iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** I **Month of publication:** January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1058

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

Nutritive Evaluation and Trace Metal Contents of Commercial Edible Mushroom –Agaricus bisporus

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Abstract*: *Two different Agaricus bisporous samples were analysed for their proximate composition, mineral contents, contribution to daily intake and comparing their results with the recommended daily intake levels were successfully achieved. Proximate composition study shows that these species are with rich sources of Protein, Carbohydrate and Fibre with low fat content. Mineral element analysis reveals the significant role of the elements, daily intake limits and toxicity level of the elements observed in the present study. According to the present study, the observed mineral elements are 0.57-0.61(As), 0.15-0.24 (Cd), 0.09 (Co), 6.84-7.12 (Cu), 87.33-92.56 (Fe), 0.26-0.29 (Pb), 13.14-14.56 (Mn), 18.05-19.11 (Ni), 1.12-1.35 (Se), 39.81-40.27(Na) and 60.61-62.34 (Zn) mg/kg DW. These values are all within the permissible limits recommended by World Health Organization and no potentially harmful mineral element levels observed.

Keywords:* *Agaricus bisporus, Mushroom, Cultivation, Essential elements, Non-essential elements and AAS

I. INTRODUCTION

Mushrooms have long been valued as delicious and nutritional foods in many countries. Mushrooms are appreciated, not only for texture and flavour but also for their chemical and nutritional characteristics [1]. Mushroom is considered to be a complete, healthy food and suitable for all age groups. Though, the nutritional value is determined by the type, stage of development and other environmental conditions, mushrooms are rich in proteins, dietary fiber, vitamins and minerals. They have insignificant lipid level and high proportion of polyunsaturated fatty acids resulting in low calorific value. The protein content, though varies greatly in different mushrooms, is usually high. Mushrooms are an excellent source of vitamins especially C and B (Folic acid, Riboflavin, Niacin and Thiamine) and minerals like potassium, sodium and phosphorus. It also contains other essential minerals like Cu, Zn and Mg in traces. Mushrooms are also known to have medicinal values as these have been shown to promote immune function, boost health, lower risk of cancer inhibiting tumour growth and support body's detoxification mechanism. Mushroom, thus has great potential for the production as quality food. Mushrooms have been evaluated for their nutritional status mainly on the basis of their chemical composition. All together with a long history as food source, mushrooms are important for their healing capacities and properties in traditional medicine and mushrooms have been relished as a delicacy since ancient history because of their delicate flavor, nice aroma and physical taste appeal [2]–[4]. They fall between the best vegetables and animal protein source. In developing countries like India with rich biodiversity, mushrooms are a boon for progress in the field of food, medicine and unemployment because of several nutriceuticals and medicinal mushrooms that have been found to be useful towards human health development as food, medicine, minerals and drugs among others [5]-[6]. Mushrooms are considered as bio-accumulators of heavy metals. The ability of mushroom species to bio-accumulate the minerals from the growth medium into the fruiting body is well documented [7]-[8]. Environmental factors such as species of mushrooms, morphological part of fruiting body, developmental stages and age of mycelium, biochemical composition, and interval between the fructifications affect mineral accumulation in macro fungi [9]-[10]. Because of ecological and genetic but known factors, the fruiting bodies of higher mushrooms often are relatively rich in mineral constituents [11]-[13]. In order to understand the health and environmental impact of an element, characterization of each form as a species has become a key challenge of modern analytical chemistry. Research has stimulated the development of analytical techniques for the identification, determination and structural characterization of different forms in biological and environmental niches. Such an appraisal is termed ―elemental speciation [14]. Present study is an attempt to investigate the Nutritive evaluation and trace metal contents of commercial edible Mushroom –*Agaricus bisporus.*

II. MATERIAL AND METHODS

A. Sample Collection and Preparation

Two samples of *Agaricus bisporus* mushroom were collected from departmental stores, one from Coimbatore, Tamilnadu and the other one from Madurai, Tamilnadu. The collected samples were washed with distilled water to eradicate dirt particles. The samples

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were dried for six days in open air under shade, thereafter they were grounded into powder using commercial mixer grinder and stored in an air-tight polythene container until required for further analysis [15].

B. Acid Digestion

For mushroom analysis, 1 g of ground-dried mushroom sample was placed in a porcelain crucible and ashed at 450ºC for 5-6 hours and then the ash was dissolved in 2 mL of concentrated HNO_3 and heated on a low heat for 1 minute. The solution was allowed to cool, filtered through Whatmann No: 42 filter paper and transferred in to a 50 mL flask and diluted to volume with double distilled water. A blank was also prepared using similar experimental procedure described by AOAC [16].

C. Proximate Analysis

The two samples of Agaricus bisporus were analysed for their proximate composition. Moisture, carbohydrate, protein, fat, fibre, ash and total lipids were determined by the method described by Raghuramalu, et al 2003 [17].

D. Elemental Composition

Calibration of AAS was carried out using the working standards used for calibration [16] and AAS was calibrated with standard solutions before measurement of each sample. The mineral elements were determined employing Double Beam Atomic Absorption Spectrometer (Schimadzu AA6300, Japan).

III.RESULTS AND DISCUSSION

The present study is resolute to assess the proximate composition and elemental composition of selected mushrooms. The selected mushrooms were collected from Coimbatore, Tamilnadu (Sample M-1) and the other from Madurai, Tamilnadu, India, (Sample M-2).

A. Proximate Analysis

TABLE I
PROXIMATE ANALYSIS OF AGARICUS BISPORUS SAMPLE M-1 & M -2

Component	Sample M-1	Sample M - 2
Moisture (%)	88.22	87.76
Carbohydrate (%)	32.72	34.31
Protein (%)	47.43	49.62
Ash (%)	6.45	4.76
Total lipid(%)	3.56	2.98
Fibre (%)	21.52	19.36

The moisture, total carbohydrates, Protein, Ash, Lipid and Fibre contents in *Agaricus bisporus* were found to 88.22,32.72,47.43,6.45,3.56 & 21.52 % in sample M-1 and 87.76, 34.31, 49.62,4.76 2.98 & 19.36 % in sample M-2 respectively.

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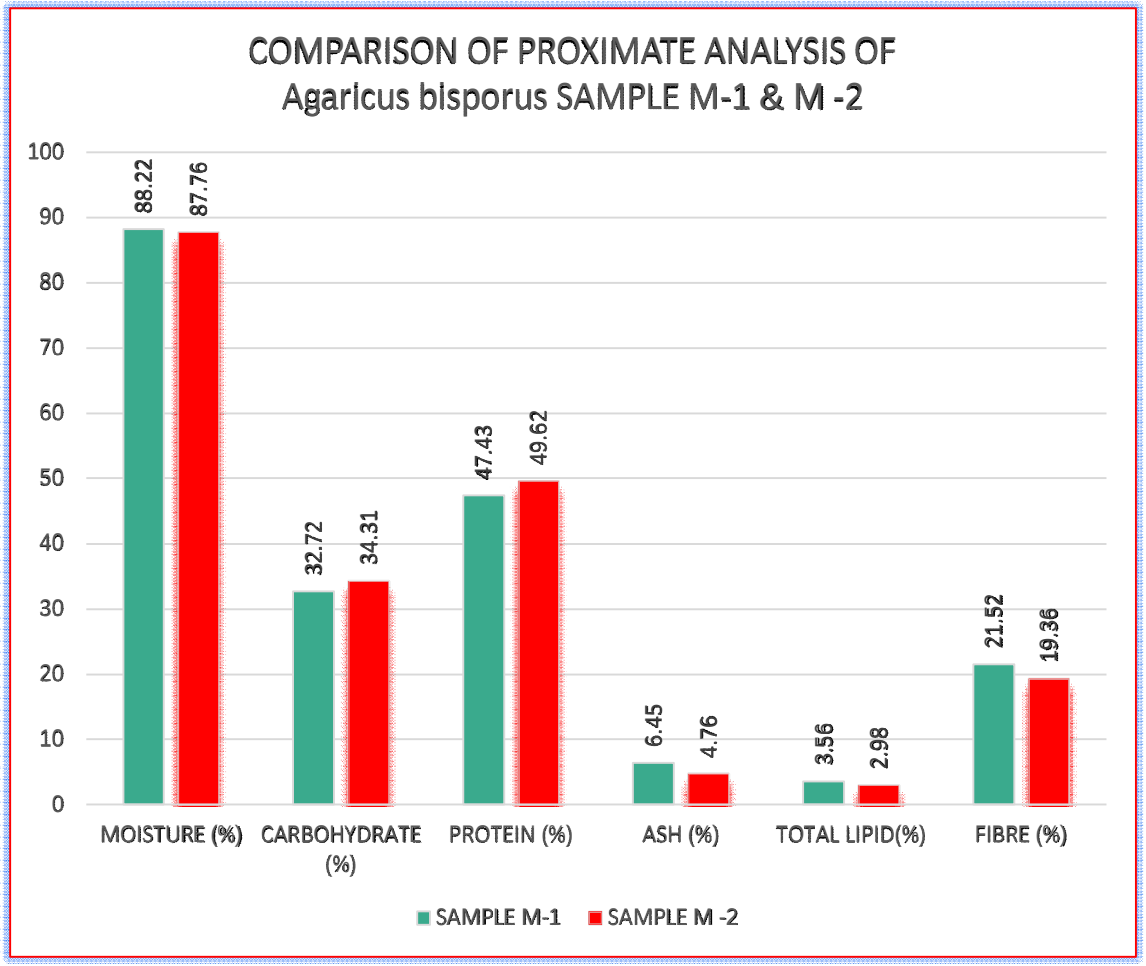


Fig. 1 Comparison of proximate analysis of *Agaricus bisporus* sample M-1 and M-2

B. Proteins

Protein content of *A. bisporus* mushroom depends on the type of mushrooms, composition of the bedrock, bulk of pileus, harvest period etc., Verma et al. (1987) reported that mushrooms are highly advantageous for vegetarian because it contains some essential amino acids which are found in animal proteins. Mushrooms normally contain 19 to 35% proteins as compared to 7.3% in rice, 12.7% in wheat, 9.4% in corn, 38.1% in soya bean and Abou et al. (1987) found 46.5% protein on dry weight basis in *A. bisporus*. In general mushrooms have rich protein content than most of the other green vegetables and wild plants. Also mushrooms contain all the essential amino acids required by an adult. According to the present analysis, both the samples M-1 and M-2 have shown 49.62%,47.43% of protein respectively and these mushrooms are excellent source of proteins.

C. Carbohydrates

Simple carbohydrates are present in mushroom, as mushrooms cannot photosynthesize. The carbohydrates present in mushroom are lesser in quantity than vegetables. Mushroom provides only a fraction of the energy requirement. Mushrooms contain an average of 85-125 kJ per 100 g of energy, whereas an adult male need about 10000 kJ per day. These low energy levels in the mushrooms make it to be used in low-calorie diets. Mushroom becomes an ideal food for diabetic patient because of its low carbohydrate value [18]. A considerable amount of carbohydrates is present in the mushroom in the form of polysaccharides. In the present study, carbohydrate level was found comparatively lesser than protein level. Values of carbohydrates in the samples M-1 and M-2 are reported 32.72% and 34.31 respectively.

D. Lipids

Mushrooms are characteristically low in fat, comprising 2-8% dry weight. Free fatty acids, sterols, phospholipids are included in the crude fat and also it includes all classes of lipid. A high amount of linoleic acid which is the only essential fatty acid required in the

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human diet, has been found to be 63-74% of total fatty acids. For brain and nervous system Sphingolipids is important, which is also found but exists in small proportion. In *A. bisporus* mushroom, the content of fat is very low as compared to carbohydrates and proteins. The unsaturated fatty acids dominate the fats present in mushroom fruiting bodies. Ogundana and Fagade (1981) indicated that mushrooms have 4.481% fats on dry weight basis. According to the present analysis, the total fat/lipid content reported in the samples M-1 and M-2 are 3.56% and 2.98% respectively.

E. Fibre

Proximate composition of the Agaricus bisporus sample M-1 and M-2 revealed that the mushrooms are of rich fibre content and shows 21.52% and 19.36 respectively. To end with, the tested Agaricus bisporus mushrooms are protein and fiber rich with low fat content. The ash content and carbohydrate content was lesser than other foodstuff from plant and animal origin. Overall, the rich nutritious composition makes cultivated mushrooms very distinctive. These nutrient contents made mushroom as a low energy, healthy foodstuff and Agaricus bisporus mushrooms may also use as protein supplementary diet.

F. Mineral element composition

TABLE III
MINERAL ELEMENT COMPOSITION OF *AGARICUS BISPORUS* SAMPLE M-1 & M -2

Component	Sample M-1	Sample M -2
Arsenic	0.57	0.61
Cadmium	0.15	0.24
Cobalt	0.09	0.09
Copper	6.84	7.12
Iron	92.56	87.33
Lead	0.29	0.26
Manganese	13.14	14.56
Nickel	19.11	18.05
Selenium	1.12	1.35
Sodium	39.81	40.27
Zinc	62.34	60.61

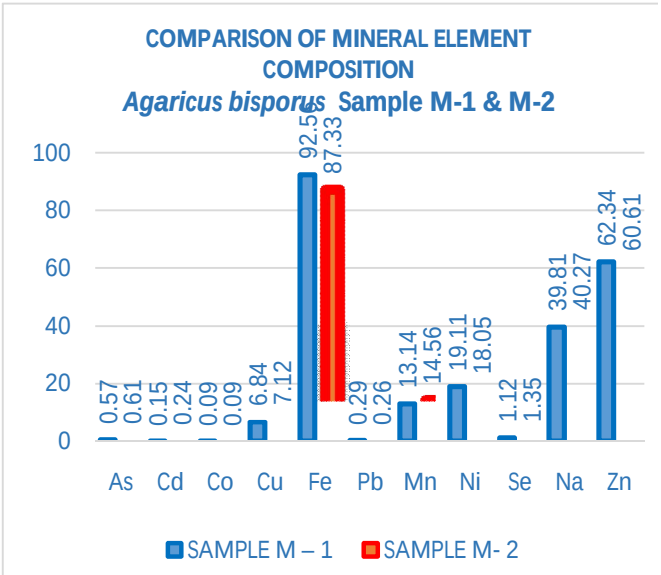


Fig. 2 Average concentration of mineral elements and Trace elements of Agaricus bisporus on dry-weight basis (mg/kg): M-1 & M- samples and that the minerals like Iron, Sodium, Zinc, Magnesium and Copper are comparatively higher than Lead, Cobalt, Cadmium and Arsenic.

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G. Arsenic

The adversative health effects of arsenic have long been documented. Even though natural soils contain arsenic generally in inorganic forms, in mushroom mainly organic arsenic compounds were found [19]. The mean concentrations of Arsenic found in cultivated mushroom samples of M-1 and M-2 was 0.57mg/kg, DW and 0.61 mg/kg, DW respectively and is within the normal limits.

H. Cadmium

Cadmium is known as a toxic element, since it can occur as an inhibitor in many life processes. Mushrooms, in specific, may be very rich in cadmium. In humans, cadmium accumulated in the kidneys, which will begin to malfunction at over- doses, dribbling proteins in the urine and make disorder in potassium metabolism [20]. Measured Cadmium levels were within the normal range in samples analysed and the results are 0.24 mg/kg DW and 0.21 mg/kg DW respectively in sample M-1 and M-2. As results from data published until 1999 [21], cadmium contents varied between 0.5 and 5mg / kg however, the usual contents were 5–50 mg/ kg.

I. Cobalt

Cobalt is an essential mineral needed in very small amounts in the nourishment. It is an integral part of vitamin B_{12}- cobalamin, which supports production of red blood cell. The present study reveals the content of cobalt as 0.09 mg/kg, DW and 0.09 mg/kg, DW in sample M-1 and sample M-2 respectively. All published papers agree that cobalt contents are generally below or around 0.5 mg/ kg, only a limited proportion exceeds 1.0 mg/ kg. These results were reported by Jan Borovička & Zden ěkŘanda [22].

J. Copper

Copper is one of the most abundant trace element in human body and plays major impact on living systems. It has been found that, in mushroom, Copper is not distributed evenly within fruiting bodies. Spore-forming part contains significantly higher copper level than the rest of fruiting body [23]. The values of Copper reported in the present sample M-1 and sample M-2 study is 6.84 mg/kg, DW and 7.12 mg/kg, DW respectively, which are in lowest concentrations comparing with the published articles where in the ranges were between 13.4-50.6 µg/g [10].

K. Iron

Iron is the most predominant of the heavy metals in the human body. High Concentrations of iron may lead to tissue damage, as a result of the formation of free radicals [24]. The reported values of Iron in the sample M-1 and the sample M-2 in the present study were 92.56 mg/kg, DW and 87.33 mg/kg, DW respectively. The iron values are similar to those of previous studies.

L. Lead

Excessive consumption of high lead content of some species of mushrooms can lead to the tolerable levels of metal intake. The observed concentration of lead in both the samples of the present study are within the limits advice by WHO and revealed 0.29 mg/kg, DW for sample M-1 and 0.26 mg/kg, DW for sample M-2.

The consumption of these *A. bisporus* mushrooms does not represent a toxicological risk, as these levels do not represent a health risk because the WHO [25] set a provisional tolerable weekly intake of Pb of 25g per kg of bodyweight, resulting into 1.50 mg Pb/week for a person with a bodyweight of 60 kg.

M. Manganese

Manganese is one of the vitally important elements. Human body contains about 15–20 mg. of manganese [26]. According to present study the content of manganese in the samples M-1 and M-2 were reported as13.14mg/kg, DW and 14.56 mg/kg, DW respectively. The values of the results are in agreement with those reported earlier. Since dietary manganese is relatively nontoxic, even 10-20 mg per day is safe as per WHO [27].

N. Nickel

Nickel is an essential trace mineral. Trace amount of Ni is beneficial as an activator of some enzyme system but it is toxic at higher level [28]. Nickel deficiency can lead to dermatitis, decreased growth, decreased reproduction capacities, pigment changes and compromised liver function [29].

Nickel concentration in the present study of Agaricus bisporus sample M-1 and M-2 are 19.11 mg/kg, DW and 18.05 mg/kg, DW respectively. The WHO [27] recommended daily intake of nickel between 100 and 300 mg/kg. The nickel values are in agreement with those reported in the literature.

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O. Selenium

*Agaricus bisporu*s contains much more selenium than other vegetables and fruits [30]. Mushrooms contain a good percentage of protein, which is expected to incorporate selenium into amino acids such as selenocistein and selenomethionine [31]. The level of selenium content in *Agaricus bisporus* is in sample M-1 and M-2 are 1.12 mg/kg, DW and 1.35 mg/kg, DW respectively. The selenium contents of these mushrooms are sufficient to provide nutritionally significant amounts in relation to the total daily intake of selenium.

P. Sodium

In general, edible mushrooms have low and stable sodium contents [32-33]. Vetter et al., analyzed Na content in several common edible mushroom species and found that the average content was varied between 0.1 to 0.4 mg/g, and appeared to be independent of habitat, nutrition type or taxonomic position. Sodium levels measured in the present analysis are 39.31 mg/kg, DW for sample M-1 and 40.27 mg/kg, DW for sample M-2.

Q. Zinc

The deficiency of zinc in children can lead to loss of appetite, growth retardation, weakness, low spirited, stagnation in sexual growth [34]. The present study shows the content of Zinc in the sample M-1 and sample M-2 as 62.34 mg/kg, DW and 60.61 mg/kg, DW respectively. Kalac., et. al (2010) reported that, Zinc content varies widely between 25 and 200 mg /kg DM and even higher levels were observed in some species. The values of zinc are in agreement with literature value.

IV. CONCLUSION

The observed levels of proximate compositions of two different Agaricus bisporus indicates that these species are with rich sources of Protein, Carbohydrate and Fibre with low Fat content and the mineral element analysis reveals the significant role of the elements, daily intake limits and toxicity level of the elements observed in the present study. The mineral elements present in the mushrooms are important for normal growth and development, maintenance of body tissues, sexual function, the immune system, and detoxification of chemicals and metabolic irritants. Mushrooms plays major role in tissue regeneration, and ensure proper working of glands (thyroid) and also contributes to the formation of antibodies etc. The consumption of mushrooms has important benefits for human body and mushrooms can prevent the emergence of serious diseases such as breast cancer, anemia, chronic fatigue and also help to strengthen the immune system and increase the male potency.

According to the present study, the observed mineral elements are all within the limits prescribed by World Health Organisation and no potentially harmful mineral element levels observed. An extensive research of trace elements in edible mushrooms during the last decade provided a bulk information. Nevertheless, data on the element speciation have been still very limited. The examination of newly cultivated mushrooms and isolation of their active ingredients remains a challenge. Hence, mushrooms will keep the notable spot light for researchers. Since fruiting bodies of mushrooms have the ability to bio accumulate metal ions; heavy metals and mineral traces may have to be analysed periodically to eliminate the risk associated with the potentially harmful element contaminated mushroom consumption.

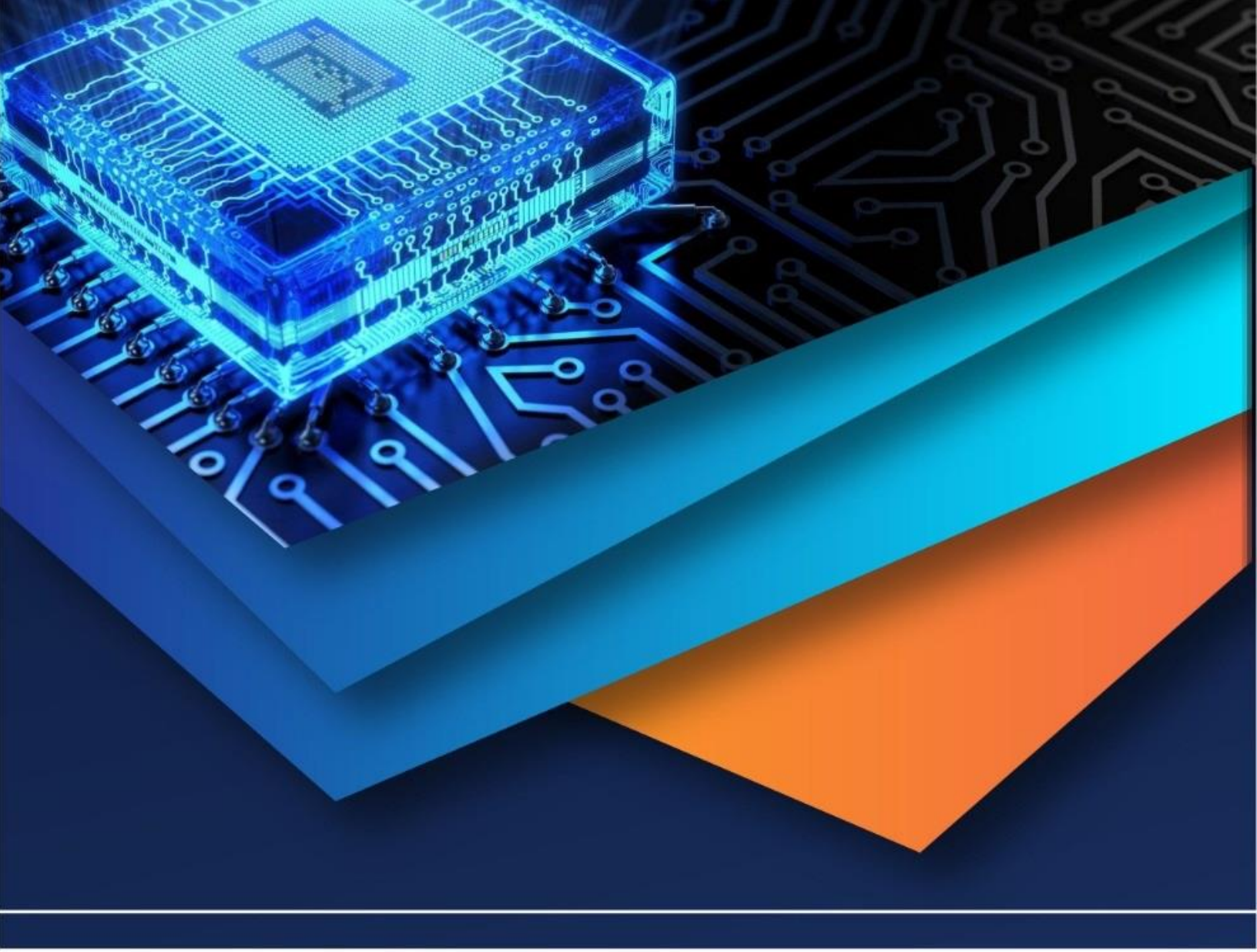
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