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An Overview on Nutritional Composition and Therapeutic Benefits of Sesame Seeds (*Sesamum indicum*)

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Abstract: ***Sesame seeds commonly known as gingelly seeds or til is one of the oldest oilseed cultivated all over the world with India and China being the largest producers. Both black and white sesame seeds are abundant in not only macro or micronutrients but also contain plethora of bioactive components such as lignans and phytosterols contributing to it being a good source of antioxidants. Presence of sesamin, sesaminol, myristic acid and lecithin in sesame seeds attributes to its anti-inflammatory, anti-hypertensive, anti-hyperglycemic, anti-hyperlipidemic and anti-cancer properties. Sesame oil is also known for its anti-microbial activity. Sesame is also an important crop mentioned in Ayurveda and is used in shirodhara, a body relaxing technique. Its oil is also used as skin softener and is utilized in the treatment of cracked heels. Seasame oil can also be substituted with regular oil and its seeds are used as garnishes in breads, biscuits and crackers. Til chikki and laddo's are also prepared in Indian households. Though it is widely used, consumption of even two sesame seeds might trigger allergic reactions in few people. In this review article topics like nutritional composition, therapeutic benefits, uses, products developed and safety and dosage of sesame is discussed.***

Keywords: sesame, sesamin, sesaminol, lignans, phytosterols

I. INTRODUCTION

Sesamum Indicum, also known sesame seeds as gingelly seeds, til or benni seed is one of the oldest seeds known to humankind. Sesame plant is an annual crop belonging to Pedaliaceae family [1]. It is an oilseed crop cultivated all the world. Since it can withstand dry conditions, it is usually grown in tropical and subtropical regions. India,China and Myanmar are largest producers of sesame in the world (Namiki 1995)[2]. According to De Candole, India might have received sesame around 1500 BC during the pre-Aryan period from Malayan and Indonesia. Archaeological evidence has shown that around 3000 BC sesame was cultivated in Palestine and Syria and in Babylonia around 1750 BC. Sesame has also been recovered from Harappa, a part of Indus Valley civilization around 3600-1500 BC [3]

Sesame seeds are not only good source of carbohydrates, protein and fats (oil) but also rich in micronutrients and bioactive components [4]. It is known as 'Queen of Oilseeds' as it is highly resistance to oxidation and rancidity. Sesame seeds are a reservoir of nutrients. Bioactive components like phytosterols, tocopherols and lignans such as sesamin and sesamolin provide numerous health benefits to humans.

Sesamin and sesamolin exhibit antioxidant, anti-inflammatory, antihypertensive and anticarcinogenic properties [5].The seeds were primarily used for preparation of oil and wine. Sesame seeds are used in preparations of biscuits, crackers, sweets and desserts. They are also used to garnish bread loaves. [1,4] Sesame seeds are usually used in the form of sesame oil. Sesame oil is used to make soaps, insecticides and medicines [5]. After the extraction of oil, defatted sesame seed meal (DSSM) can be used as cattle feed as its rich in protein [6]. The oil quality is influenced by variety and quality of sesame seeds used for oil production and also on processes used for oil production [7].

Sesame seeds colour varies from cream-white to charcoal-black whereas white and black are typical skin colours. According to food for health in traditional beliefs of Asian countries, it is believed that black sesame seeds are more superior to white sesame seeds and is included in Pharmacopoeia of the People's Republic of China (PPRC, 2015) as liver and kidney benefiting traditional Chinese medicine (TCM). It has been reported that the phytochemical content and biological activity of sesame seeds is affected by its colour. [4]

With this brief description, an attempt is made to write a review on nutritional composition and therapeutic benefits of sesame seeds.

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II. NUTRITIONAL COMPOSITION

Sesame seeds play an important role in human nutrition. It constitutes an inexpensive source of protein, fat, vitamins and minerals in the diet [8]. Sesame seeds are composed of 10-15% carbohydrates, 15-20% protein, 43-45% lipid, 5-6 % moisture, 15-20% fiber and 5-6% ash [9]. Sesame seeds are rich source of oil and contain high amounts of unsaturated fatty acids (83-90%), mainly 37-40% linoleic acid, 35-43% oleic acid, 9-11% palmitic acid and 5-10% stearic acid with trace amounts of linolenic acid. Sesame seeds are a good source of antioxidants and bioactive compounds like phenolics, phytosterols and phytates. They are also rich in polyunsaturated fatty acids (PUFA) and short chain peptides. Sesame seeds also have special significance due to its high content of Sulphur amino acids and phytosterols [10]

A comparison between white and black sesame seeds is made for various nutrients in the following tables. The macronutrient composition of white and black sesame seeds is listed below in Table 1.

Table 1: Macronutrients present in 100g of sesame seeds [11], [12], [13], [1]

Nutrient	Composition (white sesame)				Composition (black sesame)		Composition (brown sesame)
Country	INDIA	CHINA	SUDAN	NIGERIA	CHINA	NIGERIA	SUDAN
Moisture (%)	4.7	4.71	5.24	4.18	4.20	5.41	5.17
Fat (%)	51.9	52.6	47.09	46.09	48.40	45.63	47.3
Carbohydrate (%)	18.4	15.4	-	16.95	17.80	10.83	-
Protein (%)	19.8	22.2	-	21.94	20.28	23.64	18.95
Fiber (%)	10.8	-	5.61	4.70	-	7.15	4.92
Ash (%)	5.2	4.32	4.81	6.16	6.10	7.34	4.01

The vitamin content of white and black sesame seeds is listed below in Table 2.

Table 2: Vitamins per 100g of sesame seeds [12], [13]

Vitamin	Composition (white sesame)	Composition (black sesame)
Vitamin A(mg)	8.92	9.54
Thiamine(mg)	0.83	0.71
Riboflavin(mg)	0.36	0.38
Vitamin D(mg)	11.57	12.63
Vitamin C(mg)	6.21	4.25
Vitamin E(mg)	28.46	17.45
Vitamin K(mg)	19.57	13.61

Table 3. Depicts the mineral content of white and black sesame seeds.

Table 3: Minerals present in sesame seeds [12, 13]

Mineral	Composition (white sesame)		Composition (black sesame)	
Unit	(µg/g)	mg/100g	(µg/g)	mg/100g
Calcium	1167	473	22854	521
Phosphorous	134	466	158	482
Potassium	10250	465	9722	468
Sodium	1544	-	769	-
Magnesium	35	412	78	380
Iron	111	6.21	121	5.54
Selenium	-	0.03	-	0.07
Zinc	170	8.78	161	7.90
Manganese	35	5.90	78	6.22

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Table 4. Depicts the amino acid content of white and black sesame seeds.

Table 4: Amino acids per 100g of sesame seeds [13], [14]

Amino acid	Composition (white sesame) (g)		Composition (black sesame) (g)
Essential amino acids			
Histidine	2.25	3.09	3.22
Threonine	4.78	4.29	3.84
Valine	5.44	5.18	4.06
Lysine	4.78	3.30	2.43
Leucine	7.57	7.50	6.67
Isoleucine	4.85	4.29	3.08
Tryptophan	1.25	2.53	2.12
Methionine	1.87	3.46	2.83
Non-essential Amino acids			
Tyrosine	-	3.84	3.38
Phenylalanine	-	4.58	4.52
Alanine	3.13	3.37	1.93
Arginine	7.45	4.39	3.88
Serine	6.62	3.14	1.38
Glycine	-	3.33	2.81
Proline	4.08	1.31	3.19
Aspartic acid	9.88	8.95	8.10
Glutamic acid	16.54	17.68	15.15

The fatty acid content of white and black sesame seeds is listed below in table 5.

Table 5: fatty acids per 100g of sesame seeds [13], [15]

Fatty acid	Composition (white sesame)		Composition (black sesame)	
Palmitic acid (%)	9.39	14.02	9.23	12.03
Stearic acid (%)	7.86	5.72	5.88	4.93
Oleic acid (%)	45.85	47.03	46.27	45.46
Linolic acid (%)	37.89	-	38.79	-
Linoleic acid (%)	0.29	35.01	0.34	33.79
Arachidic acid (%)	0.89	1.00	0.70	1.00
Lauric acid (%)	0.08	-	0.20	-

Bioactive components of sesame is listed below in Table 6.

Table 6: Bioactive components per gram of sesame seed [16], [5]

Bioactive component		Composition (mg/g)
Lignans	Sesamin	8.80
	Sesamolin	4.50
	Sesamol	1.20
	Sesaminol	1.40
Phytosterols	β-sitosterol	3.35
	Campesterol	1.00
	Stigmasterol	0.37

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III. THERAPEUTIC BENEFITS

Sesame seeds add up to fiber and are a nutritious source of plant protein [17]. Sesame seeds help in digestion stimulate blood circulation and benefits the nervous system. Sesame seeds are one of the richest source of iron and zinc, including sesame seeds in diet would be an ideal. Sesame seeds are the best source of calcium that contains far more calcium than dairy products. Sesame seeds help relieve constipation. Sesame oil effectively treats cracked heels. Sesamin present in these seeds protects the liver from oxidative damage [11].Therapeutic benefits are exhibited by sesame seeds due to presence of .bioactive components like lignans and phytosterols. Sesame seeds help to lower blood cholesterol and hypertension, act as anti-oxidant, help to prevent alzihmer and provides immunity. [18] Few of therapeutic benefits of sesame seeds are discussed below.

A. Antioxidant Property

Many degenerative diseases are caused by production of free radicals which can be scavenged by antioxidants.[19]. Recently much attention has been given to natural antioxidants not only as safe food additives but also for medicinal purposes [20]. Isolation of antioxidants from natural sources is desirable as synthetic antioxidants may exhibit toxicity [21] Sesame seeds possess significant antioxidant activity hence they can be incorporated into normal diet, which might benefit as a natural antioxidant. [22,10]. One study have also indicated that presence of high content of phenols and flavonoids in sesame is responsible for antioxidant and antiproliferative properties and stated that white sesame seeds are potential sources of functional foods to prevent chronic diseases. [23]. Sesamin, sesamolin and myristic acid found in sesame seeds possess antioxidant properties [24]. When subjected to high temperatures sesamin and sesaminol are converted to sesamol, a more powerful antioxidant. [25] Roasting sesame seeds not only add up brown colour but also increases antioxidant activity [10].

B. Antihyperlipidemic Effect

Sesame seeds alleviates disesases related to lipid metabolism due to presence of high amounts of polyunsaturated fatty acids [26]. Monounsaturated fatty acids and polyunsaturated fatty acids present in sesame are the good kind of fats that helps to lower cholesterol. They are low in saturated fats [27]. Lecithin and lignans also inhibit production of cholesterol [5]. Sesamin, a bioactive component also attributes in lowering atherogenesis- triggering LDL, VLDL and TG levels and increasing atheroprotective HDL levels [28]. Furthermore, vitamin E and flavonoids naturally occuring in sesame are known to possess lipid-lowering properties [29]. Ingestion of sesame increases the time for erythrocyte hemolysis, lag phase of LDL oxidation, and slightly reduces the levels of thiobarbituric acid reactive substances in LDL [30]. A study conducted on albino rats showed a reduction in total cholesterol levels, when the group was treated with 3 ml of sesame oil for 8 weeks [31] Another study conducted on atherosclerotic mice showed that administration of sesame oil reduced blood lipids by 50% and also helped to prevent atherosclerosis by 85% [32]. It can be concluded that sesame reduces LDL, decreases plasma and erythrocyte membrane lipid peroxidation and increases HDL [33].

C. Anti-hyperglycemic Effect

Since primitive times sesame has been known as an imminent crop used for its medicinal properties. Recent studies have also proven that sesame is also beneficial to diabetic hypertensive patients [34]. Phytochemicals present in sesame help to reduce postprandial hyperglycemia by inhibiting carbohydrates metabolizing enzymes [35]. Bioactive components like fat-soluble lignans, sesamin, sesamolin and γ-tocopherol may have antidiabetic activity [36]. Sesame seeds are also a good source of fiber. Fiber hinders assimilation of sugar thereby maintaining glucose levels in the body. Low amount of starch present in sesame also adds up in controlling sugar levels [35]. Sesame is also beneficial for patients with diabetic nephropathy, as it has proved to improve serum parameters [37]. A study found out that diet supplemented with sesame seeds and Nigella sativa improved kidney function in diabetic patients by decreasing elevated levels of blood urea nitrogen (BUN) and Creatinine levels [38]. Another study conducted on rats revealed that liver glycogen level was significantly decreased in diabetic rats and indicated that ethanolic extract of sesame has potential effect to control hyperglycemia [39]. Sesame oil along with glibenclamide can be exceptionally valuable in clinical practice for improvement of hyperglycemia. [35].

D. Anti-hypertensive Effect

Hypertension is an independent risk factor for cardiovascular diseases (CVD) which is one of a major cause of mortality and morbidity. Vitamin E, gamma tocopherols and lignans like sesamin, sesamolin and sesamol in sesasme are known to provide anti-hypertensive effects [40]. Sesamin exhibits not only anti-hypertensive properties but also anti-atherogenic, anti- thrombotic, anti-obesity and lipolytic effect. Sesamin is also known for its radical scavenging ability, which induces endothelium dependent vasorelaxation [41].

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Studies have shown that decreasing oxidative stress and improving antioxidant status is beneficial for hypertension. Therefore, antioxidant property of sesamin contributes to its anti-hypertensive effect (Nakano et al, 2002) [40, 41, 42]. A study conducted on humans concluded that consuming 60 mg of sesamin for 4 weeks decreased 3.5 mmHg of systolic blood pressure and 1.9 mmHg of diastolic blood pressure [43]. Another study on humans indicated that using sesame oil as their regular oil instead of palm oil or groundnut oil for about 45 days resulted in remarkable reduction of blood pressure [44]. Sesame oil also has a positive effect on cardiac hypertrophy in hypertensive rats [45].

E. Anti-cancer Property

Though not many studies have been conducted on anti-cancer property of sesame, lignans present in *S. indicum* have shown anti-cancer effects both in vitro and in vivo [27]. The anti- cancer effect of sesamin has been attributed to its anti-proliferative effect, pro- apoptotic effect, anti-metastatic and pro-autophagocytic activities. Sesamin ameliorated tumor development and progression and can be used in prevention of cancer [46]. Sesamol, another lignin present in sesame acts a metabolic regulator that possess anti-proliferative, anti-mutagenic, anti-hepatotoxic, anti-inflammatory and chemo preventive properties [47, 8]. Sesamolin also induces apoptosis in human lymphoid leukemia cells by DNA fragmentation [27]. Studies have indicated that presence of alkaloids, flavonoids, glycosides and saponins might have antioxidant and anti-cancer activity (Sheela et al, 2015) [48]. A study in humans has shown that sesamin lignan can be converted by intestinal microflora to mammalian lignin, enterolactone and enterodiol, which may benefit against hormone related diseases such as breast cancer [49]. Another possible mechanism for anti-cancer activity of sesame is that sesamin arrested cell growth in early phase of cell cycle known as G1, by regulating a protein known as D1, which promotes cancer cell growth [50].

IV. SESAME IN AYURVEDA

Ayurveda is a holistic health approach, which originated in India thousands of years ago [51]. Sesame is known as Tila taila and its oil is known for its therapeutic benefits in Ayurvedic texts [52]. Ayurvedic knowledge says that sesame provides special strength to those who use it as a medicine and it acts as a strengthener and immunity booster [53]. Sesame oil is one of the best oils mentioned in Ayurveda [54]. Ayurveda mentions the use of mediated oils to treat various disorders. Sesame oil along with herbs and water is cooked for a prolonged period and utilized as mediated oil [55]. Sesame oil is also used in Shirodhara, a calming and soothing technique of the body and mind. Sesame oil is preferred as it is a neutral oil and blends well with other essential oils [52]. A study demonstrated that sesame oil shirodhara improves sleep quality in people having sleep disorders [56]. According to Ayurvedic texts, gargling with milk boiled with sesame and liquorice helps to strengthen teeth [57]. A study conducted among people with plaque-induced gingivitis concluded that there was a decline in total colony count of aerobic microorganisms [58].

V. USES OF SESAME

Sesame seeds and oils are known not only for its's traditional use but also for its neutraceutical, pharmaceutical and industrial role [5]. Uses of sesame are discussed below in Table 7.

Table 7: Uses of Sesame [5], [59], [60], [61], [62], [63], [64], [65]

Use	Bioactive component of sesame
Nutraceutical use	
Hepatoprotection	Lecithin
Cardio protective	Fiber anf Flavanoids
Skin softener	Sesame oil
Systemic pain reliever	Alkaloids
Pharmaceutical uses	
Drug vehicle and laxative	Sesame oil
Hypoglycemia	Flavonoids
Inhibition of malignant melanoma	Linoleate in triglyceride form
Solvent for intramuscular injections	Sesame oil
Antimicrobial mouthwash	Sesame oil
Industrial uses	
Antifungal	Chlorosesamone, anthraquinone

Bactericidal and insecticidal	Sesamin and sesamolin
Cosmetics	Myristic acid
Biodiesel	Sesame oil
Traditional uses	
Intestine lubrication	Sesame oil
Constipation	Sesamin
Intestinal worms	Sesamin, sesamolin
Food preservation	Lignans

VI. PRODUCTS DEVELOPED USING SESAME

Sesame is widely used around the world either in the form of seeds, flour or oil. Sesame oil has been incorporated into the diets from past 6000 years [60]. Sesame oil is highly oxidative stable vegetable oil used as regular oil in many houses [26, 66]. Sesame seeds are constituted as condiments in various recipes around the world. It is used to add flavour and texture to bread, biscuits, crackers and salad dressings [67]. Dehulled seeds can be used directly in foods like halva, laddu and chikki. Sesame flour is used in preparation of ready to eat instant foods and its flour is used as methionine supplement. Sesame protein can be used in preparation of nutritious beverages [68]. Sesame seeds are also used in preparation of tahini and bread dips. It is also used in rice and noodle dishes to add flavour and aroma into the food [25]. Sesame seeds are also used in the preparation of sweet meat known as rewari and gajak [69].

VII. SAFETY CONSUMPTION AND DOSAGE

Sesame is safe to consume and is widely used all over the world. 1-2 tablespoon of sesame seeds and 1-2 sesame seed capsule can be consumed twice a day. ¼- ½ teaspoon of sesame seeds powder can be consumed once or twice daily [70]. Consuming 60 mg of sesamin helps to lower blood pressure. [44]. Sesame oil can be given orally for a week to reduce bloating problem [71]. Around 18.39 mg/person/day of lignans from sesame can be given to males while 13.26 mg/person/day is recommended for females [72]

VIII. SESAME AS AN ALLERGEN

Sesame allergy which can be life threatening has been growing worldwide over past two decades [73, 74]. Sesame seed allergy can be associated with severe reactions [75]. Anaphylaxis to sesame could be a complication of vegetarian diet [76]. Sesame allergy is more common among children and anaphylaxis reaction tends to be less severe among adults [77, 78]. Consumption of just two sesame seeds or lowest dose of sesame protein can trigger severe reactions in sesame allergic populations [78, 80]. Studies indicate that protein and oil components of sesame can trigger immediate hypersensitivity through IgE antibody and delayed hypersensitivity via cell mediated immune responses [81]. Symptoms like Hives, Itching, rashes, wheezing, cramps, diarrhea and vomiting can be seen in allergic reactions caused by sesame [82].

IX. CONCLUSION

Sesame seeds are highly nutritious seeds and can be easily incorporated into our diets. They are not only rich in macro and micronutrients but also rich in bioactive components, which contribute to it being utilized for its therapeutic role. Sesame seeds are also known for its traditional use and it is an important crop mentioned in Ayurveda. Many products are developed using sesame and it may trigger allergic reactions in few people. Consumption of sesame on daily basis would be ideal and it may lead to improvement of health of individuals.

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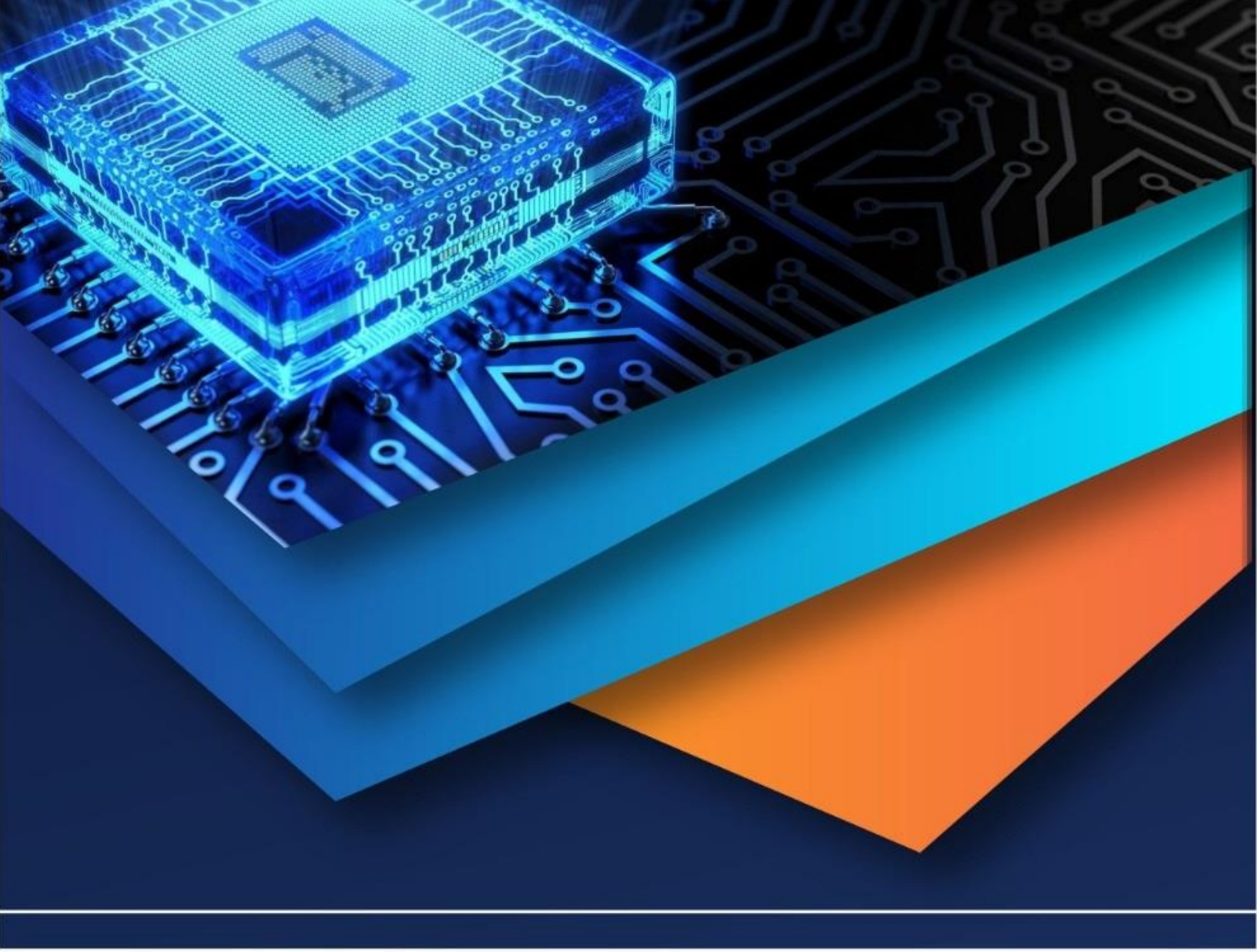
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