochemical screening was performed on a sample to detect the presence of various primary and secondary metabolites, with extracts prepared in different solvents ranging in polarity from nonpolar (petroleum ether) to highly polar (water) (Table III).

D. Alkaloids, carbohydrates, and glycosides

Alkaloids were detected in all organic solvent extracts via Wager's test but were absent in the aqueous extract, indicating their nonpolar or moderately polar nature (Fig. 1). Carbohydrates were broadly present, with a positive Molisch's test in all extracts except for water (Fig. 2). Conversely, reducing sugars were universally present, yielding a positive Fehling's test in all solvent extracts, including water (Fig. 3). This difference highlights the broader solubility of reducing sugars compared to other carbohydrate forms. Glycosides showed a similar solubility profile to alkaloids, with a positive Salkowski's test in all organic extracts but not in the aqueous extract (Fig. 4). In contrast, cardiac glycosides, detected via the Keller-Killiani test, were absent in methanol and water but present in all other organic solvents, suggesting a narrower range of solubility (Fig. 5).

E. Proteins

The absence of a positive Ninhydrin test in all extracts suggests a lack of free amino acids (Fig. 7). The Xanthoproteic test was positive only in acetone and petroleum ether extracts, indicating the selective extraction of specific proteins containing aromatic amino acids by these solvents (Fig. 6).

F. Phenolic Compounds and Flavonoids

Flavonoids demonstrated broad solubility, showing positive results in both the Ferric chloride and concentrated sulfuric acid tests across all solvents (Fig. 8). The Alkaline test produced a more selective result, with positive reactions in methanol, acetonitrile, acetone, petroleum ether, hexane, and water (Fig. 9). A positive Lead Acetate test for flavonoids was confined to the ethanol, acetone, and ethyl acetate extracts, underscoring the chemical diversity within the flavonoid class (Fig. 10).

Phenolic compounds also displayed varied solvent-dependent extraction. The Lead acetate test was positive in methanol, acetonitrile, ethanol, acetone, and water, while the Ferric chloride test was positive only in benzene, toluene, and ethyl acetate (Fig. 11, 13). The Ellagic and Gelatin test was negative across all extracts (Fig. 12, 14).

G. Other Phytochemical Classes

Tannins presented inconsistent results; the 10% NaOH test was positive in most extracts (excluding water), whereas the Gelatin test was negative across all solvents (Fig. 15, 16). This may indicate the presence of phenolic compounds that do not possess the specific protein-binding capacity of tannins. Carboxylic acid, Effervescence test were shown positive for all the solvent extract except for Benzene and aqueous extract (Fig. 17). Saponins were detected exclusively in the ethanol extract via the $NaHCO_3$ test (Fig. 18). Phytosterols were found only in the ethanol extract (Hesse's test) (Fig. 19), while the Acetic Anhydride test for phytosterols was negative in all extracts (Fig. 20). A general test for cholesterol was positive in most organic solvents but negative in acetonitrile, petroleum ether, and water (Fig. 21). Terpenoids and triterpenoids were consistently detected in all solvent extracts, including water. This widespread solubility, particularly in water, may be attributed to the presence of more polar, glycosylated forms (Fig. 22, 23).

Lignins (Fig. 24) and Resins (Fig. 28) showed high solubility across all organic solvents. Quinones were extracted by most solvents but were absent in petroleum ether, ethyl acetate, and water (Fig. 25, 26). Coumarins were present in methanol, acetonitrile, ethanol, and hexane extracts (Fig. 27). Oils and fats, as expected for nonpolar compounds, were generally extracted by most organic solvents but were absent in the more polar ethanol and water extracts (Fig. 29).

IV. DISCUSSION

The investigation into the extraction yields and phytochemical screening of cactus stem samples highlights the significance of solvent selection in phytochemical analysis. The results demonstrate that extraction yield and time are influenced by the solvent's polarity and chemical properties.

1) Solvent-Dependent Extraction Yield: The highest extraction yields obtained with benzene, methanol, and ethyl acetate suggest that compounds of moderate polarity are abundant in the sample. This is consistent with previous studies that have shown that solvents with moderate polarity are effective in extracting a wide range of phytochemicals [13]. The low extraction yields obtained with nonpolar solvents like chloroform and hexane indicate a low concentration of highly nonpolar components.

2) Extraction Kinetics and Efficiency: The extraction kinetics varied among solvents, with benzene and petroleum ether showing the shortest extraction times. This may be due to efficient mass transfer of targeted compounds [14]. Polar solvents like methanol and water required longer extraction times, possibly due to slower diffusion [15].
3) Phytochemical screening: The phytochemical screening of cactus stem samples revealed the presence of various primary and secondary metabolites, including alkaloids, carbohydrates, glycosides, phenolic compounds, and terpenoids. The results demonstrate the importance of solvent selection in phytochemical analysis.
4) Alkaloids: Detected in all organic solvent extracts, consistent with their nonpolar or moderately polar nature [16]. This is in line with previous studies that have shown that alkaloids are often extracted with nonpolar or moderately polar solvents [13].
5) Carbohydrates: Broadly present, with reducing sugars showing universal presence [17]. The difference in solubility between reducing sugars and other carbohydrate forms may be attributed to their chemical structure and properties [18].
6) Glycosides: Showed similar solubility profile to alkaloids, with cardiac glycosides displaying narrower solubility [19]. This suggests that glycosides may have specific solubility properties that need to be considered in phytochemical analysis.
7) Absence of free amino acids: Suggested by negative Ninhydrin test results [20]. This may indicate that the proteins in the cactus stem sample are not readily accessible or are bound to other compounds.
8) Selective extraction of proteins: Indicated by positive Xanthoproteic test results in acetone and petroleum ether extracts [21]. This suggests that specific proteins containing aromatic amino acids may be selectively extracted by these solvents.
9) Flavonoids: Demonstrated broad solubility, with varied results across different tests [22]. This is consistent with previous studies that have shown that flavonoids have diverse chemical structures and properties [23].
10) Phenolic compounds: Displayed varied solvent-dependent extraction, consistent with diverse chemical structures [24]. This highlights the importance of considering the chemical properties of phenolic compounds in phytochemical analysis.
11) Tannins: Presented inconsistent results, possibly indicating presence of phenolic compounds without protein-binding capacity [25].
12) Saponins and phytosterols: Detected exclusively in ethanol extract, suggesting specific solubility properties [26, 27].
13) Terpenoids and triterpenoids: Consistently detected in all solvent extracts, including water, possibly due to polar, glycosylated forms [28].
14) Lignins and Resins: Lignins and resins showed high solubility across all organic solvents, consistent with their complex and diverse chemical structures [29]. This is in line with previous studies that have shown that lignins and resins are often extracted with nonpolar or moderately polar solvents [30].
15) Quinones: Quinones were extracted by most solvents but were absent in petroleum ether, ethyl acetate, and water. This suggests that quinones may have specific solubility properties that need to be considered in phytochemical analysis [31].

Table III
Qualitative phytochemical screening of extracts obtained using different solvents

Tests	MeOH	ACN	EtOH	Ace	pet ether	Hexane	Bz	Toluene	EtOAc	$CHCl_3$	H_2O
Alkaloids											
Wager's Test	+	+	+	+	+	+	+	+	+	+	-
Carbohydrates											
Molisch's test	+	+	+	+	+	+	+	+	+	+	-
Reducing sugars											
Fehling's test	+	+	+	+	+	+	+	+	+	+	+
Glycosides											
Salkowski's Test	+	+	+	+	+	+	+	+	+	+	-
Cardiac Glycosides											
Keller-killani test	-	+	+	+	+	+	+	+	+	+	-
Proteins											
Xanthoproteic test	-	-	-	-	+	+	-	-	-	-	-
Ninhydrin test	-	-	-	-	-	-	-	-	-	-	-
Flavonoids											
Ferric chloride test	+	+	+	+	+	+	+	+	+	+	+

Conc H_2SO_4	+	+	+	+	+	+	+	+	+	+	+
Alkaline Test	+	+	-	+	+	+	-	-	-	-	+
Lead Acetate test	-	-	+	+	-	-	-	-	-	+	-
Phenolic compounds											
Lead acetate test	+	+	+	+	+	-	-	-	-	-	+
Ellagic test	-	-	-	-	-	-	-	-	-	-	-
Ferric chloride test	-	-	-	-	-	-	+	+	+	-	-
Gelatin Test	-	-	-	-	-	-	-	-	-	-	-
Tannins											
10% NAOH Test	+	+	+	+	+	+	+	+	+	+	-
Gelatin test	-	-	-	-	-	-	-	-	-	-	-
Carboxylic acid											
Effervescence test	+	+	+	+	+	+	-	+	+	+	-
Saponins											
$NaHCO_3$ Test	-	-	+	-	-	-	-	-	-	-	-
Phytosterols											
Hesse's Test	-	-	+	-	-	-	-	-	-	-	-
Acetic Anhydride Test	-	-	-	-	-	-	-	-	-	-	-
Cholesterol	+	-	+	+	-	+	+	+	+	+	-
Terpinoides	+	+	+	+	+	+	+	+	+	+	+
Triterpinoides											
Salkowski's Test	+	+	+	+	+	+	+	+	+	+	+
Lignins											
Labtat test	+	+	+	+	+	+	+	+	+	+	-
Quinones											
Conc HCl	+	+	+	+	+	-	+	+	+	-	-
Alcoholic test	-	-	-	-	-	-	-	-	-	-	-
Coumarins											
NaOH Test	+	+	+	+	-	+	+	-	-	-	-
Resins											
Acetic Anhydride test	+	+	+	+	+	+	+	+	+	+	+
Oils and Fats											
Spot Test/ Stain Test	+	+	-	+	+	+	+	+	+	+	-

Note: '+' *Positive for test;* '-' *Negative for test*

Fig 1. Alkaloids (Wager's Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

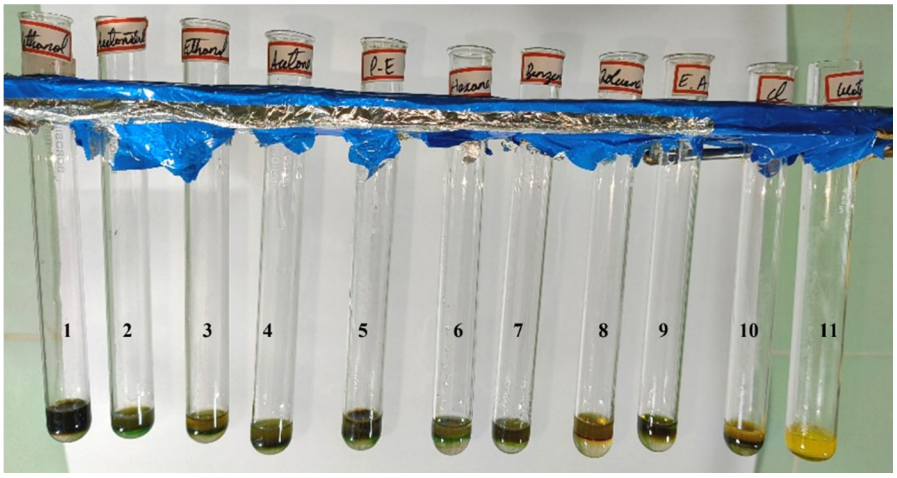

Fig. 2. Carbohydrates (Molisch's test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

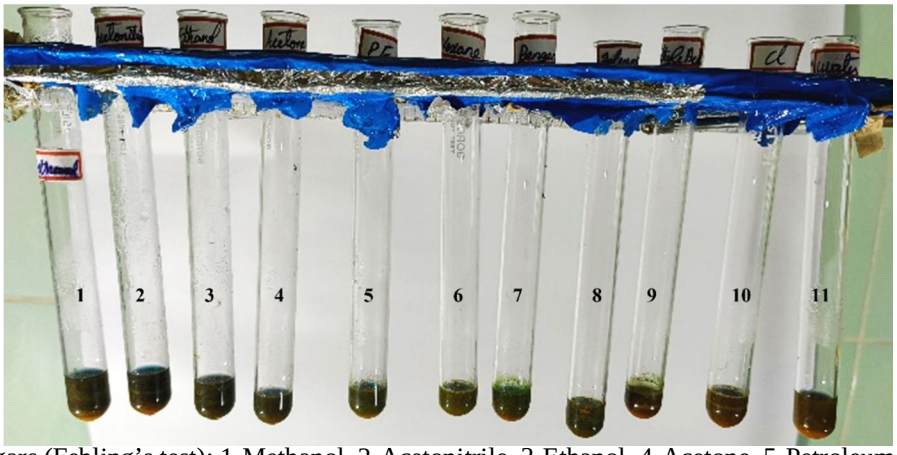

Fig. 3. Reducing sugars (Fehling's test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

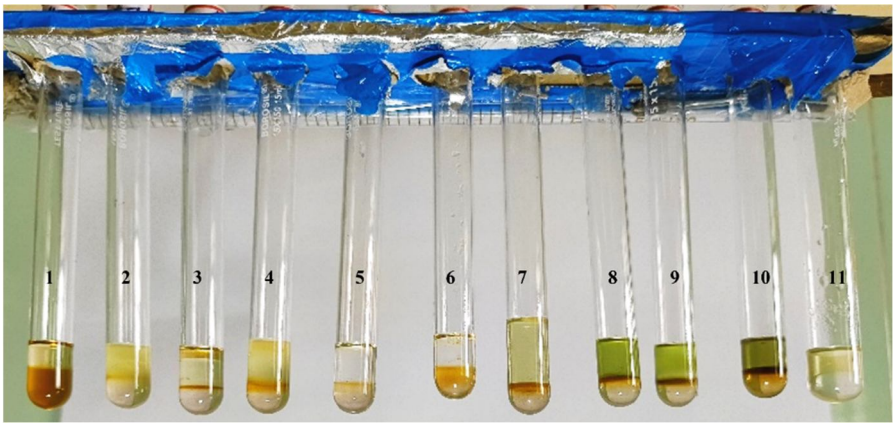

Fig. 4. Glycosides (Salkowski's Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

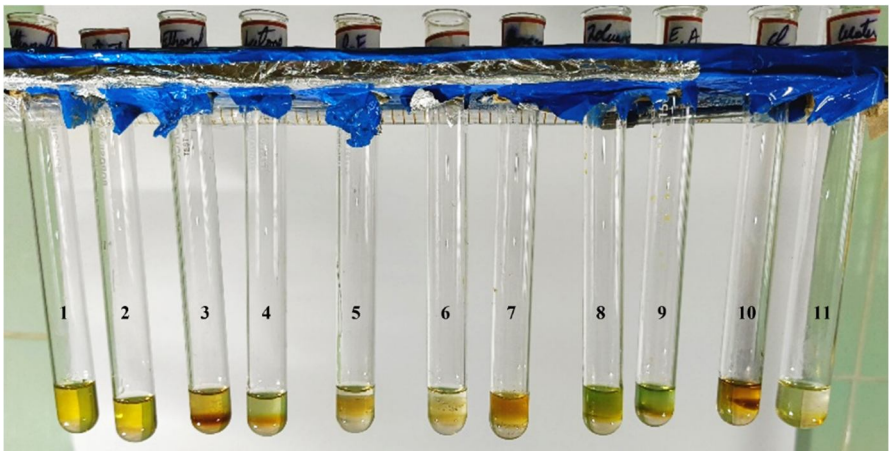

Fig. 5. Cardiac Glycosides (Keller-killani test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

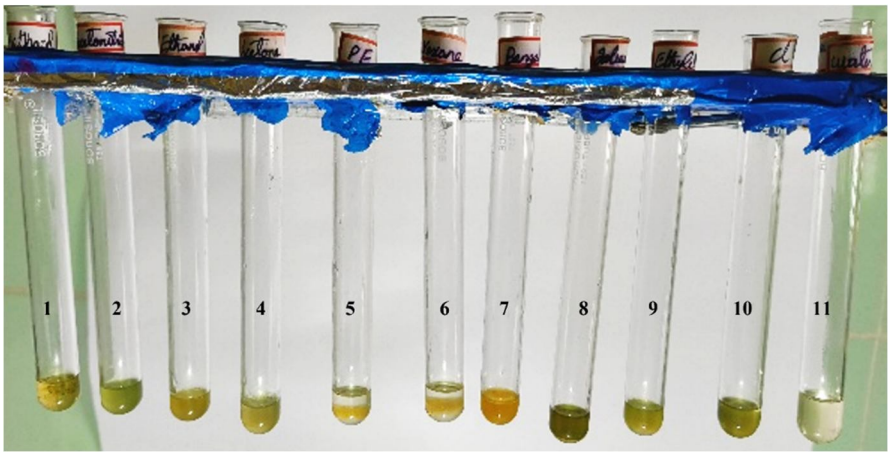

Fig. 6. Proteins (Xanthoproteic test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

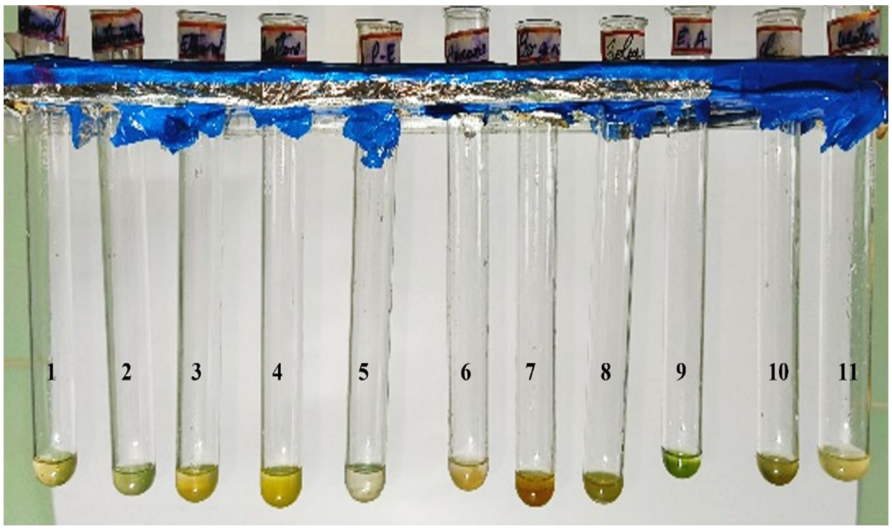

Fig. 7. Proteins (Ninhydrin test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

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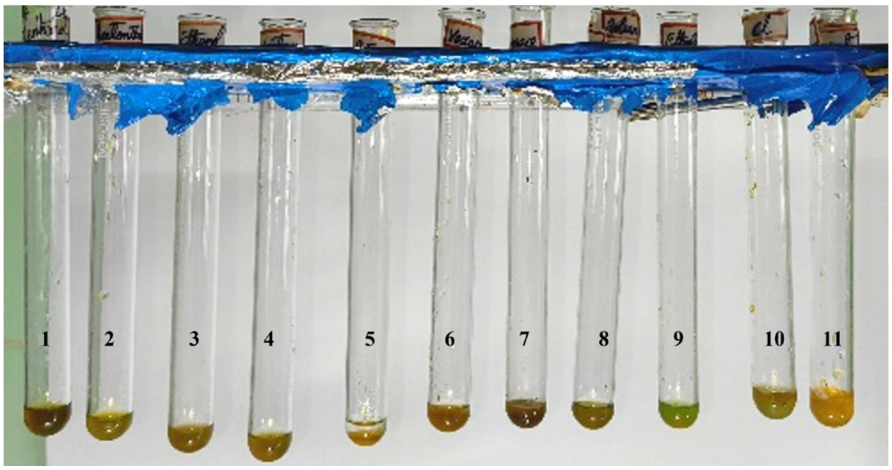

Fig. 8. Flavonoids (Ferric chloride test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

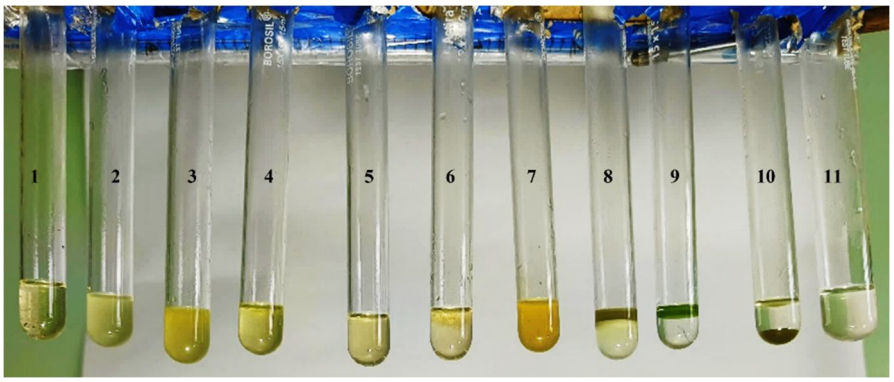

Fig. 9. Flavonoids (Alkaline Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

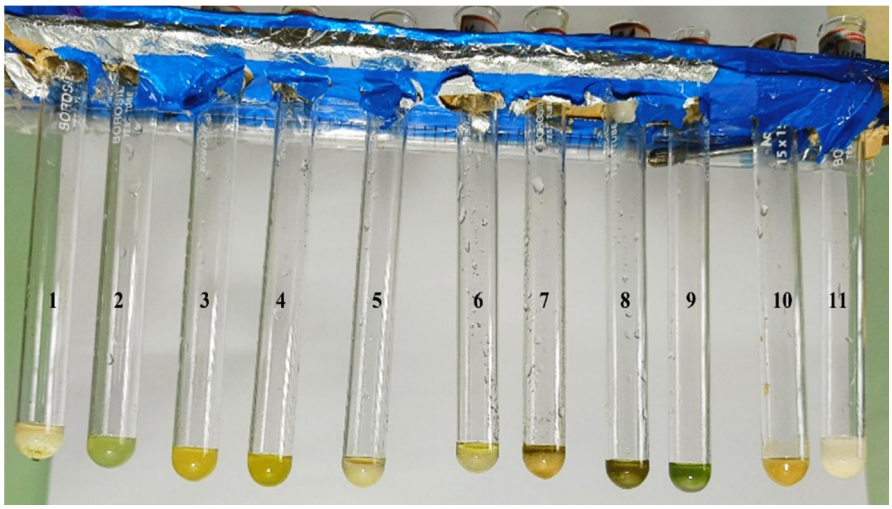

Fig. 10. Flavonoids (Lead Acetate test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

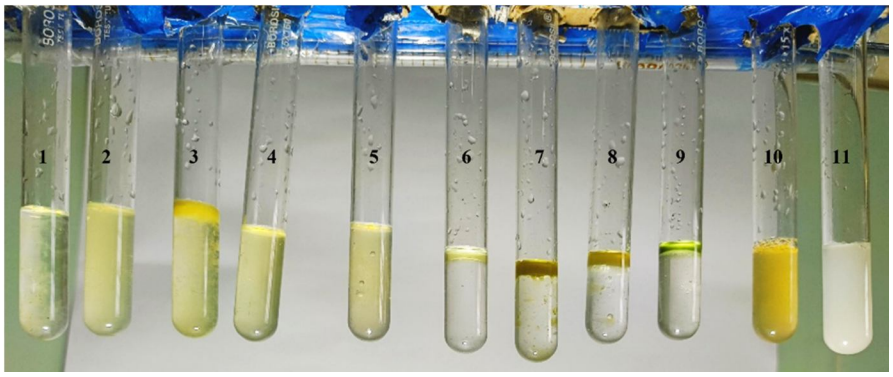

Fig. 11. Phenolic compounds (Lead acetate test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

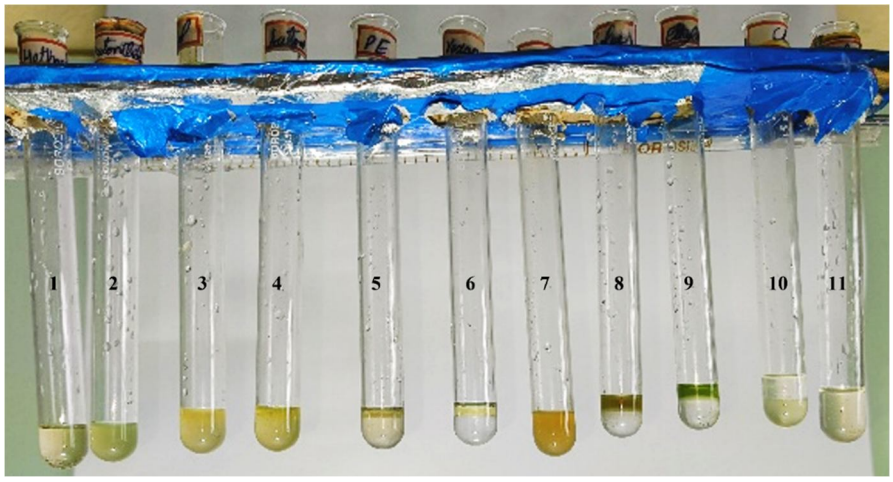

Fig. 12. Phenolic compounds (Ellagic test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

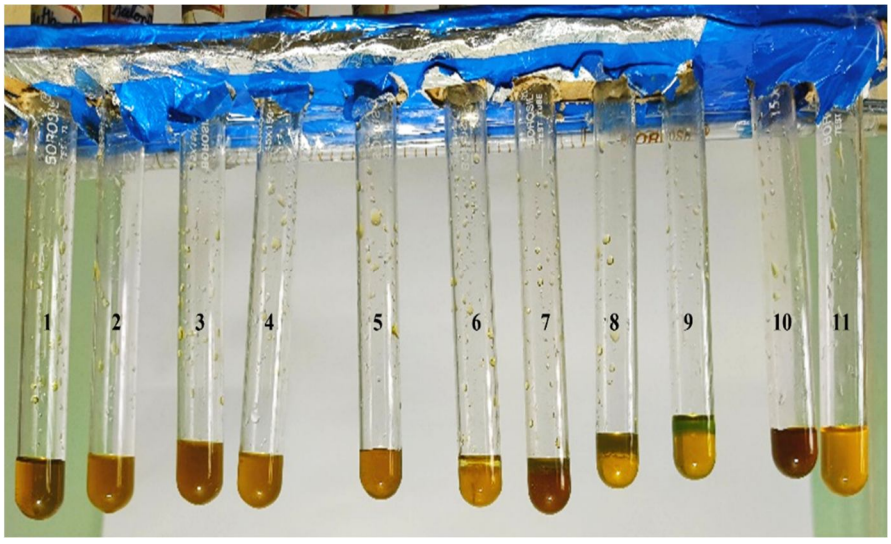

Fig. 13. Phenolic compounds (Ferric chloride test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

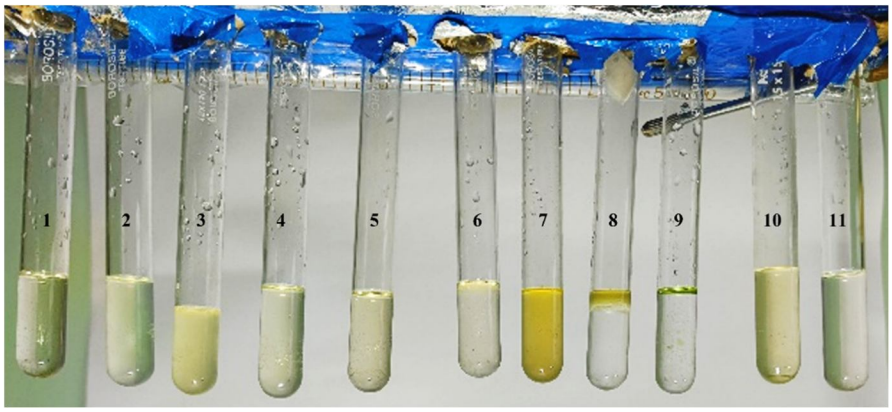

Fig. 14. Phenolic compounds (Gelatin Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

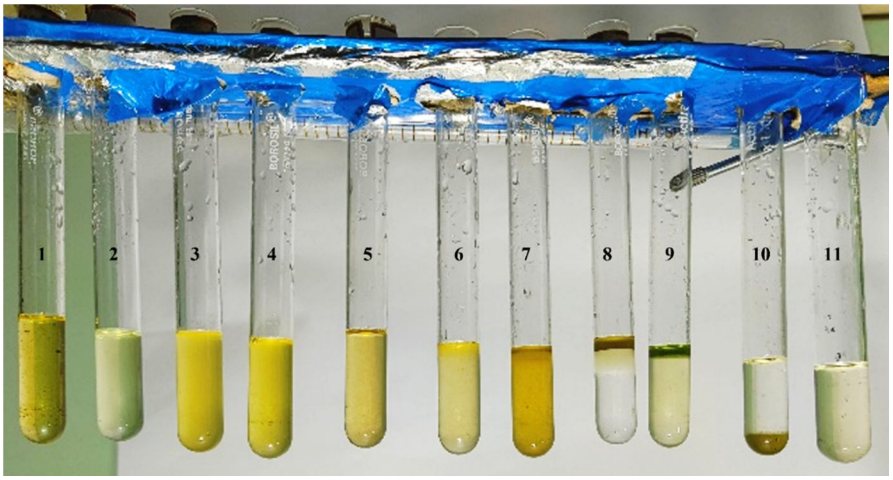

Fig. 15. Tannins (10% NaOH Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

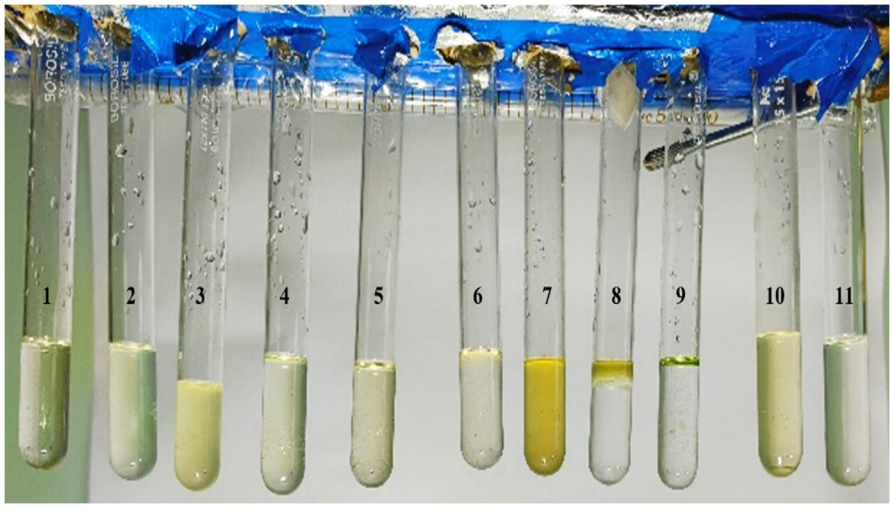

Fig. 16. Tannins (Gelatin Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

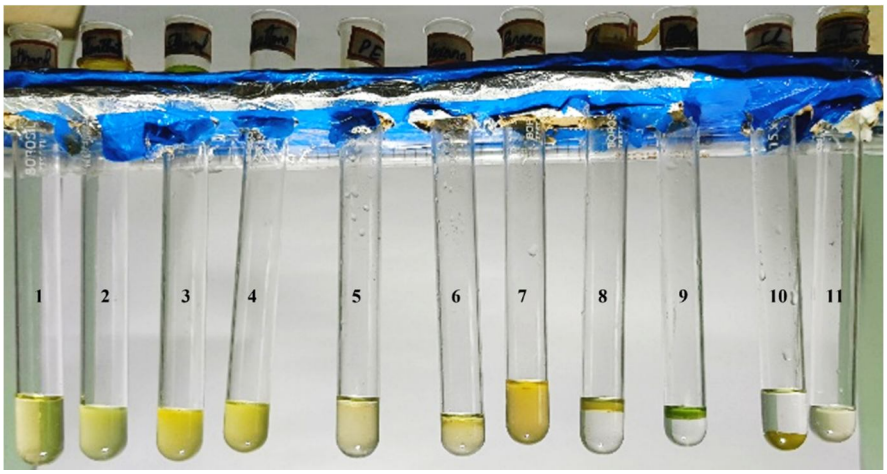

Fig. 17. Carboxylic acid (Effervescence test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

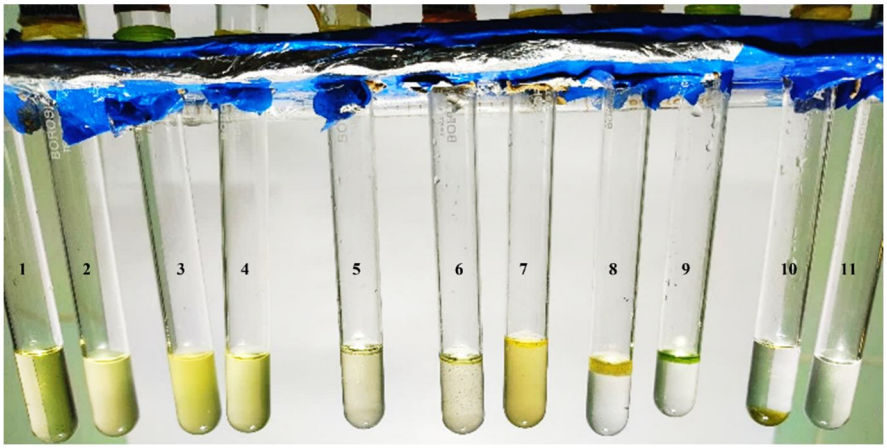

Fig. 18. Saponins (NaHCO3 Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

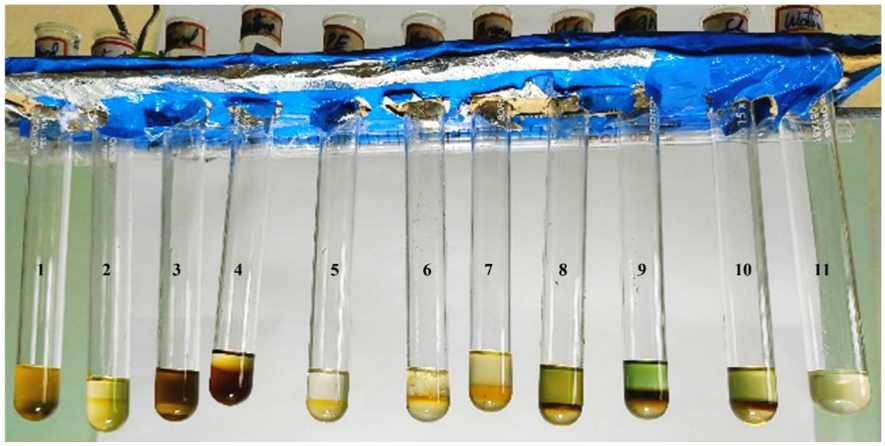

Fig. 19. Phytosterols (Hesse's Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

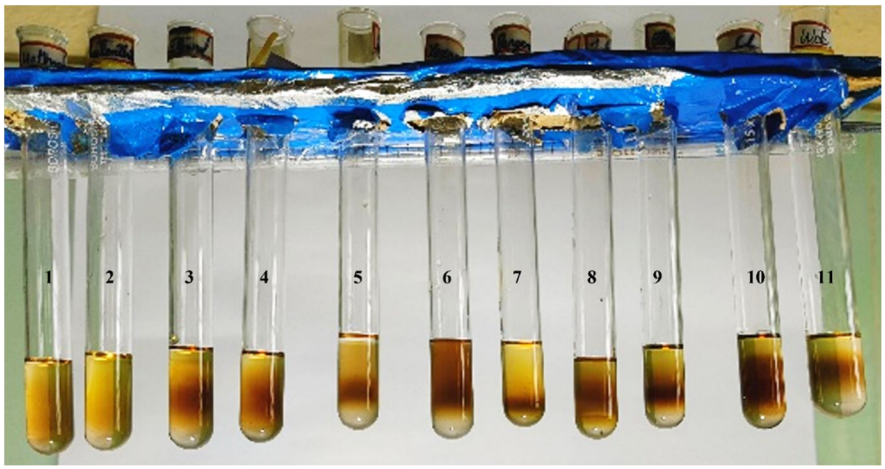

Fig. 20. Phytosterols (Acetic Anhydride Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

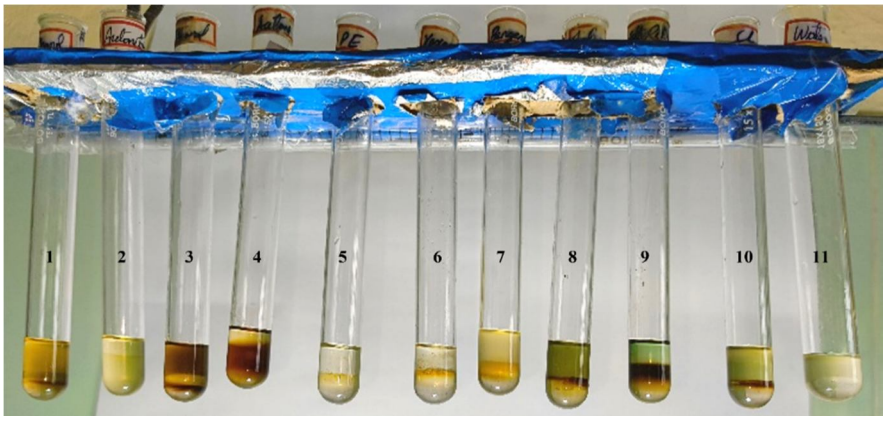

Fig. 21. Cholesterol: 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

Fig. 22. Terpinoides: 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

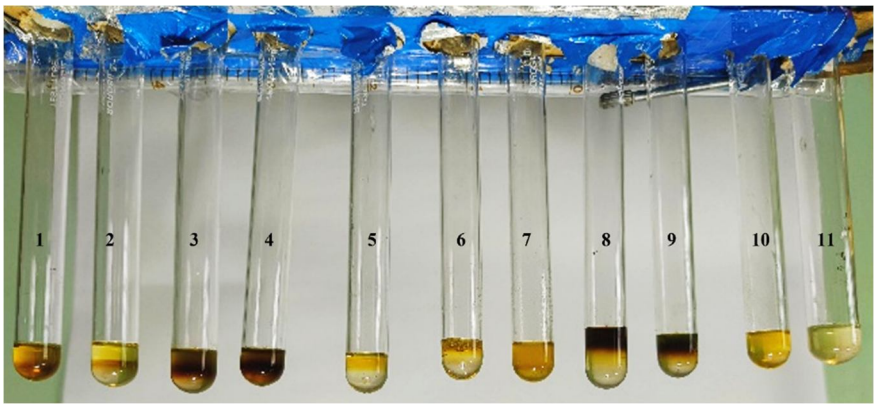

Fig. 23. Triterpinoides (Salkowski's Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

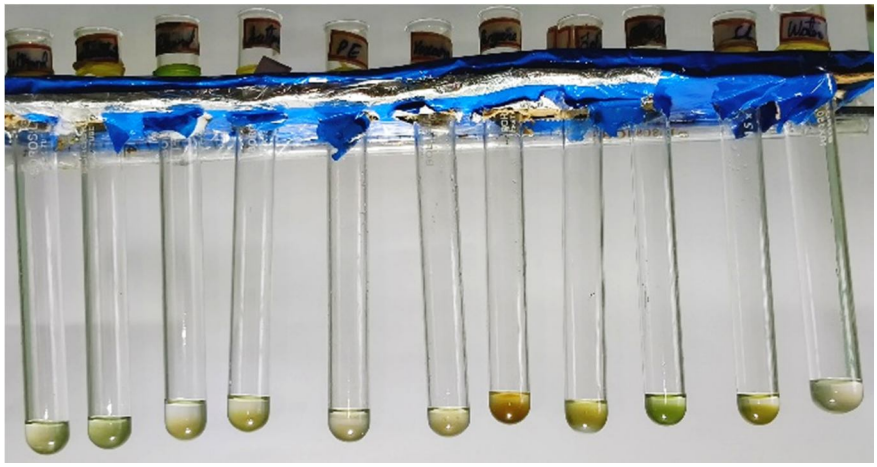

Fig. 24. Lignins (Labtat test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

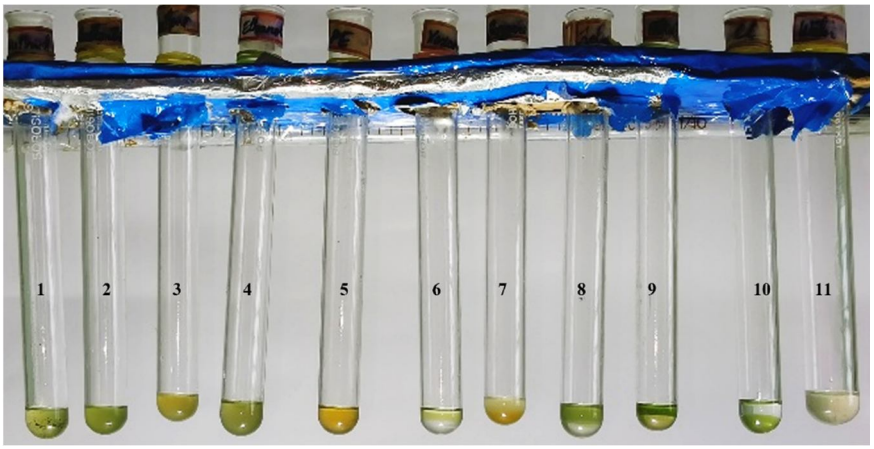

Fig. 25. Quinones (Conc HCl Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

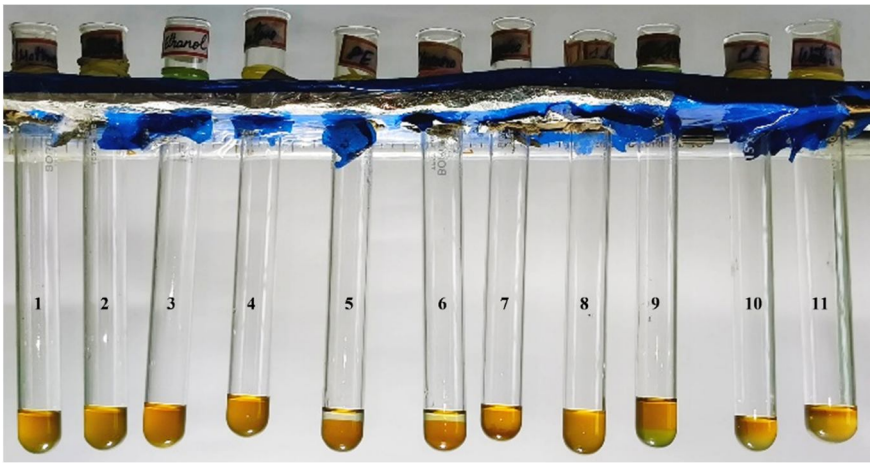

Fig. 26. Quinones (Alcoholic test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

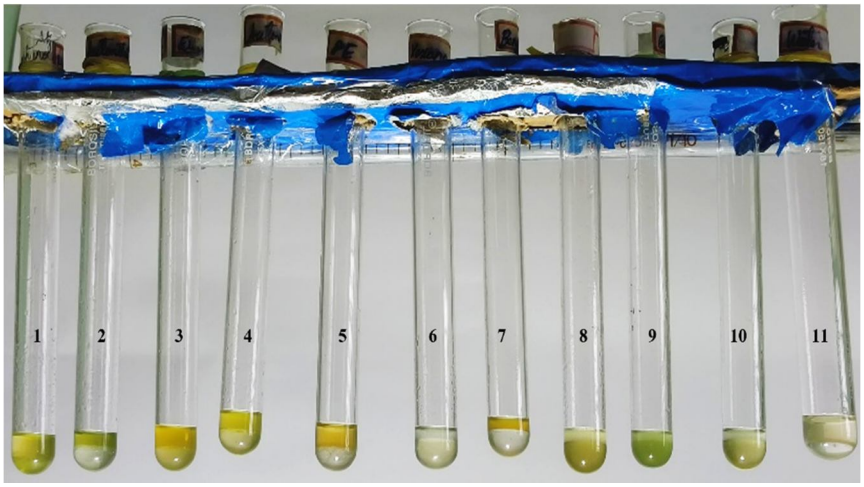

Fig. 27. Coumarins (NaOH Test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

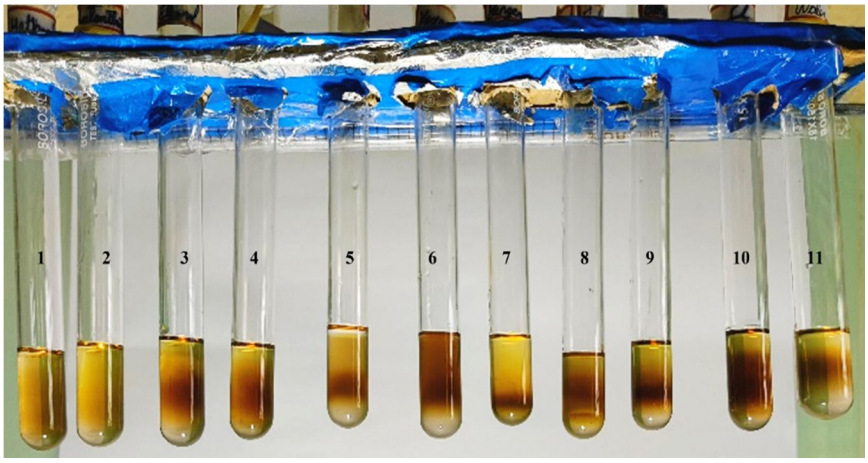

Fig. 28. Resins (Acetic Anhydride test): 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

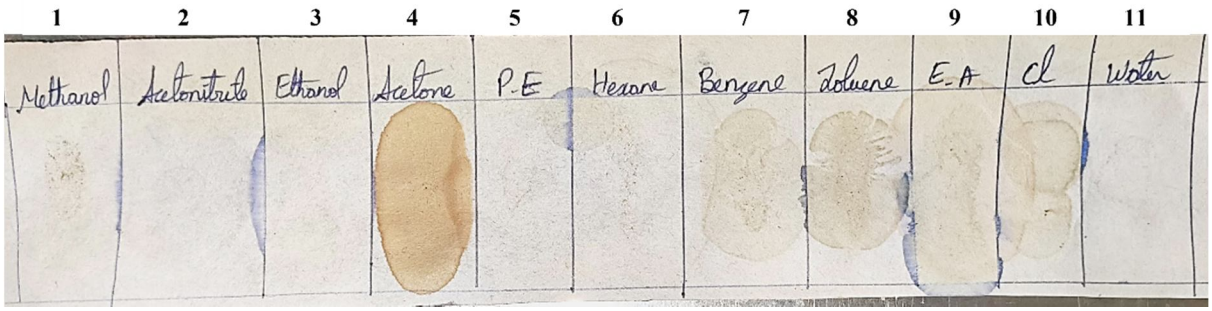

Fig. 29. Fats and Oil Test: 1-Methanol, 2-Acetonitrile, 3-Ethanol, 4-Acetone, 5-Petroleum Ether, 6-Hexane, 7-Benzene, 8-Toluene, 9-Ethyle Acetate, 10- Chloroform, 11- Water

Coumarins: Coumarins were present in methanol, acetonitrile, ethanol, and hexane extracts, consistent with their diverse chemical structures and properties [32]. This highlights the importance of considering the chemical properties of coumarins in phytochemical analysis.

Oils and Fats: Oils and fats were generally extracted by most organic solvents but were absent in the more polar ethanol and water extracts, consistent with their nonpolar nature [33]. This is in line with previous studies that have shown that oils and fats are often extracted with nonpolar solvents [34].

V. CONCLUSION

The selectivity and efficiency of solid-liquid extraction from the cactus stem are fundamentally governed by the solvent's intrinsic properties. Highest yields were obtained with solvents of moderate to high polarity, which correlated with the detection of a diverse phytochemical profile, including flavonoids, terpenoids, and alkaloids. The differential solubility of specific compound classes was evident, with cardiac glycosides and alkaloids showing limited or no extraction in aqueous and highly polar solvents, respectively. Furthermore, extraction kinetics were shown to be inversely proportional to solvent polarity, suggesting that process optimization strategies, such as sequential or multi-solvent extraction, could be employed to maximize the isolation of specific phytochemical classes based on their solubility profiles. This work provides a foundation for developing targeted and efficient extraction protocols.

VI. ACKNOWLEDGEMENT

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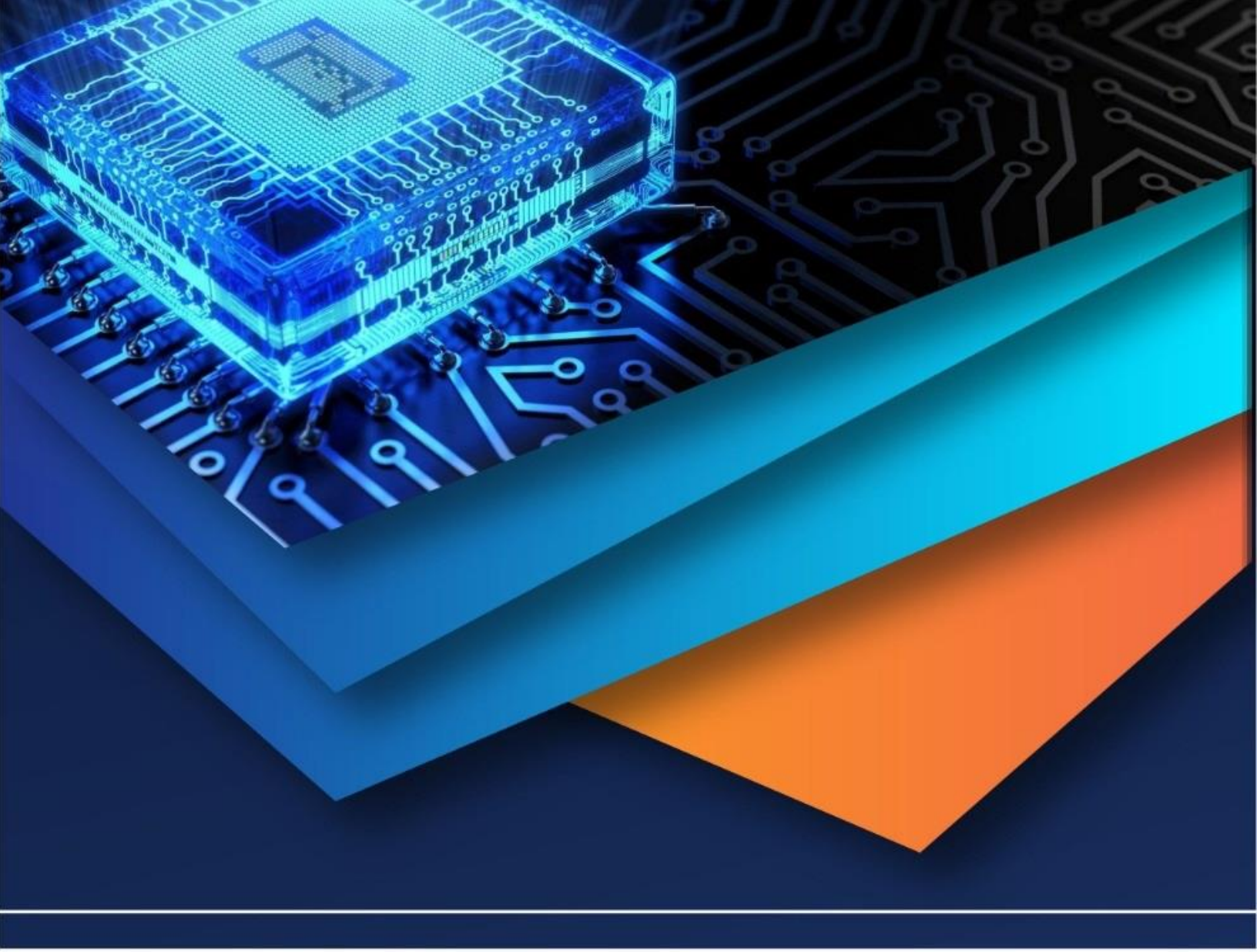

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