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Comparative Nootropic Activity of Krishna Jeeraka (*Carum carvi* Linn.) and Shweta Jeeraka (*Cuminum cyminum* Linn.) W.S.R. to Medhya Karma in Albino Rats

Dr. Abhishek[1], Dr. Dharani[2], Dr. Sampathkumar Bellamma[3], Dr. Shivananda B Karigar[4], Dr. Rajashekhar S Ganiger[5]
[1]*Final year PG scholar, Department of Dravyaguna, TGAMC, Ballari, RGUHS Karnataka*
[2]*Associate Proff, Department of Dravyaguna, TGAMC, Ballari, RGUHS Karnataka*
[3]*Associate Proff, Department of Dravyaguna, GAMC, Bengaluru, RGUHS Karnataka*
[4]*Assistant Proff, Department of Dravyaguna, TGAMC, Ballari, RGUHS Karnataka*
[5]*Proff and HOd, Department of Dravyaguna, TGAMC, Ballari, RGUHS Karnataka*

Abstract: ***Mental health is an essential component of overall well-being and significantly influences quality of life, productivity, and longevity. The global prevalence of cognitive and neurodegenerative disorders such as dementia and Alzheimer's disease is steadily increasing, and current management primarily relies on synthetic nootropic and psychotropic drugs that may produce adverse effects on long-term use. Ayurveda describes Medhya dravyas that enhance Dhee, Dhriti, and Smriti, offering safer therapeutic alternatives. Jeeraka, though traditionally indicated for Deepana and Pachana karma, is also described to possess Medhya karma. The present study was undertaken to evaluate and compare the nootropic activity of Krishna Jeeraka and Shweta Jeeraka with reference to Medhya karma using an experimental animal model. Healthy albino rats were divided into four groups: control, standard (Piracetam 200 mg/kg), Krishna Jeeraka churna (540 mg/kg), and Shweta Jeeraka churna (540 mg/kg). Memory impairment was induced using Scopolamine (8 mg/kg), and learning and memory were assessed using the Morris Water Maze test by evaluating spatial acquisition, reference memory, working memory, long-term memory, and amnesia. Statistical analysis was performed using one-way ANOVA followed by Dunnett's test. Both Krishna Jeeraka and Shweta Jeeraka produced significant improvement in learning and memory parameters compared to the control group ($p < 0.05$), and their effects were comparable to the standard drug. Krishna Jeeraka demonstrated relatively better efficacy in Grahana, Dharana, and Smarana shakti, whereas Shweta Jeeraka showed comparatively better effect on Grahana shakti. The study concludes that both varieties of Jeeraka possess significant nootropic activity, thereby validating their Medhya karma, with Krishna Jeeraka showing slightly superior cognitive enhancement.***

Keywords: Krishna Jeeraka; Shweta Jeeraka; Medhya Karma; Nootropic Activity; Morris Water Maze.

I. INTRODUCTION

Health, as defined by the WHO, is a state of complete physical, mental, and social well-being[1]. Mental health is fundamental to emotional balance, cognitive efficiency, and quality of life, governing perception, learning, memory, and decision-making. In the modern era of stress and altered lifestyles, mental health disorders have become a major global challenge. Nearly 10% of the world's population suffers from mental or neurological disorders. Dementia, including Alzheimer's disease, is rising rapidly and is expected to triple by 2050[2], with cognitive impairments appearing even in younger individuals due to chronic stress and lifestyle factors. In modern medicine, various Nootropic agents such as Piracetam, Donepezil etc, are used to enhance memory and cognitive functions. Although these drugs show measurable benefits, their long-term use is often limited due to adverse effects including insomnia, gastrointestinal disturbances, mood alterations and dependency. Therefore, there is a growing need to explore safe, natural and effective alternatives for improving memory and learning ability without adverse reactions. Ayurveda, the ancient Indian science of life, describes health as the state of equilibrium between Dosha, Dhatu and Mala along with a balanced state of Agni, Atma, Indriya and Manas[3]. Disturbance in any of these components leads to disease. Among them, Manas (mind) plays a crucial role in maintaining both physical and psychological balance.

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Medha refers to the ability of comprehension, analysis, and retention which closely resembles modern cognitive functions like learning and memory. Medhya karma is advocated in the treatment of diseases involving Smritinasha such as Unmada, Apasmara etc.

Krishna Jeeraka and Shweta Jeeraka are two Medhya Dravyas which are widely used for their actions like Deepana, Pachana etc. Both Jeeraka are easily available, cost effective, commonly used as both Ahara and Aushadha. Hence, the present study has been undertaken with the aim of evaluating their Nootropic activity under the title "COMPARATIVE NOOTROPIC ACTIVITY OF KRISHNA JEERAKA (Carum carvi Linn.) AND SHWETA JEERAKA (Cuminum cyminum Linn.) W.S.R. TO MEDHYA KARMA IN ALBINO RATS''.

II. AIM OF THE STUDY

To compare Nootropic activity of Krishna Jeeraka (Carum carvi Linn.) and Shweta Jeeraka (Cuminum cyminum Linn.) vis-a-viz Medhya karma in wistar albino rats using Morris water maze test.

III. OBJECTIVES OF THE STUDY

1) To carry out preliminary pharmacognostic and phytochemical analysis of Krishna Jeeraka (Carum carvi Linn.) and Shweta Jeeraka (Cuminum cyminum Linn.)
2) To evaluate and compare nootropic activity of Krishna Jeeraka (Carum carvi Linn.) and Shweta Jeeraka (Cuminum cyminum Linn.) in wistar albino rats.

IV. REVIEW OF LITERATURE

Shweta Jeeraka (*Cuminum cyminum* Linn.) and Krishna Jeeraka (*Carum carvi* Linn.) are important Ayurvedic drugs belonging to Umbelliferae family[4]. Both possess katu rasa, laghu and ruksha guna, katu vipaka, ushna veerya, and vatakaphahara properties, indicating their similar pharmacological actions. In classical literature, Acharya Charaka has included Shweta Jeeraka under Shoolaprashamana Dashaimani[5], while Acharya Sushruta has described it under Pippalyadi Gana, highlighting the therapeutic significance of Jeeraka in alleviating pain and digestive disorders. Furthermore, Bhavaprakasha, Kaiyadeva, and Madanapala Nighantus have mentioned the Medhya Karma of Jeerakatraya**,** indicating its role in enhancing intellect and cognitive functions.

The term Medha is derived from the root "Medh Sangame," denoting the capacity to collect and retain knowledge, while Medhya refers to substances that enhance intellectual and cognitive functions[6]. Nootropic drugs enhance cognitive functions such as memory, learning, attention, and mental performance through neurochemical modulation and neuroprotection.

V. METHODOLOGY

This study was undertaken in two phases:

1) Analytical study of trial drugs
2) Experimental study

Collection, Authentication and Preparation of trial drugs:

- *Source of drugs:* Botanically identified raw drug samples of Krishna Jeeraka (*Carum carvi* Linn.) seeds and Shweta Jeeraka (*Cuminum cyminum* Linn.) seeds were collected from regional market.
- *Authentication of drugs:* The collected raw drugs of Krishna Jeeraka (*Carum carvi* Linn.) seeds and Shweta Jeeraka (*Cuminum cyminum* Linn.) seeds were verified under the guidance of experts from the Dept. of Dravyaguna, Taranath Government Ayurvedic Medical College and Hospital Ballari, Karnataka.
- *Preparation of Drugs:* The botanically identified and authenticated raw drug samples of Krishna Jeeraka (*Carum carvi* Linn.) seeds and Shweta Jeeraka (*Cuminum cyminum* Linn.) seeds were dried under the shade in clean devoid of excessive cold, hot and wet temperature for 5-6 days. The dried seeds were made into churna at Dept. of Dravyaguna, TGAMC Ballari, Karnataka. The churna was sieved again through 100 no. sieve and stored in air tight container.

A. *Analytical Evaluation of the trial Drugs*

1) *Macroscopic Evaluation:* The Macroscopic characters (Sensory evaluation) of the trial drugs Krishna Jeeraka (*Carum carvi* linn.) beeja and Shweta Jeeraka (*Cuminum cyminum* linn.) beeja were carried out for Shabda, Sparsha, Roopa, Rasa and Gandha.

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2) *Microscopic Evaluation:* For transverse section analysis, the trial drugs were soaked in water to soften the tissues, thin sections were cut, stained with safranin, mounted in glycerin, and examined under a Zeiss AXIO trinocular microscope with Zeiss Axio Cam in bright-field illumination. For powder microscopy, a small quantity of sieved powdered drug was mounted in glycerin and the diagnostic characters were observed under the same microscope.
3) *Physicochemical Analysis:* The Physico-chemical analytical tests viz. Foreign matter, Total ash, Acid insoluble ash, Water soluble extractive value, Alcoholic soluble extractive value, were carried out as per the standard procedures of API.
4) *Phytochemical Analysis:* The Phytochemical tests for the detection of Alkaloids, Carbohydrates, Steroids, Saponins, Tannins, Flavonoids, Phenols, Coumarins, Triterpenoids, Amino acids, Carboxylic Acid Resins, and Quinones were carried out as per the standard procedures of API.
5) *Chromatographic evaluation:* One gram each of powdered Krishna Jeeraka and Shweta Jeeraka was extracted with 10 ml n-hexane by cold percolation for 24 h and filtered. Aliquots of 3, 6, and 9 µl were applied on silica gel F254 plates and developed using toluene:ethyl acetate (9.3:0.7). Plates were visualized under UV, derivatised with anisaldehyde–sulphuric acid, scanned at 620 nm, and Rf values and spot characteristics were recorded.

B. Experimental Study

1) Experimental Model

Morris Water Maze Test For Learning And Memory Assessment[7]

2) Methodology

❖ *Animal source*

The required numbers of healthy albino rats of either sex were procured from the animal house attached to Pharmacology laboratory of SDM Centre for Research in Ayurveda and Allied Sciences, Kuthpady, Udupi, Karnataka. The facility is registered with and approved by the CPCSEA (Committee for the Purpose of Control and Supervision of Experiments on Animals), Government of India.

❖ *Locale of work*

The experimental study was carried out at Pharmacology laboratory of SDM Centre for Research in Ayurveda and Allied Sciences, Kuthpady, Udupi, Karnataka.

❖ *Ethical clearance*

The experiment was carried out in conformity with the Institutional Animal Ethical Committee (IAEC) after obtaining its permission with reference number – SDMCRA/IAEC/TG-B-11. All the procedures performed were in accordance with Committee for Purpose of Control and Supervision of Experiments on Animals (CPCSEA) guidelines, under Ministry of Animal Welfare Division, Government of India, New Delhi.

❖ *Preparation of the cages*

The standard guidelines for the housing and feeding of the animals mentioned in the OECD guidelines were followed. The size of cages was 23cm×21cm, 682sqcm consisting of 6 rats in each cage.

3) Maintenance of cages

All the cages used for the experiments were cleaned with the detergent before the commencement of the study and once in three days thereafter till the end of the experiment. Paddy husk was used as bedding material. The cages were labelled with the number of animals and dosage groups.

❖ *Selection of animals*

All the wistar albino rats were subjected to general checkup for sex and weight. The animals with abnormal behavior and health were excluded.

Inclusion criteria

Adult healthy wistar albino rats of either sex,
weighing between 150 – 200gm were selected.

Exclusion criteria

Rats weighing below 150gm and above 200gm
Pregnant, diseased rats
Rats that have undergone other experiments were excluded from the study.

4) Preparation of animals

Animal house conditions

Temperature in the animal experimental room was maintained at 23 ± 1°C, with humidity between 50-70%. Daily lighting sequence of 12 hours light and 12 hours dark was maintained. The maximum and minimum temperature and relative humidity in the experimental room was recorded once daily.

Housing

Rat: polypropylene cages with provision for water bottle holder and feed hopper with husk as bedding material

Feeding schedule: The rats were given 15 – 20gm of rat pellet/day and water ad libitum

Diet: Normal diet-animal chaw food pellets (q. s to 100gm). Water ad libitum- deep bore well water passed through charcoal filters, exposed to UV rays, filled in polypropylene water bottles were provided to the animals

5) Dose of the standard and trial drugs

Dose was calculated as per OECD guidelines. The dose of the formulation was calculated by extrapolating the therapeutic dose to rat dose on the basis of Body surface area ratio (conversion factor 0.018 for rats/ 0.0026 for Mice) by referring the table of "PAGETS & BARNES" 1964

- Formula: Rat dose = Human dose ×0.018 (for 200 g rat)
- Dose of the standard drug: Dosage of Piracetam – 200mg/kg body weight
- Dose of trial drugs: Krishna Jeeraka beeja churna - 540mg/kg body weight
  Shweta Jeeraka beeja churna – 540mg/kg body weight
- Dose of Amnesia inducing drug: Scopolamine – 8mg/kg body weig

6) Experimental trial proper

Grouping: 4 groups each having 6 wistar albino rats.

Table No. 02: Grouping of Experimental animals

Group	Group name	Intervention	Dose	Duration of drug administration	Total duration
I.	Control group	Food and water ad libitum		15 days	
II.	Standard drug	Piracetam	200mg/kg	Day 1 to Day 9: Drug	15 days
				Day 10 to Day 14: Resting period	
				Day 14 to Day 15: Drug with Scopolamine	
III.	Test group 01	Krishna Jeeraka beeja churna	540mg/kg	Day 1 to Day 9: Drug	15 days
				Day 10 to Day 14: Resting period	
				Day 14 to Day 15: Drug with Scopolamine	
IV.	Test group 02	Shweta Jeeraka beeja churna	540mg/kg	Day 1 to Day 9: Drug	15 days
				Day 10 to Day 14: Resting period	
				Day 14 to Day 15: Drug with Scopolamine	

7) Route of administration

- Oral route for standard and trial drugs
- Intra peritoneal route for Scopolamine

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8) Vehicle for administration of drug

Distilled water was added to the drugs to make a homogenous suspension and administered orally once a day.

a) Procedure

Morris water maze test for learning and memory assessment

Apparatus: The maze used was a cylindrical black metallic pool with a diameter of 170 cm, filled with water to a depth just below the surface of a circular platform disc. The water was maintained at ambient temperature, and both the depth and temperature were checked at the beginning of each testing day and adjusted as necessary to ensure uniform conditions. Proper lighting was provided by placing a fluorescent tube light directly above the centre of the maze. Only one escape platform was used throughout the experiment, which was hidden just below the water surface.

The platform's location remained constant during the entire study. To make the water opaque and prevent visual identification of the platform, skimmed milk was added (approximately 1 to 1.25 liters per day). Both water and milk were replaced daily after the completion of training sessions. At the end of each testing week, the maze was cleaned thoroughly by scrubbing with 70% ethanol.

Training protocol: The trial protocol remained the same throughout, regardless of the platform's location. On each testing day, animals were brought into the experimental room at least 30 minutes prior to the first trial. Only the animals scheduled for testing on that day were brought in to minimize stress.

The pool was virtually divided into four equal quadrants - East, North, West, and South using two imaginary lines intersecting at the centre. A circular escape platform (10 cm in diameter) was hidden 2 cm below the water surface in a fixed quadrant of the pool for the duration of the study. Each trial began by placing a rat into the pool facing the wall from one of four starting positions. The starting location was randomly assigned, ensuring that each of the four positions was used once per session.Before training began, animals were allowed to freely swim in the maze for 60 seconds without the platform for habituation. Each rat received four trials per session, one from each starting point, for five consecutive days. Each trial had a maximum duration of 60 seconds, with an inter-trial interval of approximately 30 seconds.

If the animal located the platform within the time limit, it was allowed to remain on it for 60 seconds. If it failed to find the platform, it was gently guided to it and allowed to remain there for the same amount of time. After each session, the animal was removed from the maze, dried thoroughly with a towel and hair dryer, and then returned to its home cage.

b) Assessment parameters

- *Spatial Acquisition Test (Day 7)*

The escape latency (time taken to locate the hidden platform) and the navigation strategy used by each rat were recorded to evaluate spatial learning ability.

c) Thigmotactic Behavior Test (Day 7)

Thigmo comes from the Greek word *thigma*, meaning touch. In behavioural science, thigmotactic refers to an animal's tendency to stay close to the walls or edges of an environment; this is natural anxiety related behavior in rodents. Static refers to something that is still, stationary, or unchanging. "Thigmotactic" behavior in this context likely refers to the static preference of the rats to stay near the walls (i.e., low exploration of the centre zone), which may reflect anxiety, fear, or impaired spatial learning. An imaginary inner boundary was drawn within the pool, positioned at a fixed distance of 10cm from the outer wall. This created a central zone, separating it from the outer (peripheral) zone of the pool.

The thigmotactic behavior of each rat was assessed by monitoring:

A) Frequency: How many times each rat entered the imaginary zone.
B) Duration: How much time each rat spent in imaginary zone.
This was recorded for each trial and from each starting direction.

Thigmotactic behavior is the tendency of rats to stay close to the edges of the pool rather than swimming in the center. By measuring how often and how long they enter the inner zone, researchers can assess anxiety levels and willingness to explore. Less time spent near the walls and more time in the centre suggests reduced anxiety and improved spatial confidence.

- *Reference Memory or Retention Test (Day 8)*

The platform was removed, and each rat was placed in the maze for 60 seconds. The time spent in the target quadrant, where the platform had previously been located was recorded as a measure of memory retention. A longer duration in the target quadrant was indicative of stronger memory consolidation. The Reverence memory of each rat was assessed by monitoring:

- Latency to enter platform
- Number of cross over's
- Time spent in North-West zone

- *Working Memory or Re-evaluation Test (Day 9)*

The platform was reinstated in its original location and escape latency was recorded again. An improvement in cognitive function was inferred from a decrease in escape latency and an increase in target quadrant time.

- *Resting Day (Day 10 to Day 14)*

From Day 10 to Day 14, animals were given a rest period with no testing conducted. This interval was incorporated to eliminate short-term memory effects and to assess long-term memory retention. Animals remained in their home cages under standard housing conditions during this period.

- *Long Term Memory (Test Day 14)*

On Day 14, a long-term memory test was conducted. The platform was reintroduced in its original fixed location, and each rat was placed in the maze for a standard trial. The escape latency was recorded. A reduction in escape latency was considered indicative of enhanced cognitive performance and the presence of long-term memory retention.

9) Induction of Memory Impairment

Following the long-term memory assessment on Day 14, animals were administered scopolamine, a muscarinic acetylcholine receptor antagonist commonly used to induce memory impairment in experimental models. Simultaneously, the trial drug was administered to evaluate whether the test compound exhibited Nootropic (cognitive-enhancing) properties even after pharmacologically induced cognitive deficits.

- *Amnesia Test: Post Scopolamine Escape Latency Test (day 15)*

On Day 15, a standard trial was conducted with the escape platform reintroduced at the same fixed location as before. The escape latency was recorded to assess the ability of the animals to locate the platform after scopolamine-induced memory impairment. Groups with decreased latency compared to untreated controls demonstrate the potential memory-enhancing effects of the test compounds.

10) Statistical Analysis

The data generated is mentioned as Mean ± SEM. Statistical analysis is done by using One Way ANOVA followed by Dunnet's test as Post Hoc test if $P<0.05$ using Graph pad Instat software.

V. OBSERVATIONS AND RESULTS

Observation and results of the study were done under two headings;

- Analytical observations
- Experimental observations

A. Analytical study

1) Macroscopic and microscopic features

Table No.03: Comparative Macroscopic (sensory) evaluation of Krishna Jeeraka and Shweta Jeeraka

Features	Krishna Jeeraka	Shweta Jeeraka
Sparsha (External surface)	Rough and thick Prominent distinct visible ridges	Rough and thin less visible ridges
Rupa (Colour & Shape)	Dark brown to black More curved	Light brown to yellowish Less curved
	Seed length – 5 to 7mm	Seed length - 4 to 6 mm
	Seed width - up to 2mm	Seed width - up to 2.5mm
Rasa (Taste)	Bitter and Pungent taste	Pungent taste
Gandha (odor)	Strong aromatic	Aromatic
Shabda (fracture)	Fibrous	Fibrous

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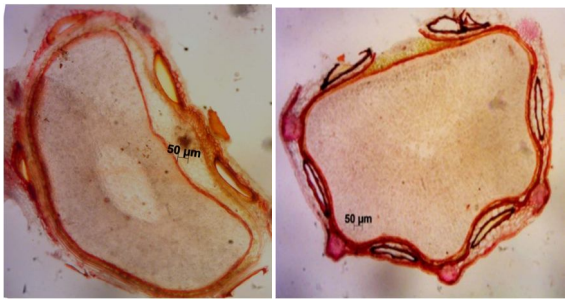
Figure 01: Macroscopy of Krishna Jeeraka and Shweta Jeeraka

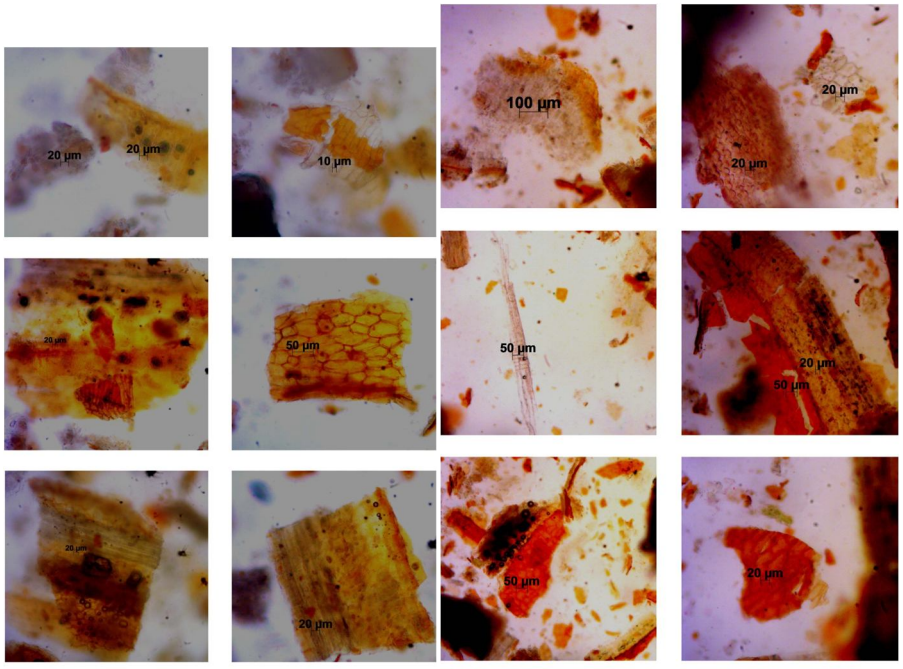
Krishna Jeeraka and Shweta Jeeraka

Figure 02: Transverse section of Shweta Jeeraka and Krishna Jeeraka



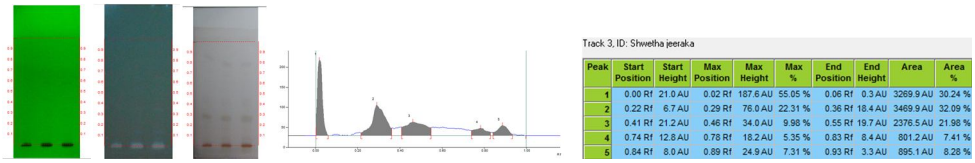
Shweta Jeeraka Krishna Jeeraka

Figure 03: Powder microscopy of Shweta Jeeraka and Krishna Jeeraka



Shweta Jeeraka Krishna Jeeraka

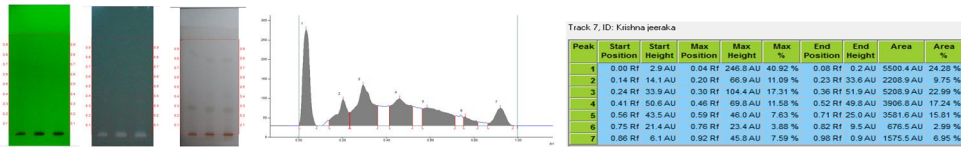
Figure No. 04: Densitometric scan of Shweta Jeeraka at 620nm



Track 3, ID: Shwetha jeeraka

Peak	Start Position	Start Height	Max Position	Max Height	Max %	End Position	End Height	Area	Area %
1	0.00 Rf	21.0 AU	0.02 Rf	187.6 AU	55.05 %	0.06 Rf	0.3 AU	3269.9 AU	30.24 %
2	0.22 Rf	6.7 AU	0.29 Rf	76.0 AU	22.31 %	0.36 Rf	18.4 AU	3469.9 AU	32.09 %
3	0.41 Rf	21.2 AU	0.46 Rf	34.0 AU	9.98 %	0.55 Rf	19.7 AU	2376.5 AU	21.98 %
4	0.74 Rf	12.8 AU	0.78 Rf	18.2 AU	5.35 %	0.83 Rf	8.4 AU	801.2 AU	7.41 %
5	0.84 Rf	8.0 AU	0.89 Rf	24.9 AU	7.31 %	0.93 Rf	3.3 AU	895.1 AU	8.28 %

Figure No. 05: Densitometric scan Krishna Jeeraka at 620nm



2) Physicochemical analysis

Table No. 04: Comparative Results of Physico-chemical analysis of Krishna Jeeraka and Shweta Jeeraka

PARAMETER	Results (in %w/w)	
	Krishna Jeeraka	Shweta Jeeraka
Foreign matter	0.2	0.4
Loss on drying	9.49	7.9
Total Ash	4.49	6.42
Acid Insoluble Ash	0.92	0.54
Alcohol soluble extractive value	20.5	20.82
Water soluble extractive value	40.28	32.89
pH	4.38	4.16

Loss on drying and pH test were done by triplicate method as standard values were not available in API

3) Phytochemical analysis

Table No. 05: Comparative Results of Phytochemical analysis of Krishna Jeeraka and Shweta Jeeraka

SL NO	Test	Krishna Jeeraka	Shweta Jeeraka
1.	Alkaloid	+	+
2.	Carbohydrate	+	+
3.	Steroid	-	-
4.	Saponins	+	+
5.	Tannin	+	+
6.	Flavanoids	+	+
7.	Phenol	+	+
8.	Coumarins	+	+
9.	Triterpenoid	+	+
10.	Amino acids	-	-
11.	Carboxylic acid	-	-
12.	Resins	+	+
13.	Quinone	+	+

(+) –Present; (-)-Negative

B. Experimental study

The results obtained from the experimental study were presented as MEAN±SEM and the data were analysed using one way ANOVA and Dunnet's test as Post Hoc test.

MORRIS WATER MAZE TEST

1) Effect of Krishna Jeeraka and Shweta Jeeraka on Spatial Acquisition Memory (SAM- day 7)

Table No. 06: Showing the effect of Krishna Jeeraka and Shweta Jeeraka on Spatial acquisition memory (SAM - day 7)

Group	Total (in sec.)	% of change	Average (in sec.)	% of change
Control	99.79±18.72	-	24.94±4.69	-
Standard	80.77±11.91	19.06↓	20.19±2.97	19.04↓
Shweta Jeeraka	73.44±14.22	26.40↓	18.35±3.55	26.42↓
KrishnaJeeraka	73.65±17.29	26.19↓	18.40±4.32	26.22↓

The effect of Standard drug, Shweta Jeeraka and Krishna Jeeraka on wistar albino rats in spatial acquisition memory on all the four poles of morris water maze are as follows;

- In Spatial Acquisition Memory test, observations revealed that the time taken by the standard, Shweta Jeeraka and Krishna Jeeraka groups were less when compared to control group.
- Though statistically not significant, both Shweta Jeeraka and Krishna Jeeraka showed similar and better acquisition memory compared to standard.

2) Effect of Krishna Jeeraka and Shweta Jeeraka on Duration taken in Thigmotactic behaviour (day – 7)

Table No. 07: Showing the effect of Krishna Jeeraka and Shweta Jeeraka on duration taken in Thigmotactic behaviour (day – 7)

Group	Total Duration (in sec.)	% of change	Average Duration (in sec.)	% of change
Control	50.33±15.34	-	12.58±3.83	-
Standard	32.33±10.49	35.76↓	8.08±2.62	35.77↓
Shweta Jeeraka	20.5±7.87	59.26↓	5.12±1.96	59.30↓
Krishna Jeeraka	21.6±8.67	57.08↓	5.4±2.16	57.07↓

- In Thigmotactic Behaviour test, the duration taken by the Standard, Shweta Jeeraka and Krishna Jeeraka groups were comparatively less than control group.
- Though statistically not significant, both Shweta Jeeraka and Krishna Jeeraka showed similar and better result than Standard in duration parameter.

3) Effect of Krishna Jeeraka and Shweta Jeeraka on Frequency in Thigmotactic behaviour (day – 7)

Table No. 08: Showing the effect of Krishna Jeeraka and Shweta Jeeraka on frequency in Thigmotactic behaviour (day – 7)

Group	Total Frequency	% of change	Average Frequency	% of change
Control	8±1.21	-	2±0.30	-
Standard	7.33±1.60	8.37↓	1.83±0.40	8.5↓
Shweta Jeeraka	7.33±1.96	8.37↓	1.83±0.49	8.5↓
Krishna Jeeraka	6.4±1.43	20↓	1.6±0.35	20↓

- In Thigmotactic Behaviour test, the frequency taken by the Standard, Shweta Jeeraka and Krishna Jeeraka groups were comparatively less than control group.
- Though statistically not significant, both Standarad and Shweta Jeeraka showed similar and better result than Krishna Jeeraka in frequency parameter.

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4) Effect of Krishna Jeeraka and Shweta Jeeraka on Reference Memory (day 8)

Table No. 09: Showing the effect of Krishna Jeeraka and Shweta Jeeraka on Reference memory (day 8)

Group	Latency to enter platform (in sec.)	% of change	No. of crossover (Frequency)	% of change	Time spent in NW zone (in sec.)	% of change
Control	6.83±1.09	-	3.83±0.30	-	28±2.76	-
Standard	5.57±0.38	18.44↓	3.5±0.34	8.61↓	33.83±2.22	20.82↑
Shweta Jeeraka	7±2.06	2.48↑	4±0.44	4.43↑	27.5±3.46	1.78↓
Krishna Jeeraka	9.36±3.15	37.04↑	3.2±0.48	16.44↓	29.2±6.80	4.28↑

a) Latency to enter platform
- In Reference memory test, the Standard group showed better result in latency to enter platform compared to other groups in the order Standard > Shweta Jeeraka > Krishna Jeeraka, though statistically non significant
- Among the trial groups, Shweta Jeeraka showed better result than Krishna Jeeraka

b) No. of cross over
- The Krishna Jeeraka group showed better result with less number of cross over compared to other groups in the order of Krishna Jeeraka > Standard > Shweta Jeeraka, though statistically non significant

c) Time spent in NW zone
- The Standard group showed better result in spending more time in N-W zone compared to other groups in the order of Standard > Krishna Jeeraka > Shweta Jeeraka , though statistically non significant.

5) Effect of Krishna Jeeraka and Shweta Jeeraka on Working Memory (day 9)

Table No. 10: Showing the effect of Krishna Jeeraka and Shweta Jeeraka on Working memory (day 9)

Group	East (in sec.)	% of change	South (in sec.)	% of change	Total (in sec.)	% of change	Average (in sec.)	% of change
Control	22.04±8.85	-	21.64±7.39	-	43.68±12.83	-	21.84±6.41	-
Standard	22.04±8.85	00	11.52±3.72	46.76↓	49.32±8.34	12.91↑	24.65±4.17	12.86↑
Shweta Jeeraka	34.10±8.12	54.71↑	13.70±3.96	36.69↓	47.81±8.31	9.45↑	23.90±4.15	9.4↑
Krishna Jeeraka	18.77±6.13	14.83↓	11.95±2.12	44.77↓	30.72±5.97	29.67↓	15.36±2.98	29.67↓

The Krishna Jeeraka group showed better result in working memory compared to other groups though statistically non significant.

6) Effect of Krishna Jeeraka and Shweta Jeeraka on Long term memory (day 14) - After a gap of 5 days

Table No. 11: Showing the effect of Krishna Jeeraka and Shweta Jeeraka on Term memory (day 14)

Group	South end (in sec.)	% of change
Control	21.46±8.34	-
Standard	18.09±2.95	15.70↓
Shweta Jeeraka	20.50±8.28	4.47↓
Krishna Jeeraka	41.71±9.74	94.36↑

- The Standard group showed better result in long term memory compared to other groups though statistically non significant
- Shweta Jeeraka was found to be better in long term memory compared to Krishna Jeeraka though statistically non significant.

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7) Effect of Krishna Jeeraka and Shweta Jeeraka on Amnesia Memory (DAY 15)

Table No. 12: Showing the effect of Krishna Jeeraka and Shweta Jeeraka on amnesia memory (day 15)

Group	South (in sec.)	% of change
Control	25.88±10.10	-
Standard	26.86±6.92	3.78↑
Shweta Jeeraka	20.04±8.10	22.56↓
Krishna Jeeraka	12.76±2.09	50.69↓

- In Amnesia Memory test, Krishna Jeeraka was found to be effective than standard group
- Among the trail drugs Krishna Jeeraka was effective than Shweta Jeeraka though statistically not significant.

VI. DISCUSSION

A. *Macroscopic and Microscopic Analysis*

1) Organoleptic and macroscopic features of Krishna Jeeraka and Shweta Jeeraka were in accordance with standard parameters, confirming their identity.

2) Powder microscopy of Krishna Jeeraka revealed sclereids, fibers, oil globules, and starch grains, while Shweta Jeeraka showed abundant oil globules, starch grains, stone cells, and parenchyma cells, confirming authenticity of both samples.

B. *Physicochemical Analysis*

1) Foreign matter was minimal (0.2% in Krishna Jeeraka and 0.4% in Shweta Jeeraka), the standard limits indicating very minimal physical impurities.

2) Loss on drying was higher in Krishna Jeeraka (9.49%) than Shweta Jeeraka (7.9%), suggesting comparatively better stability of Shweta Jeeraka.

3) Total ash and acid-insoluble ash values of both samples were within limits, indicating minimal inorganic and siliceous impurities.

4) Alcohol-soluble extractive values were comparable in both samples, while water-soluble extractive value was higher in Krishna Jeeraka, indicating greater water-soluble constituents.

5) Both samples showed acidic pH, correlating with their *Ushna veerya* and *Deepana–Pachana* properties.

C. *Phytochemical Analysis*

Both Krishna Jeeraka and Shweta Jeeraka showed the presence of alkaloids, carbohydrates, saponins, tannins, flavonoids, phenols, coumarins, triterpenoids, resins, and quinones, indicating similar phytochemical profiles.

D. *Chromatographic Profile:*

HPTLC analysis confirmed the presence of cuminaldehyde, with higher area percentage in Krishna Jeeraka (7.41%) compared to Shweta Jeeraka (2.99%).

E. *Experimental Study*

In modern medicine, Nootropics constitute an important, and in certain conditions the primary line of treatment for cognitive and neurodegenerative disorders such as Alzheimer's disease, dementia etc, acting mainly by enhancing neurotransmitter activity, improving neuronal metabolism, and increasing cerebral blood flow. In Ayurveda, Medhya Karma is advocated in conditions involving Smriti Nasha such as Unmada and Apasmara, where Medhya dravyas relieve Srotovarana, facilitate proper Rasa flow, support Dhatu Poshana, maintain doshic equilibrium, and promote stability of body and mind. Piracetam (2-oxo-1-pyrrolidine acetamide), a cyclic derivative of GABA and the prototype of the racetam class of nootropics, enhances neuronal membrane fluidity, hemispheric communication, and cerebral oxygen and glucose utilization, while modulating acetylcholine, glutamate, and NMDA receptors to improve synaptic plasticity and long-term potentiation essential for learning and memory; owing to its well-established mechanism, reproducible cognitive effects, and favorable safety profile, Piracetam is widely used as a standard reference drug in experimental nootropic studies and was therefore selected for the present study. The Morris Water Maze test was employed as it is a validated and sensitive behavioral model for assessing spatial learning and memory, hippocampal function, and cognitive enhancement in experimental animals.

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F. Discussion on parameters of Experimental study

1) *Spatial Acquisition test:* Acquisition memory measures how rapidly an animal learns the position of the hidden platform. Key parameter is the escape latency (the time taken by the rat to reach the hidden platform from each starting direction). Lower escape latency indicates that the rat has learned the location more efficiently and thus shows better acquisition of spatial learning and memory.
2) *Thigmotactic behavior test:* Thigmotactic behavior (tendency for rodents to stay close to the perimeter rather in central zone) indicates anxiety, fear or poor adaptation to the task which can confound learning/memory results. The key metrics are Duration (time spent in outer zone) and frequency (number of entries into the outer zone). Lower values of both duration and frequency suggest better cognition performance i.e less anxiety/distraction and more active spatial exploration.
3) *Reference memory:* Reference memory refers to memory of fixed platform location over multiple trials or in other words conducting a probe trail (removed platform) after training. It is measured in terms of time spent in target quadrant; the number of crossings of the former platform location, latency to first entry into the target zone indicates how well the learned memory is retained.
4) *Working memory:* It is form of short term memory describing the ability to form recent/short term memory and to adapt to change (cognition flexibility) and which is assessed by placing platform at its original location and measuring the escape latency. Lower the latency indicates better the working memory performance.
5) *Long term memory:* long term memory shows retention of the learned platform location over extended delay by using a probe trial or hidden platform trial to see if performance is retained (escape latency: lower the time better the memory)
6) *Amnesia memory:* This parameter concerns reversal of memory deficits induced by an agent (scopolamine) and enables testing whether trial drugs can reverse the pharmacological amnesia. It is assessed by escape latency: a reduced latency strengthens the nootropic claim.
7) Spatial Acquisition and Thigmotactic behaviors can be compared to the power of grasping i.e., Grahana shakti. Reference, working and long term memory indicate the power of memory retention i.e, Dharana Shakti. Amnesia memory test can be correlated with power of recalling i.e, Smarana Shakti.

G. Discussion on Results

1) *Spatial acquisition test:*

- Better Spatial acquisition was observed in Standard, Shweta Jeeraka and Krishna Jeeraka compared to control group.
- Both Shweta Jeeraka and Krishna Jeeraka showed similar and better acquisition memory compared to standard indicating that Grahana shakti is similar in both Jeerakas.

2) *Thigmotactic behaviour test:*

a) *Duration*

- Standard, Shweta Jeeraka and Krishna Jeeraka groups show better results than control group.
- Both Shweta Jeeraka and Krishna Jeeraka showed similar and better result than Standard in duration parameter.

b) *Frequency*

- Standard, Shweta Jeeraka and Krishna Jeeraka groups show better results than control group.
- Standarad and Shweta Jeeraka showed similar and better result than Krishna Jeeraka in frequency parameter
- Above results indicate similar Grahana shakti in both Jeerakas.

c) *Reference memory*

1. *Latency to enter platform*
   - Standard group showed better result in latency to enter platform compared to other groups in the order Standard > Shweta Jeeraka > Krishna Jeeraka
   - Shweta Jeeraka showed better result than Krishna Jeeraka
2. *No. of crossover*
   - The Krishna Jeeraka group showed better result compared to other groups in the order of Krishna Jeeraka > Standard > Shweta Jeeraka,
   - Krishna Jeeraka showed better result than Shweta Jeeraka
3. *Time spent in NW zone*
   - The Standard group showed better result compared to other groups in the order of Standard > Krishna Jeeraka > Shweta Jeeraka

- Krishna Jeeraka showed better result than Shweta Jeeraka
- Though both Jeerakas showed good retention power, Krishna Jeeraka was comparatively better.

d) Working memory:

- Krishna Jeeraka group showed better result in working memory compared to other groups indicating better Dharana shakti.

e) Long term memory:

- Standard group showed better result in long term memory compared to other groups.
- Shweta Jeeraka was found to be better in long term memory compared to Krishna Jeeraka indicates better Dharana shakti.

f) Amnesia memory:

- Krishna Jeeraka was found to be effective than other groups
- Krishna Jeeraka was effective than Shweta Jeeraka indicating better Smarana shakti.

H. Probable Mode of Action

Based on Rasapanchaka

1) Both *Shweta Jeeraka (Cuminum cyminum Linn.)* and *Krishna Jeeraka (Carum carvi Linn.)* possess Katu-Tikta Rasa (Shweta Jeeraka has an additional Madhura anurasa), Laghu-Ruksha Guna, Ushna Veerya, Katu Vipaka, Deepana-Pachana, Balya, Pittala and Vata-Kapha Shamana karma.

2) Katu rasa, by its Deepana-Pachana[8] karma enhances neuronal metabolism and facilitates the nutrients required for brain function. It also opens and clears the channel of circulation (Srotamsi vivrunoti), thereby improving circulation towards the brain and enhancing oxygen and nutrient supply to neuronal tissue. Consequently it supports proper neuronal communication and over all cognitive performance by supporting both metabolism and circulation at the cerebral level, promoting enhanced Medha and Smriti.

3) Tikta Rasa is attributed with Medhya karma, highlighting its ability to support intellect and mental clarity. It does Amapachana and Srotoshodhana. By removing Ama (toxins and undigested metabolic residues), it facilitates the proper flow of rasa dhatu which is essential for the nourishment of Majja Dhatu, the substratum of Medha thereby enhancing memory, learning, and cognitive functions.

4) Madhura Rasa and Balya karma contribute to Medhya Karma by nourishing Majja Dhatu and Sadhaka Pitta, both of which are essential for cognitive functions, memory consolidation, and mental stability. It strengthens brain tissue and helps to promote mental clarity, emotional balance, and overall intellectual capacity supporting both short-term cognitive performance and long-term neuroprotection.

5) Laghu guna of Jeeraka promotes lightness and mental alertness at both physical and cognitive levels, thereby stimulating Vata Dosha which governs higher functions of the nervous system such as Smriti (memory) and Medha (intellect). Ruksha Guna, by its drying quality, counteracts heaviness and sluggishness caused by Kapha, preventing obstruction in Srotas and thus maintaining clarity of thought and alertness.

6) Laghu and Ruksha are the gunas of vata. *"Vayuhu sarvendriyaṇam udyojaka"* - Vata is the activator of all sense organs and is responsible for the initiation and coordination of all sensory and mental activities. This highlights its governing role over perception, cognition, and memory processes. Prana Vata, regulates higher mental functions such as Dhee (grasping), Dhṛti (retention), and Smriti (recall), which collectively constitute Medha. Prana Vata resides in the head and controls the functions of intellect, mind, and sensory faculties. Vata in equilibrium facilitates quick perception, clarity of understanding, and efficient synaptic communication paralleling the modern concept of enhanced neuronal signaling and neuroplasticity.

7) Ushna Veerya stimulates Jatharagni, thereby enhancing ahara paka and promoting proper formation of Rasa Dhatu, responsible for nourishing all successive dhatus through the process of Dhatu Poshana Krama. Proper circulation of rasa provides adequate nourishment to brain leading to the promotion of Medha and Smriti.

8) Katu Vipaka stimulates Vata Dosha, which governs all movement and communication in the body, including the transmission of impulses in the nervous system. Katu Vipaka may facilitate quicker neuronal firing, improved synaptic plasticity, and enhanced neurotransmitter activity. This supports the classical Medhya karma by promoting Smriti (memory), Buddhi (intellect), and overall cognitive performance.

9) Pittala karma: 'Medha' and 'Dhee' are considered as functional expressions of Pitta Dosha. Sadhaka Pitta, which resides in the Hridaya[9], is specifically associated with Medha, as it governs perception, memory, and the capacity to comprehend and retain knowledge and responsible for mental processing, allowing the mind to gather, interpret, and store information, thereby supporting cognition and intellectual growth.

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10) Combining the influence of Rasa, Guna, Veerya, and Vipaka, both Shweta Jeeraka and Krishna Jeeraka perform Deepana, Pachana, Balya and Pittala karma. These actions ensure optimal digestion and metabolism, proper nourishment of Majja Dhatu and Sadhaka Pitta. This integrated mechanism enhances Medhya Karma, supporting cognitive functions such as comprehension, retention, and recall.

I. Based on Phytoconstituents

Krishna Jeeraka and Shweta Jeeraka possess Alkaloids, Carbohydrates, Saponins, Tannins, Flavanoids, Phenols, Coumarins, Triterpinoids, Resins and Quinone compounds.

1) Alkaloids and flavonoides have neuroptotective and cognitive enhancing properties, including antioxidant effect and modulation of neurotransmitter system.
2) Phenols and tannins contribute to antioxidant activity, plays important role in cognition by protecting neuronal cells from oxidative stress.
3) Coumarins are known to possess neuroprotective and anti-inflammatory action, which can support brain function.
4) Triterpinoieds and quinones possess anti-inflammatory, antioxidant, and neuroprotective actions. These compounds play a significant role in enhancing memory and learning, primarily through modulation of neurochemical pathway involved in cognition, particularly by the influencing the cholinergic system, which is crucial for cognitive function.
5) Carbohydrates support neuronal energy metabolism and neurotransmitter synthesis, thereby maintaining optimal brain function and cognition.
6) Saponins and resins exert neuroprotective and cognitive-enhancing effects through antioxidant, anti-inflammatory, and membrane-stabilizing actions.

Thus both Krishna Jeeraka and Shweta Jeeraka were found to possess effective Nootropic activity W.S.R.to Medhya karma.

VII. CONCLUSION

1) Pharmacognostic, Physicochemical and Phytochemical studies showed the results as per API standards confirming the identity and genuinity of the trial drugs.
2) The HPTLC study showed the presence of minimal percentage of Cuminaldehyde in both Jeeraka's implying its less contribution to Medhya karma.
3) Both Krishna Jeeraka and Shweta Jeeraka exhibited effective Nootropic activity, thus found to possess Medhya karma.
4) Both Krishna Jeeraka and Shweta Jeeraka showed similar Nootropic activity where in Krishna Jeeraka was comparatively better.
5) Shweta Jeeraka was better in Grahana Shakti where as Krishna Jeeraka was effective in Grahana, Dharana and Smarana Shakti.

A. Scope for Further Study

1) Dose optimization and long term safety evaluations can be conducted to determine the most effective and safe therapeutic dosage for potential clinical applications.
2) Comparative studies on different extracts of both drugs can be undertaken for to identify which extract possesses superior Nootropic activity.
3) Isolation of active Phytoconstituents and exact mechanism of action on neurotransmitter responsible for Medhya karma followed by Pharmacological validation using receptor binding and Neuroprotective assays.
4) Clinical trials in humans can be planned to validate the preclinical results and establish therapeutic relevance in conditions like memory impairment, Alzheimer's disease etc.
5) Exploration of synergistic combination of Jeeraka species with other Medhya dravyas can be carried out to enhance cognitive efficacy.

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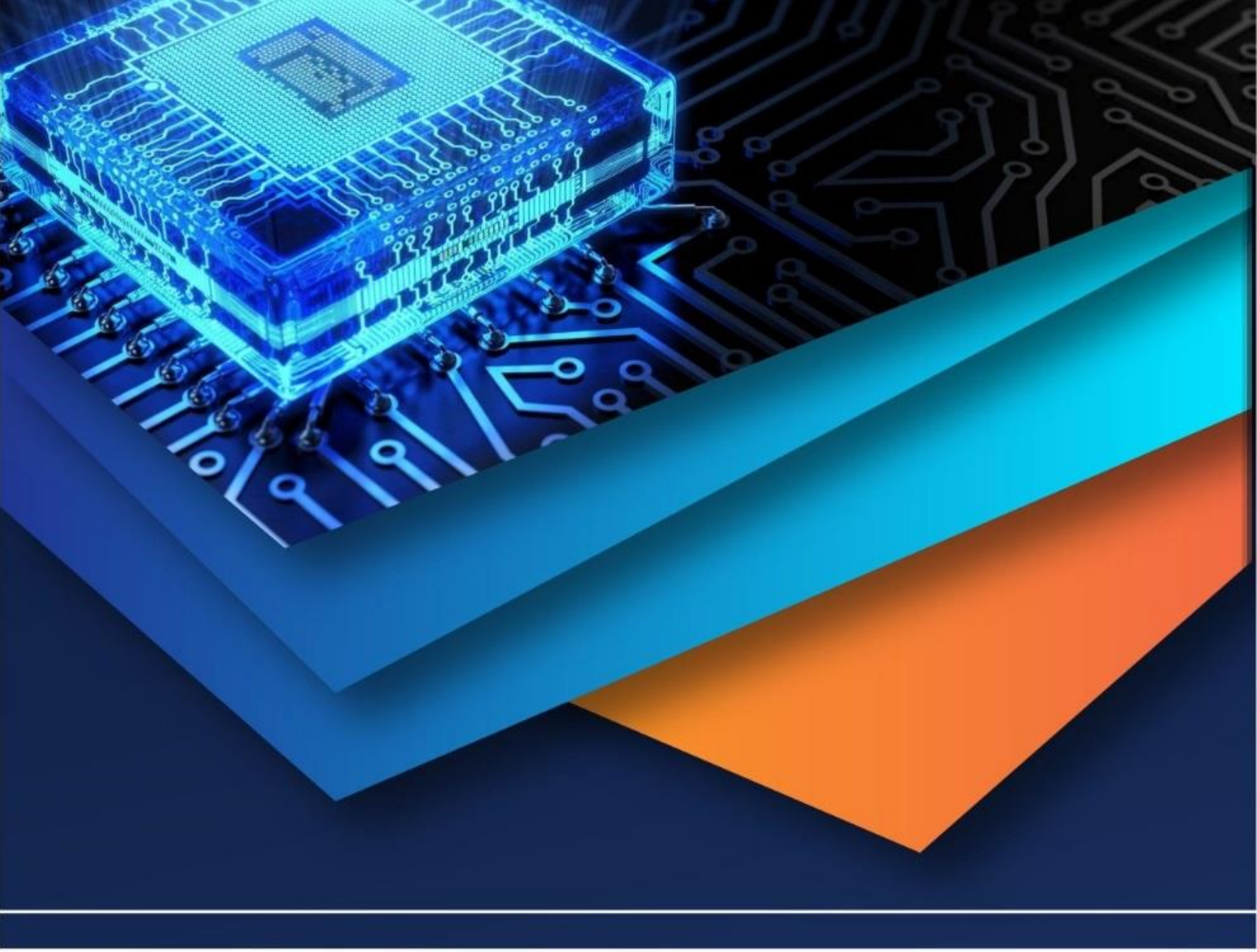

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