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Health-Promoting Moringa Enriched Millet Cookies: Integrating Moringa and Millet for a Functional Snack Option

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Abstract: ***The present study focuses on the development of cookies enriched with moringa (Moringa oleifera) leaf powder and millet flour. With rising consumer interest in functional foods and nutrient-rich alternatives to conventional baked products, this research aims to develop cookies that offer superior health benefits while maintaining acceptable sensory qualities. Millet, known for its high fibre and mineral content, serves as a gluten-free base, while Moringa oleifera contributes essential micronutrients such as iron, calcium, and antioxidants. Cookies were prepared using varying concentrations of moringa leaf powder (2.5%, 5%, 7.5%, and 10%) incorporated into a composite flour consisting of finger millet (Ragi). The cookies were evaluated for sensory characteristics including appearance, colour, texture, taste, and overall acceptability using a 5-point hedonic scale by a semi-trained panel. Results showed that while the addition of moringa leaf powder led to noticeable changes in colour and flavour, cookies with up to 5% moringa incorporation maintained acceptable sensory quality. Beyond this level, a decline in palatability was observed due to increased bitterness and green coloration. The study concludes that moringa-enriched millet cookies are sensorially acceptable up to a certain inclusion level and hold promise as a functional food product.***

Keywords: Moringa oleifera, millet cookies, sensory evaluation, functional food, product acceptability, hedonic scale

I. INTRODUCTION

As India's population continues to grow, so does the demand for bakery items, particularly in the capital city(RN et al., 2023). The annual growth rate for these goods stands at 10.07%, making them a popular and easily accessible choice(Ranjeet Chunilal & Chavan, n.d.). Muffins, bread, cookies, cake, and pastries are among the most typical bakery items. Cookies are known for their crispy texture and are sometimes referred to as flat cakes. The high consumer acceptance of baked goods, such as biscuits and cookies, facilitates the introduction of bioactive compounds into the human diet(Keerthana & Jayashankar, n.d.).

The Moringa oleifera tree is widely considered a miraculous plant, owing to the fact that every part of it can be used for various purposes, including food, medicine, water purification, and animal bedding(Rathore et al., 2022). Research has shown that the leaves are an excellent source of both macro and micronutrients, including important amino acids. The micro-nutrient content is even more in dried leaves; (ten times the vitamin A of carrots), (17 times the calcium of milk), (15 times the potassium of bananas), (25 times the iron of spinach) and (9 times the protein of yogurt)(Rajput et al., 2019). Its leaves, pods, seeds, gums, bark, and flowers are used to treat mineral and vitamin deficiencies, support a healthy cardiovascular system, number of chronic diseases, such as inflammatory diseases, neuro-dysfunctional diseases, diabetes, and cancer. Enhance regular blood levels, neutralise free radicals, thereby reduce malignancy, provide excellent support of the body's anti-inflammatory mechanisms, enrich anaemic blood, and support the immune system(Masitlha et al., 2024). Moringa has been used in traditional medicine for centuries in many cultures around the world, for skin infections, anaemia, anxiety, asthma, blackheads, blood impurities, bronchitis, chest congestion, cholera, conjunctivitis, Cough, diarrhoea, eye and ear infections, fever, glandular, swelling, headaches, abnormal blood pressure, hysteria, pain in joints, pimples and respiratory disorders(Shokry, n.d.).

Finger Millets are cultivated in 25 countries in Asia and Africa and occupies around 12% of the area dedicated for the Millet crops(Gebreyohannes et al., 2024). Millets are rich in fibre, gluten-free, energy-boosting, heart-friendly, aid digestion, control diabetes, support weight loss, improve immunity, are climate-resistant, and are good for sustainable farming(Sandhya & Kanniammal, 2024). Finger millet is highly valued for its content of macro- and micronutrients(Neeruganti, 2017).

It is rich in carbohydrates, protein, and fat. Its micronutrients include calcium (0.38%), dietary fibre (18%), and phenolic compounds (0.3–3%), such as catechin, epicatechin, as well as ferulic, salicylic, protocatechuic, cinnamic, and hydroxybenzoic acids, etc(Jagati & Mahapatra, 2021). Finger millet is also recognized as a source of vital amino acids, including isoleucine, leucine, methionine, and phenylalanine, which are otherwise deficient in starchy meals(Gaikwad et al., 2024).

Jaggery is considered one of the nutritive and healthiest sugars in the world(Model Detailed Project Report JAGGERY POWDER UNIT National Institute of Food Technology Entrepreneurship and Management (NIFTEM), n.d.). Jaggery granules also showed the presence of fat, protein, and minerals like iron, calcium, phosphorus, and magnesium(Pathak & Dwivedi, 2019). The study on the nutritional composition of jaggery (100 g) prepared from sugar cane showed the presence of carbohydrates (sucrose: 72–78 g; fructose and glucose: 1.5–7 g), minerals (Ca: 40– 100 mg; Mg:70–90 mg; P: 20–90 mg; Na: 19–30 mg; Fe: 10–13 mg; Mn: 0.2–0.4 mg; Zn: 0.2– 0.4 mg; Cl: 5.3–0.0 mg;0.1–0.9 mg), vitamins (vitamin A: 3.8 mg; vitamin B 2:0.06 mg; vitamin B 1, B 5, and B6: 0.01 mg; vitamin C:7.00 mg; vitamin: D2: 650 mg; vitamin E: 111.30 mg), and protein (280 mg) in significant amount. The highest value of sucrose (99.70%–99.95%) was observed in refined sugar, but glucose (2%–4%), fructose (2%–4%), inorganic ash (2%–4%), ash organic (1%–3%), amino acids (0.5%–0.25%), and total polysaccharide (0.3%–0.6%) were found in cane juice Refined sugar was reported with less amount of mineral content than sugarcane juice and molasses (mineral content in sugar cane and molasses: P: 0.4%–2.0% and 3.5%; Na: 0.03%–0.1%and 0.1%; chloride: 0.10%–0.29% and 1.3%; Ca:0.17%–0.32% and 0.7%; Mg: 0.20%–0.33% and 0.3%; Fe: 0.07%–0.14% and 0.02%; phosphate: 0.01%–0.40% and 0.3%; sulphate: 0.11%–0.52% and 1.5%)(B. K., 2019).

II. MATERIALS AND METHODS

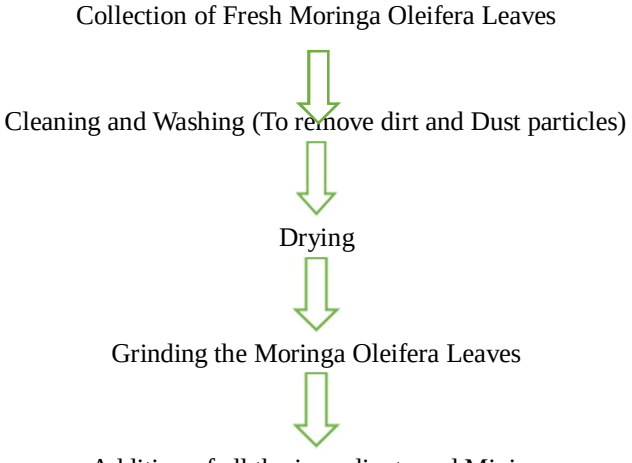
A. Collection and Selection of the Materials

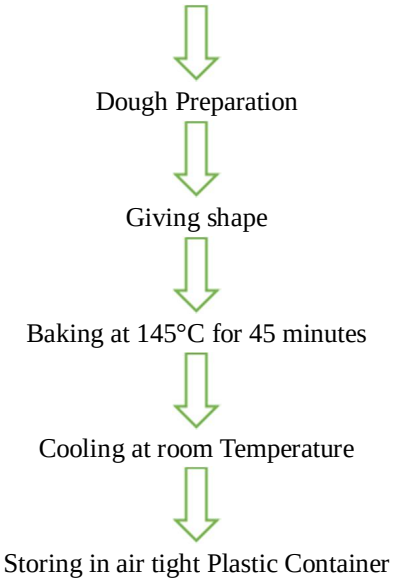
Ingredients selected in the present studies are Finger Millet flour, Moringa Powder, Butter, Jaggery Powder, Baking Powder, Baking Soda, Vanilla Essence and Salt which are purchased from grocery shop at smart Bazar Bhubaneswar.

1) Formulations for preparation of Cookies: The Moringa Millet Cookies were prepared in four different formulations to check which among them are tasty and nutritionally have extra health benefit. The flours such as Ragi flour, Moringa powder were taken in different proportions for the preparation of cookies. As per the experiment Moringa powder taken in different proportion such as 2.5%, 5%, 7.5% and 10%. The other ingredients were kept constant.

2) Preparation of Cookies: Initially the Finger Millet or Ragi were grinded into flour. Also, the Moringa Oleifera leaves which are dried in shade for 3 days then grinded it into powder. All the ingredients such as Finger millet flour, butter, jaggery powder, baking soda and baking powder were weighed, mixed them with kneaded quantity to form a dough. The standing time given for the dough was 5 minutes as all the floors has high capacity of water absorption. After that, the dough was shaped in form of cookie. Now, the cookies were baked at a temperature of 145°C for about 45 minutes. After baking the cookies were allowed for cooling for 5-10 minutes. Cooling is important for confirming the substantial loss of the moisture from the cookies. After cooling, the cookies were packed and warehoused in a plastic container. Further the cookies were taken for sensory evaluation and proximate analysis. This process is also shown in the flowchart given below.

Flow chart for preparation of cookies:





As pre our Research Nutritional Composition of the Materials:-

Nutrient	Amount per 100g
Energy	350–370 kcal
Protein	25–30 g
Fat	5–7 g
Carbohydrates	40–45 g
Dietary Fiber	10–15 g
Calcium	2,000–2,500 mg
Magnesium	300–400 mg
Phosphorus	200–300 mg
Potassium	1,200–1,500 mg
Iron	20–28 mg
Zinc	2–3 mg
Copper	0.5–0.7 mg
Manganese	4–6 mg
Vitamin A (β-Carotene)	16,000–18,000 IU
Vitamin C	15–30 mg
Vitamin E	80–120 mg
Vitamin B1 (Thiamine)	2–3 mg
Vitamin B2 (Riboflavin)	15–20 mg
Vitamin B3 (Niacin)	6–8 mg

Table 2.1: Nutrition Composition of Moringa Powder

Nutrient	Amount
Energy	336 kcal
Carbohydrates	72.6 g
Protein	7.3 g
Fat	1.3 g
Dietary Fiber	3.6 g
Calcium	344 mg
Iron	3.9 mg
Phosphorus	283 mg
Magnesium	137 mg
Potassium	408 mg
Zinc	2.3 mg
Thiamine (Vitamin B1)	0.42 mg
Riboflavin (Vitamin B2)	0.19 mg
Niacin (Vitamin B3)	1.1 mg
Folate	35 µg
Moisture	12.5 g

Table 2.2: Nutritional Composition of Finger Millet

Nutrient	**Amount**
Energy	383 kcal
Carbohydrates	97 g
Protein	0.4 g
Fat	0.1 g
Calcium	80 mg
Iron	11 mg
Phosphorus	20 mg
Magnesium	70-90 mg
Potassium	1056 mg
Sodium	19-30 mg
Zinc	0.2 mg
Copper	0.1 mg
Vitamin B6	0.01 mg
Moisture	4-6 g

Table 2.3: Nutritional Composition of Jaggery powder

Preparation Process of Cookies


Fig 2.1.1 Mixing of dry Materials


Fig 2.1.2 Dough Preparation


Fig 2.1Giving Shape


Fig 2.1.4 Baking at 145^0C for 45 min


Fig 2.1.5 Cookies after Baking


Fig 2.1.6 Packaging

3) Sensory Evaluation

Sensory assessment is a science that measures, examines, and interprets the responses of individuals to products as proposed by the senses. The key purpose of sensory analysis is to:

- Choice qualified juries and learn human remark of food features
- Compare sensory with chemical and physical dimension
- Learn processing effects, keep quality, check raw material choice, and create storage constancy

Assess quality of the product or regulate consumer reaction against the product Moringa Enriched Millet cookies prepared by using finger millet flour and Moringa Powder was served to panel members consisting of 15 members which includes students and staff using 5-point hedonic scale (5-like extremely, 4-like moderately, 3- neither like nor dislike, 2- dislike moderately, 1- dislike extremely). All the samples were evaluated for colour, taste, shape, appearance, texture and overall acceptability. The evaluation procedure was clarified to all the members present for the evaluation. The test was directed in midmorning after 3-hour gap from tiffin Cookie samples were given to the panel members and adequate amount of period was given to avoid any misconception. Water was given to rinse the mouth after every sample was tasted. The finest fused cookie samples were recognized depending on their sensorial satisfactoriness and studied more for their nutritional assessment. Sensory evaluation sheet is prepared to get the information.

III. PROXIMATE ANALYSIS OF THE DEVELOPED PRODUCT

Proximate examination refers for a process, which governs the values of the macronutrients in food samples. In universal, those values are being specified as nutritional proofs shown generally on the tags of the finished or end food products, but they are also being estimated during the manufacture procedure. The start of the nutritional investigation initiates back in 1861 and later then endlessly advanced, improved and upgraded.

A. Estimation of Moisture Content

Moisture estimation is most vital and broadly used dimensions in the testing and processing of foods. Moisture is the volume of water available in a sample, articulate as a percentage.

Moisture content shows a noteworthy role in founding proper circumstances for storability, preservation and packaging of food products. Sample was prepared by grinding the cookie and with mortar pestle. Moisture was determined by oven drying method. Firstly, empty petri dish was weighted (W1), then approximately 10gm of prepared sample was added to the petri dish and weight was noted as (W2). Then, the petri dish was kept in oven for 2 hours at 120^0C. After 2 hours the Petri dish was taking out from the oven and kept it in the desiccator to bring it down to room temperature. Then, the cooled petri dish was weighed (W3).

Moisture content (%) = 100×(W2-W3)/ W2−W1

Where,

W1 = Weight of empty Petri dishes

W2 = Weight of Petri-dish with sample before drying

W3 = Weight of Petri-dish with the sample after drying

IV. RESULTS AND DISCUSSION

A. Sensory Evaluation

Hedonic 5-Scale rating method was carried out. In this formulation, 50% of millet and 10% of moringa were added. Among all the attributes shape was scored high but taste was low. The highest score given in the sample was 2 i.e., for appearance and texture. The lowest score given was 1 for the taste. Appearance was neither liked nor disliked. Taste was moderately disliked. Colour was neither liked nor disliked. Texture was moderately liked. The overall acceptability for the sample C1 given was 2 i.e., the sample was neither liked nor disliked by the panellists.

Table 4.1 Sensory evaluation of C1

Attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total sum	Mean
Appearance	3	3	3	3	3	2	3	2	2	3	3	2	3	2	3	40	2.6
Taste	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	1
Colour	2	3	2	2	3	2	3	2	2	3	1	3	3	2	1	34	2.26
Texture	4	4	3	4	3	3	2	4	3	4	3	4	4	3	2	50	3.3
Acceptability	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	30	2

Hedonic 5-Scale rating method was carried out. In this formulation, 50% of millet and 7.5% of moringa were added. Among all the attributes taste and appearance was low. The highest score given in the sample was 3 i.e., for the texture. The lowest score given was 1.5 for the taste in C1 and also in C2. Appearance and Texture was neither liked nor disliked. Taste was moderately disliked. Colour was moderately liked. The overall acceptability for the sample C2 given was 3 i.e., the sample was moderately liked by the panellists.

Table 4.2 Sensory evaluation of C2

Attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total sum	Mean
Appearance	3	3	2	3	4	3	4	2	3	4	3	3	4	2	3	46	3.06
Taste	2	3	2	3	2	3	2	3	2	2	3	3	2	2	3	37	2.46
Colour	3	4	3	3	4	3	3	3	4	3	4	4	3	3	3	50	3.33
Texture	3	3	3	3	3	3	3	2	3	2	3	2	3	2	3	41	2.73
Acceptability	3	3	3	2	3	3	2	3	3	3	3	4	3	4	3	45	3

Hedonic 5-Scale rating method was carried out. In this formulation, 50% of millet and 5% of moringa were added. Among all the attributes shape was scored high but appearance and Texture was low. The highest score given in the sample was 3 i.e., for appearance and texture. The lowest score given was 2.2 for the taste. Colour was neither liked nor disliked. Taste was disliked. Texture and appearance were moderately liked. The overall acceptability for the sample C3 given was 3.8 i.e., the sample was neither liked nor disliked by the panellists.

Table 4.3 Sensory evaluation of C3

Attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Tota l sum	Mean
Appearance	4	4	3	4	3	4	3	4	3	4	3	4	3	4	3	53	3.53
Taste	4	4	4	4	3	4	3	4	3	4	3	4	3	4	4	55	3.66
Colour	4	4	4	4	4	3	3	3	4	3	4	3	4	3	3	53	3.53
Texture	4	4	3	4	3	4	3	4	3	4	3	4	3	4	3	53	3.53
Acceptability	4	4	3	4	3	4	4	4	4	4	4	3	4	4	4	57	3.8

Hedonic 5-Scale rating method was carried out. In this formulation, 50% of millet and 2.5% of moringa were added. Among all the attributes shape was scored high. The taste was Moderately liked. The highest score given in the sample was 4.5 i.e., for Taste and texture. The appearance was extremely liked. Taste was moderately disliked. Colour was Moderately liked. Texture was moderately liked. The overall acceptability for the sample C4 given was 4.5 i.e., the sample was neither liked nor disliked by the panellists.

Table 4.4 Sensory evaluation of C4

Attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total sum	Mean
Appearance	5	5	5	4	4	5	4	5	4	5	4	5	4	5	4	68	4.52
Taste	4	5	4	5	4	4	4	4	4	4	5	4	5	4	5	65	4.33
Colour	4	5	4	4	5	4	5	4	5	4	5	5	4	4	5	67	4.46
Texture	4	4	4	4	5	4	5	4	4	4	3	3	4	4	5	61	4.06
Acceptability	5	4	5	4	5	4	4	5	5	5	4	4	5	4	5	68	4.52

B. Moisture Content

SL. No	Formulations	Moisture (%)
1	C1	3.774
2	C2	3.673
3	C3	3.419
4	C4	3.391

Table 4.2.1 Moisture content

According to AOAC, the standard moisture content for the cookies is below 5%. The moisture content obtained for the prepared cookies were 3.774%, 3.673%, 3.419% and 3.391%. For all the 4 Formulations the moisture content obtained for the cookies were within standard.

V. CONCLUSION

Moringa Enriched Millet cookies offer a unique and nutritious snack option. The addition of Moringa powder enhances the nutritional value of the cookies by providing protein, fibre, and healthy fats. Ragi flour is gluten-free, making it a great alternative for people with gluten intolerance Moringa powder is also rich in antioxidants, which can provide health benefits like reducing the risk of chronic diseases. The nutty flavour and crunchy texture of the cookies make them a delicious snack option that can provide a quick energy boost. However, the cost of Moringa powder is slightly higher than the cookies available in the market. Considering its overall health benefits people will prefer to purchase Moringa Enriched Millet cookies. Overall, Moringa Enriched Millet cookies are a healthy and tasty snack option that can cater to a wide range of consumers.

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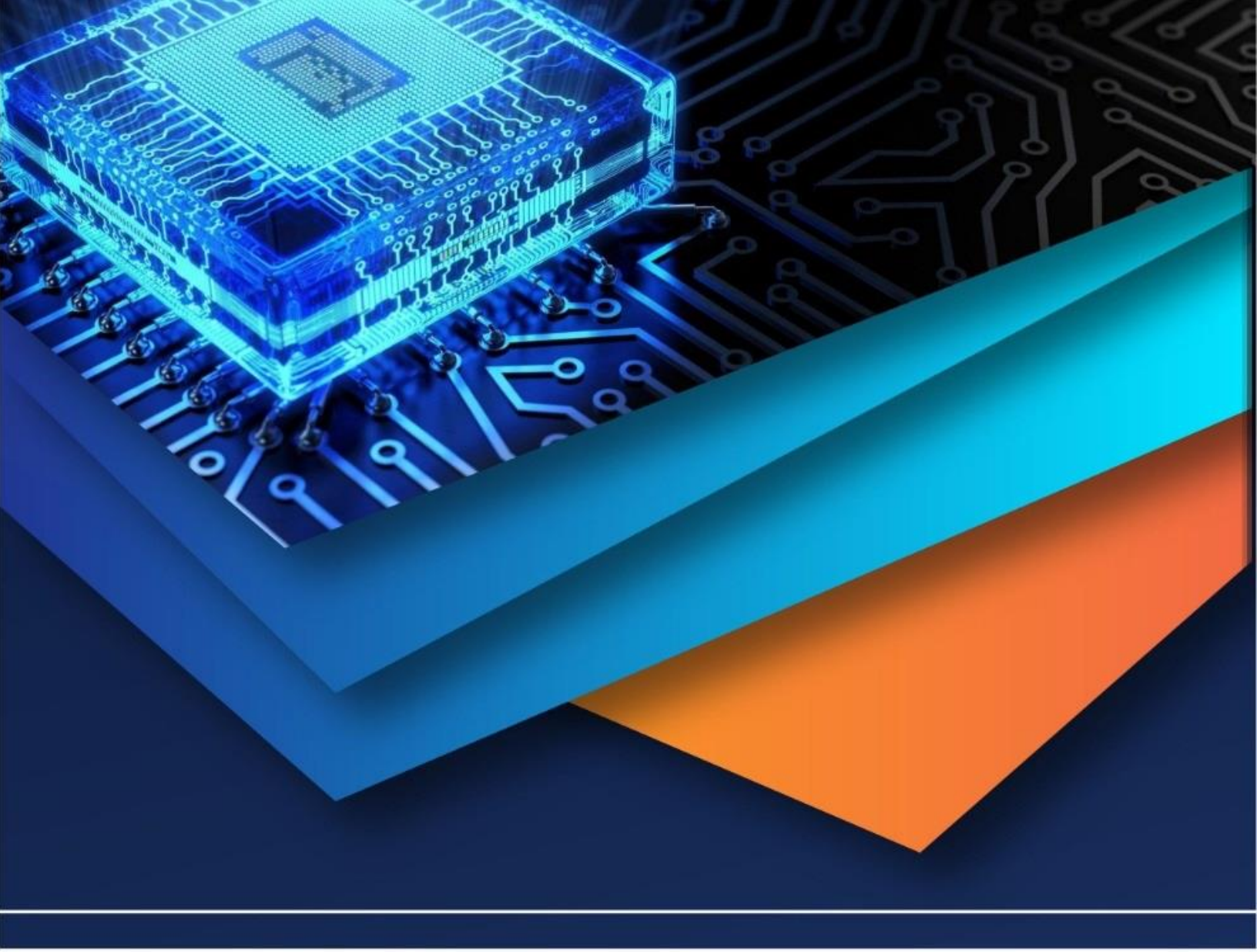

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