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A Review on Peeling Techniques for Development of Shallot Peeling Machine

Arshavarthni R[1], Dr. P. Hema Prabha[2]
Department of Food Processing and Preservation Technology, Avinashilingam institute for home science and higher education for women

Abstract: Shallot is among the essential marketable vegetable and spice crops, extensively used in the south Indian kitchen for seasoning curries. Shallots are known for their subtle, delicate taste, and shallots can be pickled, caramelized, or roasted and used in salad dressings, gravies, and vinaigrettes. The shallots are peeled by hand before using in food operations. The peeling process faces a multitudinous problem of time consumption and is veritably important for minimal process and from a domestic point of view. Automation of processing operations plays a vital function in removing the negative attributes of traditional processing ways and promoting desired quality. The proposed system helps to identify the peeling method for effective peeling of shallot onion at the domestic level to acquire a quality product.
Keywords: Peeling, shallots onions, automation, Food processing

I. INTRODUCTION

Onion (*Allium cepa L.*) is extensively cultivated and consumed worldwide. (1) The common onion kinds with three colors, red, yellow, and white, are typically available in the food market. Onions are widely used for culinary purposes and as a vegetable ingredient in warm dishes by cooking, baking, boiling, braising, grilling, frying, roasting, sauteing, or steaming. They can also be eaten raw in salads, made into juice, pickled in ginger, or used as a spice. As a herbal medicine, onion is recommended to relieve or help several common conditions, like atherosclerosis, asthma, bronchitis, and coughs. The health benefits of onion are substantially attributed to its different bioactive constituents, like organosulfur compounds, phenolic compounds, polysaccharides, and saponins (2). The multilayer tissue of onion bulbs is a rich source of bioactive compounds belonging to two main chemical groups: the alk(en)yl cysteine sulfoxides and flavonoids (3). Onions exist in different colors of skin and bulbs, ranging from red to yellow, and are rigorously dependent on flavonoid composition, where the yellow color is substantially due to quercetin and derivatives (4) while red is due to anthocyanins. As lately reported, onion bulbs are ranked among the stylish sources of beneficial flavonoids, substantially belonging to flavonols and anthocyanins. The major onion-producing states in India are Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, Bihar, Gujarat, Andhra Pradesh, Haryana, West Bengal, and Uttar Pradesh. These States cover almost 90% of the total onion production in the country

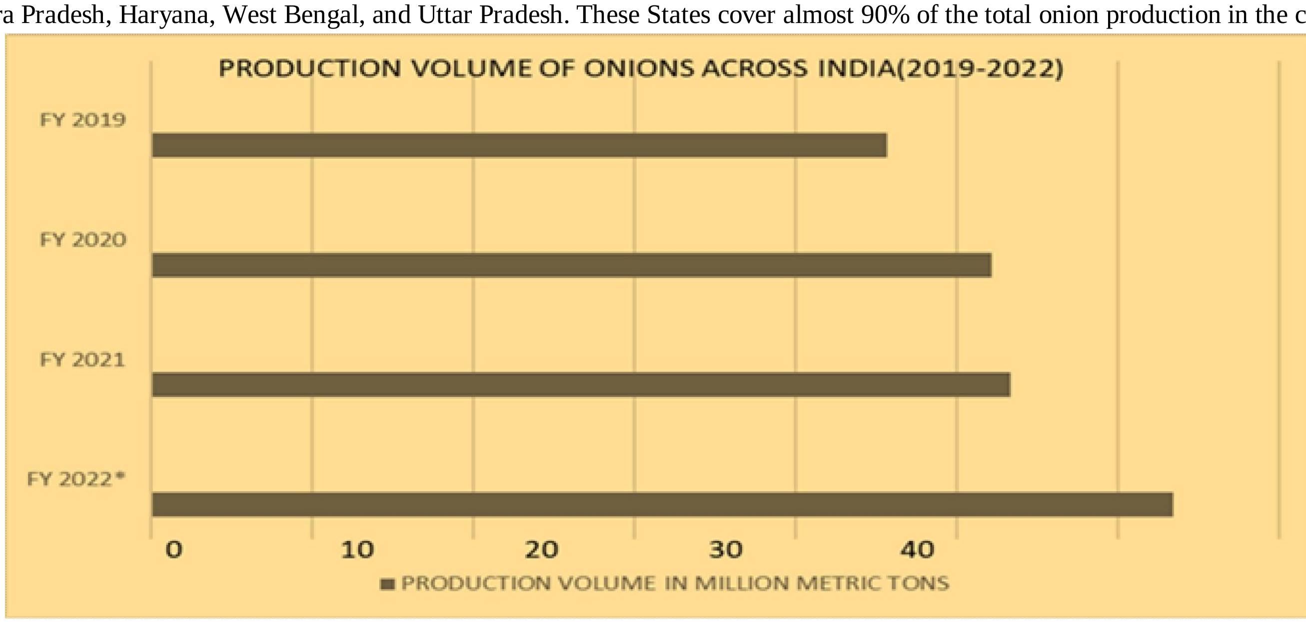

Figure 1 Production volume of onion across India (2019-2022)

Shallot is an essential class of the onion family and has a significant role in the diet of the global population. There is a long-held belief in their health-enhancing properties. Shallots onion belongs to the Allium family, but its flavor is more prosperous, sweeter, and more potent. The essential benefits of shallots are that they are a high source of antioxidants, they improve heart health, cancer prevention, and diabetes, they are anti-inflammatory and antimicrobial, they help to fight obesity, and they help to prevent or treat allergies. Shallots are a rich source of flavonoid antioxidants like quercetin and kaempferol. They contain sulfur antioxidant compounds like diallyl disulfide, diallyl trisulfide, and allyl propyl disulfide. Shallots hold more vitamins and minerals proportionately than onions, especially vitamin- A, pyridoxine, folates, thiamin, etc. (6)

II. LITERATURE REVIEW

A. Minimal Processing

Over the past decade, consumption of ready-to-eat minimally processed products has mainly increased worldwide because of convenience and health benefits. Minimally processed yield is made by several unit operations like sorting, washing, peeling, curing, tailing, slicing, dewatering, and packaging (7) Generally, whole peeled, minced, sliced, slivered, and pureed onions come under the order of fresh-cut onion products. The pungency of onion varies from mild to intense depending upon the variety and cultivation. However, cutting onion induces mechanical injury and unpredictable releases of composites to the face, which causes numerous biochemical responses and surface drying, promoting a suitable environment for microbial growth. The minimally processed onions market needs to be exploited better. Onions, when subjected to processing like peeling and cutting, release unpredictable compounds responsible for pungency and lachrymatory effect, leading to water in the eyes and irritation to the hands of utmost people. Indeed, after cutting an onion, the onion odor is perceived more in the handler hand for longer. Because of this, there is a tremendous demand for fresh-cut and ready-to-eat onion products in the Market. (8)

B. Peeling

Peeling is a standard unit operation for different varieties of fruits and vegetables to produce fresh-cut, minimally processed, and canned food products. The peeling process intends to remove the undesirable rind or natural skin layer. Peeling products are prepared to meet high quality and safety conditions for human consumption or other forms of subsequent processing, like dicing, slicing, and canning. In food product lines, the peeling operation represents an essential introductory step, typically performed at the initial stage [9]

C. Conventional Peeling Methods

1) *Lye Peeling:* Lye peeling, or caustic Peeling, is a chemical process to remove thin skin from particulars. In this process, raw food is subjected to a hot solution containing caustic chemicals (most constantly sodium hydroxide or potassium hydroxide), which can dissolve the skin. Wet and dry(dry-acidulous) lye peeling are new categories under which lye peeling can be subdivided. The wet lye Peeling technique has been altered to include dry-caustic Peeling. The product surfaces are sprayed with lye solution at a high temperature, in which thermal energy accelerates lye-peeling activities. This method removes lye from products without soaking them in hot lye water. The most often used method in industrial peeling procedures, wet lye peeling, has been applied on many fruits and vegetables, including tomatoes, sweet potatoes, potatoes, peaches, guava, pears, and apricots. Practical benefits for an industrial-scale operation include its excellent applicability for different types of goods, ease of process automation and control, high peeling quality, and efficiency. (10)
2) *Steam Peeling:* In steam peeling, raw fruits or vegetables are placed within a pressure vessel and heated quickly over a short period using high temperatures and pressurized steam (15–30 sec). Peel detachment results from thermodynamic modifications at the product surface as the pressure is released. [11]. The loosened skins are eliminated using mechanical pinch rollers or pressurized water spray. As a non-chemical alternative to lye peeling, steam peeling of potatoes, tomatoes, pimiento peppers, sweet potatoes, and other vegetables has gained popularity in the food business. Compared to lye peeling, steam has two key advantages: it reduces chemical pollution and the salinity problem in wastewater treatment. The main drawbacks of the commercialized steam peeling method are its inferior appearance, decreased firmness, and high mass losses.
3) *Flame Peeling:* In the thermal-based peeling technique, a flame is used to scorch the product outer layer at extremely high temperatures (>1000°C) for a predetermined amount of time (1-3 s). Products are passed through a furnace tunnel equipped with gas burners designed to provide uniform adjustable and adequate thermal intensity. Peppers, garlic, and onions are among the fruits and vegetables that undergo flame peeling because of their exceptionally high moisture content [12]. High moisture content materials have sufficient heat capacity, which makes it comparatively simple to burn off the material's outer skin

without overheating the internal flesh [13]. The two main benefits of flame peeling are that it can increase shelf stability by decreasing bacteria populations and can preserve the ascorbic acid content. Since flame peeling involves the relatively complicated construction, installation, and maintenance of equipment, the high capital outlay precludes its adoption by small-scale food processors [14].

4) *Mechanical Peeling:* In mechanical peeling, knives, blades, or other abrasive devices remove the undesirable part directly from raw food materials. After that, skin residuals are washed down using water. Since it is substantially performed in dry form at ambient temperature, mechanical peeling causes the least injury to peeled products' freshness and nutritional values. Compared to other chemicals and thermal-based methods, mechanical peeling operates using lower energy, with lower capital costs, and has minimal negative environmental impact. But relatively low throughput and high peeling losses (23 – 30) limit its operation to some high-value fruits and many roots vegetables that are delicate to peel using other means. Common mechanically hulled products include citrus fruits, pears, pineapples, bulb onions, carrots, squashes, cassavas, and other tubers. Mechanical peeling can be classified as abrasive peeling and non-abrasive cutter peeling. In abrasive peeling, food materials, like carrots and potatoes, are treated in a batch or nonstop process equipped with abrasive elements, like stiff brushes, carborundum rollers, and revolving bowls or cans with abrasive surfaces along the inner wall [15]. The abrasive element removes the outer skin through the shear stress developed at the peel–flesh interface. In non-abrasive peeling, tough-skinned items are removed by pressing stationary knives or razor-like blades on the surface of rotating materials. For vegetables with tough skins like parsnips, turnips, and Swedes, abrasive and non-abrasive knife peeling can be combined into a single step. Such a design enables items to be treated sequentially by abrasive tools and knife tools with a controllable depth of knife penetration and adjustable rotating speed, resulting in a completed product with a considerably cleaner cutting surface. Cutting implements and abrasive materials can be specifically created to match the food products' geometrical properties and the skin's characteristics that need to be peeled. The main factors considered in designing mechanical peeling devices are the variability in product forms and sizes and the differences in skin thickness, texture, and skin adhesion strength to the flesh [16].

D. *Emerging Peeling techniques*

Over time, new and sustainable peeling methods have been increasingly studied and developed to reduce the operation of chemicals, energy, and water in conventional peeling methods. Recently reported alternative Peeling approaches include infrared dry-peeling, enzymatic Peeling, ohmic Peeling, and ultrasonic Peeling.

1) *Infrared Peeling:* Infrared Peeling is a sustainable and promising technique that can eliminate any chemicals, and hot water or pressurized steam act as a heating media for skin separation. Further, there is a lower cost of wastewater treatment. Given these competitive advantages, this necessary lye/ steam peeling technique could herald a step-change in food peeling. Improvement of the overall heating rate and uniformity for products varying in shapes and sizes while achieving an industrially good outturn must be addressed before this new technique becomes a marketable reality.
2) *Enzymatic Peeling:* Enzymatic Peeling is a natural Peeling system. Polysaccharide hydrolytic enzymes like pectinases, hemicelluloses, and cellulases can be used to infuse into the surface of fruits and vegetables, performing in a weakened adherence of peel to the flesh because of the degradation of the pectin matrix and the breakdown of the hemicellulose – cellulose network in fruit epidermal and hypodermal layers. Enzymatic Peeling is done on different types of fruits, including citrus, grapefruit, and stone fruit. It is profitable that this system does not require considerably harsh treatments constantly seen with chemical and thermal styles.
3) *Ohmic Peeling:* The ohmic heating technique was investigated for tomato peeling [14]. By confirming the electrical conductivity of the peeling medium, where the tomato product is submerged in a sodium chloride or sodium hydroxide result, ohmic Peeling is fulfilled by electro-heating the tomato skin. Bench-scale exploration indicated some implicit for the combined lye- ohmic Peeling to enhance tomato peel quality, minimize peeling losses, and lower lye use.
4) *Ultrasonic Peeling:* Ultrasonic Peeling involves low-frequency ultrasound (20 – 100 kHz) to treat fruits or vegetables submerged in high-temperature water. The ultrasonic cavitation effect through consecutive contraction and rarefaction of high-intensity sound waves detaches the skin from the flesh. This system was primarily done for fruit peeling, which can be a replacement for the lye Peeling technique [14]. Other Peeling methods have been investigated in recent decades, like cryogenic Peeling, vacuum peeling, acid Peeling, and peeling with ammonium mariners or calcium chloride. These styles can be considered variations of the above-mentioned conventional approaches. The low throughputs and high processing costs have hampered the successful commercialization of these other alternatives.

E. Peeling Fundamentals

The mode of action associated with any chemical- or thermal-based peeling process usually combines biochemical and biophysical changes occurring at the product's outermost surface and adjacent inner layers. [15].

After peeling, changes in product quality, such as texture and nutritional content, are attributed to the thermal softening or chemical degradation in the peeling process, where a kinetic modeling approach is typically employed to describe any chemical process within the product's surface tissues [33].

In terms of transport phenomena, many peeling processes involve complex heat and mass transport processes inside and outside of the food product that may possess a unique skin structure. Knowledge of the skin anatomy and fruit physiology can facilitate the evaluation of the multi-physicochemical transport phenomena underlying a peeling process.

A mechanistic understanding of a peeling process can provide valuable insights into developing new peeling processes and designing new equipment. The design of peeling processes and equipment would benefit from a sound mechanistic understanding of the peeling fundamentals. Understanding the peeling basics can help the successful peel release and prevent potential loss of nutritional content [35].

F. Peeling Performance and Product Quality

A good peeling process must be established in order to achieve satisfactory peel removal with maximum peeling efficiency, to produce premium-quality peeled products, minimize peeling loss, product quality changes, and pollution hazards associated with a peeling process, reduce chemical, water, and energy consumption, save time, labor, and money.

Due to the considerable variability in raw product physicochemical qualities, cultivars, product defects, seasonal fluctuations, and many other agronomic factors, practical assessment of the peeling performance of arriving essential goods takes a lot of work.[5]

Quantifications that are both objective and subjective can be applied to evaluate peeling. According to a general rule, it is best to avoid adopting a single grading system or criterion when considering peeling since it might induce prejudice. Instead, developing an encompassing statistic from several viewpoints on product safety, efficiency, and quality enables better and more thorough analyses of the peeling process. The capacity to peel, peeling yield/loss, peeling ease, percentage of peel removal, peeled skin thickness, peeling residence time, peeling efficacy, peeling throughput, the efficiency of water usage, energy consumption, and others are some of the frequently used criteria. The total economic efficiency may also be given more thought. Many assessment matrices may be created to measure the effectiveness of peeling, including those for raw materials and final desired products.

Commercial processors are concerned with the effectiveness of peeling and the security and quality of peeled products. Due to cellular damage to the outer pericarp surface, which guards the inner edible tissue, removing the skin during peeling causes mechanical injuries in fruits and vegetables. Food quality and safety standards are primary considerations while peeling foods. The quality and shelf-life of peeled items may be harmed due to the higher susceptibilities to degradation that can happen on the peeled surfaces at any moment during food processing and handling, such as enzymatic alterations and microbiological contaminations [23].

Accordingly, visual appearance, texture, flesh color, taste, nutritional loss, the integrity of peeled items, and other factors are included in the industrial quality controls of peeled products. To keep a careful eye on any quality changes throughout the peeling process, practical choices include a sample methodology for arriving goods and fruit tagging processes like the radio frequency identification (RFID) technology [31]

Innovative methods for quality control have been investigated to obtain the most significant quality assurance and management, employing digital image analysis, analytical spectroscopic techniques, dynamic temperature analysis, and magnetic resonance imaging.[31]

G. Peeling Sustainability

Traditional peeling processes can use a lot of energy and water, and they always produce trash that needs additional waste treatment to prevent environmental damage.[34] [32] Due to these new issues facing the fruit and vegetable processing business, there is a tremendous motivation to develop sustainable and affordable peeling alternatives that can decrease peeling waste, water, energy use, and total peeling process costs [35] Overall, the sustainable elements in terms of lowering energy and carbon footprints, limiting chemical pollution, and increasing water-use efficiency must be considered while developing and selecting the proper peeling techniques. In the fruit and vegetable business, peeling is a frequently utilized procedure to create a variety of premium-quality goods. Peeling may be a resource- and energy-intensive approach. Choosing an appropriate peeling technique for various fruits and vegetables can influence the high-level production of completed products, including the inherent waste management and operational costs, as well as product quality and safety.

The most widely used industrial techniques from a few decades ago might produce massive volumes of peeling effluents at substantial expenses for management and disposal. Developing sustainable and affordable peeling alternatives that may lower water, chemical, and energy consumption and limit wastewater creation while creating high-quality goods will be a focus of future efforts. Any developing peeling technology that can be used efficiently and affordably on various food products must be improved using a holistic approach.

The standard methods used in modern onion processing are lye treatment, flame peeling, and mechanical peeling. Lye peeling and flame peeling methods are harsh and unsuitable for many onion products. The machine has crushing, roller, and separation mechanisms. It peels the dry peanut and separates the waste.[15] designed and constructed an onion skin peeling machine to meet the standards the customer or user requires. In general, machine construction methodology is based on friction on the onion's surface and topped with water to help soften the surface of the onions before the peeling process can be done. Meanwhile, the methods and the use of machines are based on the rotation of a soft brush attached to the shaft and fully controlled by a single-phase ac motor. This process is expected to make onion skin come out. This machine is built to meet the demand from small-and-medium industries in design, function, and price. This machine is also expected to be used for wedding fest preparation in the villages. The efficiency of this machine has been measured, and the data are analyzed using design expert software for the ANOVA procedure.[23] discussed the green mango peeling machine. In this study, a mango peeling machine was designed, fabricated, and tested, which used a different peeling approach – peeling along the direction of the longitudinal axis of the fruit against the more common peeling around the longitudinal axis. It was implemented successfully, and the mango skin was peeled up to 77%.

[19] have developed automatic vegetable-cutting machines. They used the slider crank mechanism to cut the vegetables. An ac motor powers the system. The rotary is converted into a reciprocating motion, pressing the vegetable, and cutting it.

III. AUTOMATION IN PEELING PROCESS

Emerging automatic and semiautomatic machines like extruding, dispensing, cutting, slicers, mixers, and depositors are introduced in the food processing industries. Automatic equipment has witnessed higher demand in recent years than equipment compared to semiautomatic machinery. The manufacturing industry transition to Industry 4.0 supports automation in the Food Processing Sector.

A semiautomatic potato peeler to hasten the process of French fries' production. The mechanism employed for peeling is abrasion and rotary motion to remove peels from the potatoes. The drum was vertically designed and was powered directly by an electric motor devoid of the drive assembly. This machine utilized spring-loaded peeling knives and power screw mechanics during peeling operations rather than abrasion and was designed to peel yam tubers. The peeling efficiency determined ranged from 72.8 % to 100%. A pineapple cutting machine is a machine used to cut and peel the pineapple to form a cylindrical shape pulp. Various fruit-cutting machines are available in the market, but most of the machines can only accomplish some of the processes automatically. They developed a pineapple-cutting machine to solve the problems faced by Small and Medium Enterprise (SME) industries, where the machine developed can reduce the time taken for pineapple slice preparation.

One of the most frequently used vegetables for cooking is the onion, which is utilized after the skin has been removed and the onion has been diced. Onion skin peeling is time consuming and a laborious process and is very difficult to prepare a significant quantity of onions at domestic level. The need to automate the peeling process at the domestic level is driven by several requirements for reducing work fatigue and reducing time. They can be listed as those needing to improve productivity, product quality, and profitability

Table 1
Domestic peeling machine capabilities

Domestic peeling machine capabilities	Method of benefits
Reduce Floor space	Compact systems with mounting versatility
Decrease in production time	Higher speed and efficiency, fast reconfigurability
Improve the Product quality	More efficient process control, high repeatability, and accurate task execution
Improve the Product uniformity	Errors caused by human error and fatigue eliminated
Increased Flexibility	Reconfigurable and easy to apply to a variety of tasks
Increased Efficiency	Optimized processes, increased yield

The previous literature made it abundantly obvious that hand peeling is a laborious and time-consuming process that also compromises product quality through physical contamination. Thus, automation in peeling will be a promising solution and would result in a most effective method for peeling shallot onions at a domestic level**.**

IV. CONCLUSION

The Manual Processes of peeling is a time-consuming and tedious process. The hand peeling techniques also leads to physical contamination of the raw materials. The Fruits and vegetables were peeled by a variety of peeling devices which are available in the Market. Selection of suitable peeling technique for various fruits and vegetables can impact the production of end products and inherent the waste management, as well as ensures product quality and safety. Among them, the abrasive peeling technique was discovered to be beneficial for domestic uses and very effective for shallot onions.

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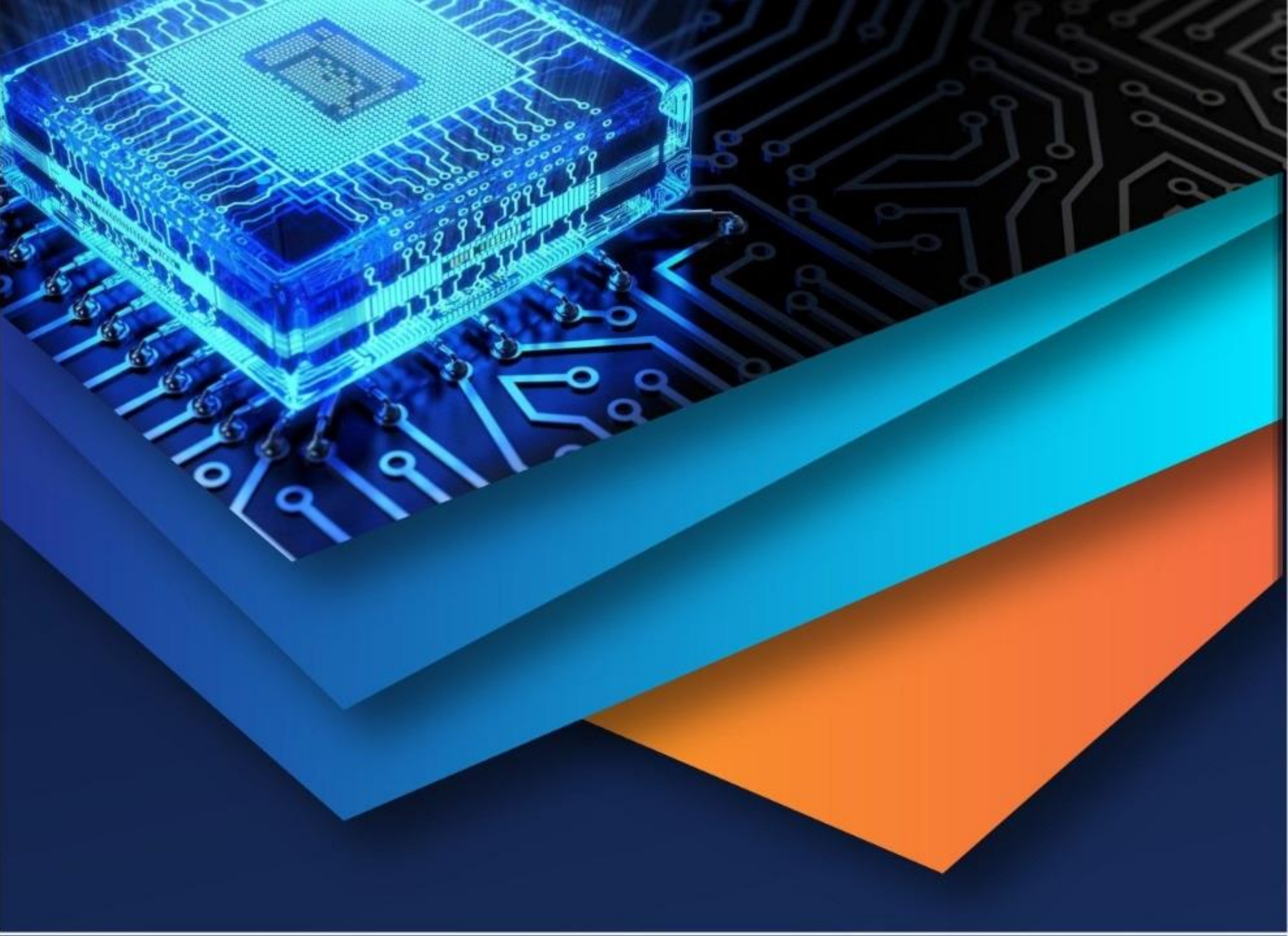

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