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A Systematic Review of the Health Benefits of Black Bean and its Role in Combating Chronic Non-Communicable Diseases

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Abstract: ***Dicotyledons, or legumes, are grown all over the world and include a variety of bean kinds. Phaselous vulgarius sp., or beans, typically make up a sizable portion of the Legume family. Black beans are among the most consumed beans in India, and as their use is exploited there, this is chosen as the study's topic of attention. The literature review focused on the advantages of black beans for health. It has been discovered that black beans are an excellent source of all macro- and micronutrients as well as anti-nutritional elements such tannins, flavonoids, phytochemicals, and saponins. It has been demonstrated that black beans provide health benefits that help prevent chronic non-communicable diseases (NCDs), such as diabetes, cancer, and cardiovascular disease (CVD). In general, black beans black beans are a great substitute for meat and show promise in terms of consumption.***

Keywords: Legumes, Black beans, Health Benefits, non-communicable diseases, Nutrition

I. INTRODUCTION

The formal term for the food group that is commonly consumed, legumes, is Leguminoseae. With over 20,000 species, legumes are thought to be the third biggest flowering plant family. They are composed of dicotyledons inside a pod. They are typically grown in tropical and humid regions of the world and are prized globally for their economic and sustaining qualities (Stagnari et al., 2017 [1]). Under these weather circumstances, crops grow substantially, and cold temperatures inhibit this growth. Beans make up legumes, and *Phaseolus vulgaris sp.* is one of the oldest crops and is accepted as the general word for beans (Broughton et al., 2003 [2]). The growing growth of beans on a global scale has led to their consideration, making them a more commercial crop (Robinson-Garden and McNeal, 2019 [3]). Different bean varieties, including pinto beans, red kidney beans, white kidney beans, navy beans, northern cannellini beans, cranberry beans, soybeans, chickpeas, peas, white speckled kidney beans, yellow beans, mung beans, green beans, and many more, are consumed more widely in different parts of the world. Black bean has been selected as the study's object of interest. Because of their appearance and colour, black beans are also referred to as turtle beans. It is renowned for having a high fiber and protein content. The US Dietary Guidelines for Americans state that black beans are a better auxiliary plant-based protein source. With their unique nutty flavour, black beans are well-known for their outstanding adaptability as a stand-in for other foods. Numerous health advantages demonstrate how black beans help prevent chronic non-communicable diseases (NCDs), which are thought to be the main causes of morbidity and mortality in the world. These diseases include diabetes, hypertension, cancer, cardiovascular disease, chronic pulmonary disease, and many others (Speciale et al., 2020 [4]). The purpose of the study is to compile and highlight all the research that has been done on the health advantages of black beans, as these nutrient-rich beans are underappreciated and overused in many nations, particularly India, and because of their potential to fight silent killer diseases like diabetes, obesity, cholesterol, atherosclerosis, cardiovascular disease, cancer, and so forth.

II. HEALTH BENEFITS AND MECHANISM OF ACTION OF BLACK BEANS

Beans are a healthy option for those who are health-conscious and want to lose weight. Black beans are an excellent choice for Ovo vegetarians and Lacto-vegetarians and are well-known for their nutritional value and health benefits The deep black colour of black beans is caused by the presence of anthocyanin, which has a variety of biological effects including anti-inflammatory, anti-cancer, antioxidant, and chemo preventive qualities (Speciale et al., 2020 [4]).

Anthocyanins also have special capacity to modulate the cell redox- dependent signalling and they interact with the NF-KB a nuclear factor kappa light chain enhancer of activated B cells, located in the cytoplasm are a chain of transcription factors that gets activated during cellular behavior especially during inflammatory responses, cellular growth and apoptosis (Barket and Gilmore, 1999 [5]) and (Dolcet et al., 2005 [6]) and AP-1 signal transduction pathways (a transcriptor factor which responds during a stimuli such as cytokines, growth factors, stress, and bacterial and viral infections). AP-1 controls several cellular processes including proliferation and growth which respond to oxidative signals and mediate a pro-inflammatory effect, and the Nrf2/ARE pathway and its regulated cytoprotective proteins (GST, NQO, HO-1, etc.), involved in both cellular antioxidant defences and annihilate toxic compounds caused by chemical/oxidative stress. (Wu, Nicole, Lingam 2021 [7]).

The chief source of energy being starch in Black Beans comprises of two molecules amylose, a linear polysaccharide in which glucose residues are linked solely by α-1,4 glycosidic bonds and amylopectin a branched molecule in which the branching points compose of α-1,6 glycosidic bonds. The correlation of the amylose: amylopectin starch found in black beans also refines the glycaemic response since amylopectin has higher molecular weight (10^7–10^8 g/mol) compared to amylose (10^5 and 10^6 g/mol) and greater surface area owing to the branching structure of amylopectin which results in faster digestion than amylose. Studies have shown that in normoglycemic individuals who consume 70% amylose meals have exceptional lower levels of plasma glucose than with 70% of amylopectin meals at the rate of 30 and 60 min after meal consumption (Kallio et al., 2007 [8]). According to Thorne, Thompson, and Jenkins (1983) [9], Black beans comprise of higher percent of starch in the form of amylose (30-40%) as regarding cereals (5-10%). One of the chief antinutrient comprising in Black bean is phytic acid which is believed to influence the glycaemic response as it has a direct and indirect correlation to the absorption of starch in the body. The direct correlation is the structural bonding of phytic acid to starch supported by phosphate bonds thereby reducing in the digestibility of starch (Thompson, Button and Jenkins, 1987) [10]. The indirect correlation is that for the stability of different digestive enzymes such as alpha amylases and pancreatic amylases for the digestion process requires Calcium (Ca) (Yoon, Thompson, and Jenkins, 1983) [11]. The adherence of phytic acid to cation Calcium (Ca) results in the decreased effectiveness of these digestive enzymes since their stability is determined by the presence of Calcium (Ca). The decreased effectiveness results in decline of the digestion of the starch in the body maintaining the glucose response at control (Thompson Button and Jenkins, 1987) [10]. This mentions only the action of phytic acid with cation Calcium (Ca) to keep the glucose response at bay but does not emphasize on the action of phytic acid on other cations such Iron, Magnesium, Zinc etc and the mechanism of action in tolerance of glucose. Therefore, there is a need of study in this area of how phytic acid responds to various cations in the human body and its response to glucose.

Black beans contain moderate amounts of dietary fibre thereby helps in modulating postprandial lipemia (Lairon et al., 2007 [12] and helps to keep the level of glycaemic index at control (Lairon et al., 2007 [12]). There are two factors where beans provide beneficial amounts of fibre content. One of the factors is the presence of slower absorption protein level in the body thereby slowing the rate of fibre absorption in the body. The second factor is due to significant amount of soluble fibre. Consumption of Soluble fibre results in slower digestion of beans. Beans are usually consumed in their whole form without being fragmented into smaller particles since it is minimally processed with negligible or no grinding of the beans and this makes the intact bean preserves the coherence of the cell wall. Intact beans resist eupepsia to a larger extent than that of cereal grains which gets absorbed into the body swiftly. This proves to be one of the prime mechanisms of action in reducing the glycemic response (Hutchins, Winham and Thompson, 2012 [13]).

The dietary fibre of black beans is viscous in nature and forms a gel like substance along the gastrointestinal tract dwindling the bean metabolism and reduces 44% of the blood glucose response (Wolever and Jenkins, 2001 [36]). This viscous nature curtails the gastric emptying which in turn also decelerates the absorption of nutrients. (Hutchins, Winham and Thompson, 2012 [13]). Therefore, adhesive nature of black bean reduces the postprandial insulin levels than fibres which are non-adhesive. Insoluble fibre in Black beans helps to ameliorate bulk of the stool and declines certain digestive disorders such as irritable bowel syndrome, ulcerative colitis, inflammatory bowel disorder, and diverticulitis. Nevertheless, additional research must be done regarding the digestive disorders mentioned above and to elucidate the mechanism of how Black beans plays a crucial role in treating these disorders since only action of how fibres reduce glycaemic response is mentioned.

Flavonoids and saponins (a compound present in plants) in the extracts of Black bean seed coat increase the excretion of cholesterol out of the body. Chávez-Santoscoy et al., (2014) [14] studied the mechanism behind the decreasing level of cholesterol biosynthesis and hepatic lipogenesis extracting the nutrients flavonoid and saponin from black beans. It is believed that the FSE from the Black beans regulates the activity of Transcription Factor LXR called as Liver X receptors which play a vital role in the metabolism of cholesterol by regulating the various genes involved in the process, absorption, and the elimination of cholesterol in the body.

LXR is also known for its anti-atherogenic and anti-inflammatory properties signalling it to be effective to be against cardiovascular diseases (Zhu et al., 2012 [15]). On activation of LXR receptors it leads to reverse cholesterol transport by acting on enzymes such as ABCG5/ABCG8 (where these are heterodimers present in the smaller channels of the liver cells acts as a carrier to export cholesterol from the liver. Suppression of this cholesterol carrier can lead to inflammation in the body (Karpen, 2012 [16]). ABCG5/ABCG8 also inhibit the absorption of the biliary and dietary sterols (Yu and Li-Hawkins , 2002 [17]) and (Sabeva, 2011 [18]). Furthermore, an enzyme AMPK (AMP – activated kinase protein) was stimulated on consumption of FSE extract from the seed coat of black beans.

This enzyme is stimulated in the skeletal muscle during exercises and recent studies have shown that PGC1α mRNA (Peroxisome proliferator-activated receptor-γ coactivator-1α (PGC-1α) is a transcriptional cofactor involved in the metabolism of oxidation that influence the cellular responses to metabolic demands which also activates energy metabolism genes (Ventura et al., 2008 [19]). Exercise plays a crucial role in the stimulation of AMPK factor and induces glucose uptake and lipid oxidation to produce energy (Long and Zruithth, 2008 [20]).

Several studies have shown that the activation of AMPK factor in insulin resistant and type 2 diabetic individuals has an increased rate of skeletal muscle glucose uptake by an insulin – independent mechanism. AMPK factor involves 12 heterotrimeric complexes with regards to different subunits (α/β/γ) (Birk and Wojtaszewski, 2006 [21]) of which the specialized form is the AMPK γ-subunits (Mahlappu et al, 2004 [37]) of which AMPK γ_3-subunit (Andersson, 2003 [38]) present in the glycolytic fibres of the muscle leads to increase in the AMPK phosphorylation.

A similar phenotype present in humans is the AMPKγ_3^{R225W} mutation, that increases the AMPK activity, muscle glycogen content and reduces the levels of intramuscular triglyceride levels (Costford et al., 2007 [22]). The long-term expression of AMPKγ_3^{R225W} mutation can lead to an equilibrium status between the metabolism of glucose and lipid especially for those are insulin resistant and type 2 diabetic (Osler and Zierath, 2008 [23]) and (Savage, Petersen, and Shulman, 2007 [24]). The hypothalamus is the chief controller of food intake in our body. This brings an activation of the AMPK factor in play since it also plays in the regulation of food by hormones that involved in increasing appetite (Zachariah et al., 2014 [25]). On the contrary, Leptin (an adipose derived peripheral hormone) alleviates the hypothalamic AMPK factor and thus stimulates to reduce the intake of food and hence promote lipid oxidation and exhaust the triglyceride stores (Minokoshi et al., 2004 [26]). Gibbs et al., 1995 [27] and Brozinick et al., 2001 [28] have found that in severely obese diabetic leptin receptor-deficient *db/db* mice, the GLUT4 (insulin-responsive facilitative glucose transporter, Atkinson et al., 2013 [29]) studies that an overexpression of GLUT4 improves the tolerance of glucose and skeletal muscle insulin sensitivity. Supplementary investigational research must be done whether apart from the above-mentioned enzymes are involved in the tolerance of glucose and insulin sensitivity since majority results prove to be effective in *invitro* studies than in *in vivo*.

Priyadarshini and Beatrice, (2022) [30] have studied the anti-proliferative action of phytochemicals (phytonutrients potentially found in plant foods) present in the extracts of black beans where the predominant phytochemicals present in black beans were quercetin, myricetin, palmitic acid, vanillyl alcohol and gallic acid of which found that quercetin has anti-cancer properties especially in that of breast cancer where MCF-7 cells (Human breast adenocarcinoma) obtained from National Centre for Cell Science, Pune and cultured in Rose-well Park Memorial Institute and used as cell culture to determine the efficacy of quercetin on these cells.

The presence of quercetin has led to necrosis of cancer cells which is due to the up-regulation of Bax (activated by BH – 3 proteins present in cytoplasm, responding to stimuli therefore causing the release of cytochrome – 8 and activating APAF-1 dimerization in the mitochondrial pathway and performing apoptosis (Pawloaski and Kraft, 2000 [31]).

Another down – regulation of Bcl – 2 (family proteins that play a vital role in the resistance of cancer cells to chemotherapy, Nasseri et al., 2015) regulates β-catenin and its genes (Srinivasan et al., 2016 [32]) and (Duo, 2012 [33]) since β-catenin inhibits the development of cancer by modulating cell signaling pathways and destroys the cancer cells (Khan et al., 2006 [34]). Correspondingly, myricetin, another phytochemical present in the extraction of black bean was found to cause apoptosis of the human colon cancer cells by the similar mechanism of Bax/Bcl-2 dependent pathway (Kim et al., 2014 [35]). Nonetheless, this study was an *in vitro* experiment, further accuracy of the activity of phytochemicals extracted from black bean and its anti-cancer property must be done in *in-vivo* trials. The table mentioned below gives the systematic review of supplementation of Black beans in *in vivo* and *invitro* studies.

Table I
Systematic Review of Health Benefits of Black Beans

S.No	Author And Corresponding Author	Title, Journal, Year and Place	Sample, Sample Size, Age, Duration	Intervention	Health Benefits
1.	Thompson, S.V., Winham, D.M And Hutchins, A.M [13]	Bean And Rice Meals Reduce Postprandial Glycemic Response in Adults With Type 2 Diabetes: A Cross-Over Study: *Nutritional Journal*, 2012, USA	17 Human Subjects Male (n = 9) Female (n = 8) Age = 35 – 70 Years Old Duration = 3 Months	Test Meals: Control Group: White Rice (180 G). Test Group 1: White Rice (128g) + Pinto Beans (177g) Test Group 2: White Rice (128 G) + Black Beans (115 G) Test Group 3: White Rice (128g) + Red Kidney Beans (138g). Rotations Repeated After Washout Period of One Week. Experimental Diet Consumed After 12 Hours Fast. Blood Glucose Concentration At 30 Min Intervals To 180 Min Was Taken.	Reduces Postprandial Net Glucose Compared to White Rice Control Group. Increased Fiber Content Improvement In Composition of Phytochemicals And Phytonutrients That Aids In Reducing Glycaemic Response.
2.	Chávez-Santoscoy, R. A., Gutiérrez-Uribe, J. A., Granados, O., Torre-Villalvazo, I., Torres, N., Palacios-Gonza´Lez, B., Tovar A. R., And Serna-Saldívar, S. O [14]	Flavonoids And Saponins Extracted from Black Bean (Phaseolus Vulgaris L.) Seed Coats Modulate Lipid Metabolism and Biliary Cholesterol Secretion In C57BL/6 Mice: *British Journal of Nutrition*, 2014, Mexico	48 C57BL/6 Male Mice Taken for Study. Age = 21 Days Old Duration = 5 Weeks	Mice Divided Into 6 Experimental Groups. All Groups Fed with *Ad Libitum* (Control Diet) For 35 Days. 6 Experimental Group Consumed 6 Different Experimental Diets. Group 1 = Only Control Diet Group 2 = Control Diet with Flavonoid- And Saponin-Rich Extract (0·25%) From Black Bean Seed Coat. Group 3 = Control Diet with Cholesterol (0.5%) Group 4 = Control Diet + Cholesterol And (0.5%) Flavonoid- And Saponin-Rich Extract (0.5%) Group 5 = Control Diet + Cholesterol and Flavonoid- And Saponin-Rich Extract (0.25%) Group 6 = Control Diet + Cholesterol (0.5%) and Simvastatin (0.25%) End Of Study – Plasma Collected After 12 H Fast to Evaluate Serum Biochemical Parameters Prior To Mice Being Killed in A CO_2 Chamber. Liver And Ileum Excised and Stored At – 80ºC.	Diet With FSE (Flavonoid- Saponin Rich Extract) Alleviates Total Cholesterol Level, Serum Cholesterol LDL Cholesterol and Triacylglycerol S. Decreased Lipogenic Protein in The Liver. Attenuate Lipogenesis Beneficial In Reducing Hepatic Liquid Depots. Impedes Hepatic Lipid Accumulation. Revitalize Fatty Acid Oxidation and Cholesterol Excretion.
3.	Reverri, E. J., Randolph, J. M., Steinberg, F. M., Kappagoda, C. M., Edirisinghe, I., And Burton-Freeman, B. M [36]	Black Beans, Fiber, And Antioxidant Capacity Pilot Study: Examination Of Whole Foods Vs. Functional Components On Postprandial Metabolic, Oxidative Stress, And Inflammation In Adults With Metabolic Syndrome: Nutrients, 2015, USA	12 Female Human Subjects Age = 14 – 49 Years Old Duration = 33 Days	12 Adults with Metabolic Syndrome Consumed BB (Black Bean Meal), FM (Fiber Matched Meal) And AM (Antioxidant Capacity Meal) BB Meal – Comprised Moderate Fat Meal and Soup Made from Dried Black Beans Prepared According To Packaged Instructions. FM And AM Meal – Constituted Moderate Fat Meal and Soup Which Were Couscous- Based. Blood Was Collected and Analysed Prior To Fasting And Five Hours Postprandial After Consumption Of Experimental Diet. Rotations Repeated After Washout Period of One Week.	Enervates Postprandial Insulin Response. Lessen The Level Of Glucose And Insulin For 3 Hour Post Prandial Period.
4.	Simons et *al* [37]	Predicting Anthocyanin Content in Canned Black Beans Based on Color. 2020	12 Black Bean Genotypes of Which 40 Grams Were Collected In 8 Ounce	10 Grams of Raw Black Bean Seeds (In Triplicate) Was Weighed in A 45 Ml Centrifuge Tube And 20 Ml Of 50% Ethanol (Acidified with Hcl, Ph = 3.0) Added. Tubes Were Then Partially Sealed and Placed In A Water Bath At 65 ˚F For Extraction For 2 Hours. Similar Steps Were Followed for Cooked	Anti-Inflammatory, Anti-Cancer and Anti-Viral Properties.

			Tightly Sealed Water Jars and Autoclaved At 115 ˚C And 10 Psi For 15 Min, Following Which The Jars Were Removed And Cooled To Room Temp.	Black Beans Except That the Tubes Were Centrifuged (3000 Rpm, 10 Min) Finally, Incubator Treatment Was Used to Settle Particulates Produced During Cooking.	

III. CONCLUSION

In summary, Conventional foods such as beans and food combinations such as beans and other carbohydrate sources should be perpetuated in the long run for their numerous health benefits which has a positive impact in maintaining insulin resistance, decreased hepatic cholesterol and serum cholesterol, increased fibre content and anti- cancer properties as mentioned in the review article. Furthermore, research regarding the health benefit of Black beans should be encouraged and its mechanism of action which would provide authentic nutritional information to individuals who have or who are at the risk of having chronic non communicable diseases (NCD's).

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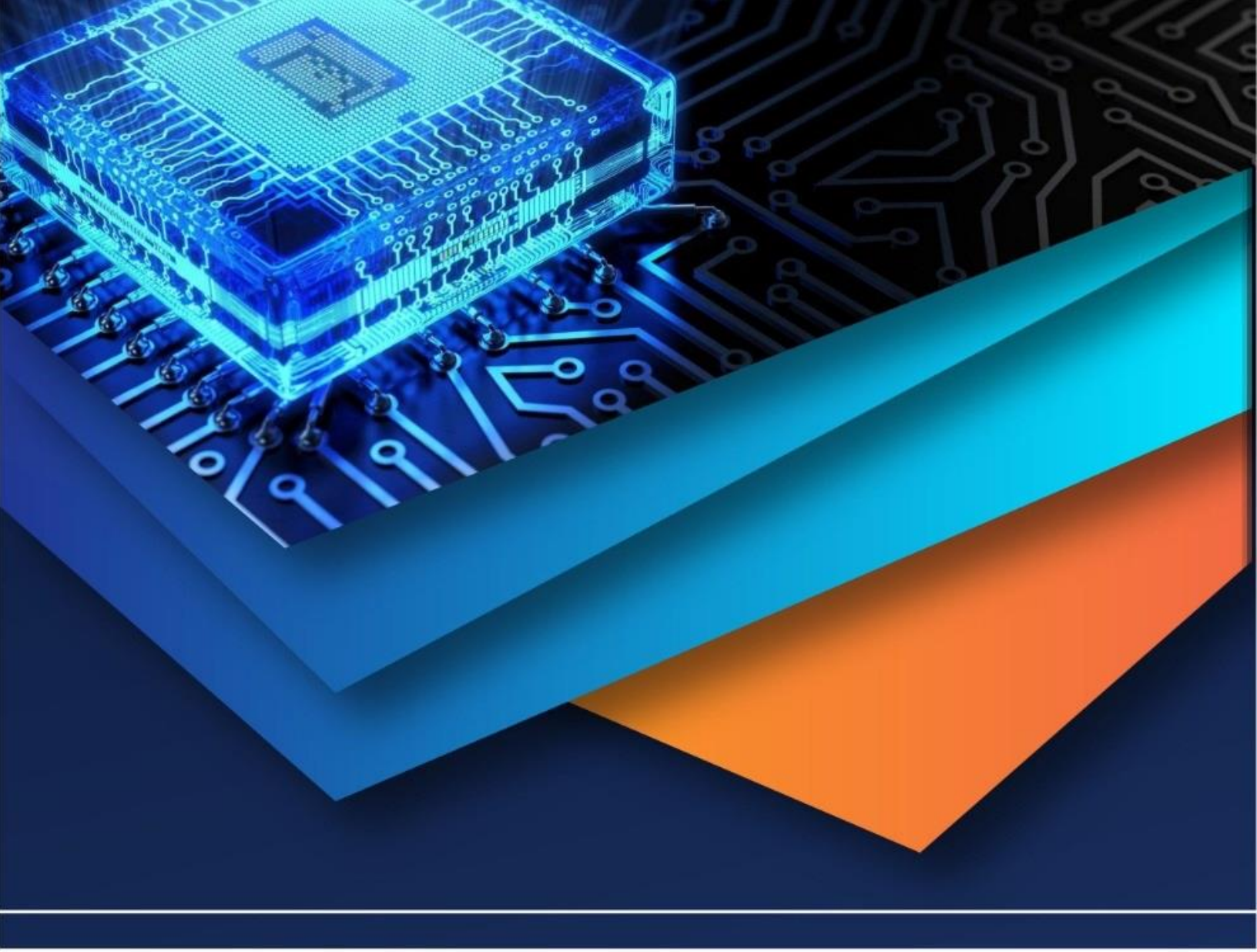

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