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Development of Dragon Fruits Based Jam and their Quality Evaluation

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Abstract: The herbaceous perennial climbing cactus known as dragon fruit (Hylocereus spp.), belonging to the family Cactaceae, thrives in dry, tropical or sub-tropical climates with annual rainfall ranging between 20–50 inches. Despite its significant nutritional and medicinal value, this superfruit remains underutilized due to the absence of standardized processing and preservation techniques. This study aimed to develop and standardize processing technologies to preserve dragon fruit and promote its consumption in processed forms, thereby ensuring its availability throughout the year. Comprehensive physicochemical analyses revealed that dragon fruit is rich in essential nutrients, antioxidants, and minerals. However, its high perishability poses a major challenge. Various processed products, including jam, jelly, and ready-to-serve (RTS) beverages, were prepared using dragon fruit. Natural sweeteners such as honey and sugar were used in the preparation of jams and jellies, while stevia was employed as a sweetener in RTS beverages. The products were evaluated for physicochemical, microbiological, and sensory properties over a storage period of 180 days, with observations taken at 30-day intervals (30, 60, 90, 120, 150, and 180 days). Storage was conducted under both ambient room temperature and low temperature conditions (5°C). Results indicated that the nutritional quality of all products remained stable, with minimal nutrient losses observed under both temperature conditions. Microbiological analyses confirmed that the jam and jelly remained safe for consumption throughout the 180-day period under both storage conditions. The RTS beverage remained microbiologically safe for up to 60 days at both temperatures and up to 120 days under low-temperature storage. Sensory evaluations by panelists indicated high acceptability, with ratings ranging from "liked very much" to "liked moderately," even after 120 days of storage. Standardized protocols for processing, storage time, and storage conditions were successfully developed, ensuring product stability and safety. Shelf-life studies concluded that the processed products remained stable for up to six months with minimal nutrient degradation. This research underscores the potential of the underutilized dragon fruit in enhancing dietary diversity and promoting nutritional security through value addition and preservation.
Keywords: Dragon Fruit, Jam, Physico-chemical analysis, Microbial analysis, sensory analysis, Processing, preservation, and Value addition.

I. INTRODUCTION

Dragon fruit (*Hylocereus spp.*) is recently introduced amazing fruit in India, its cultivation gaining popularity because of its high nutritional value and antioxidant property. Recently, it drawn the much attention of the Indian consumers owing to its pleasant flavour, colour, with their attractive appearance, tremendous health and nutritional benefits.It has attracted a lot of interest from Indian growers due to its attractive red or pink colour and fruit's high economic value. Dragon fruits are primarily imported from Vietnam, Thailand, Malaysia, and Sri Lanka and sold in Indian marketplaces. Other names for dragon fruit include strawberry pear, pitaya, and pitahaya. The global dragon fruit market is expected to grow at a CAGR of 3.9% over the next five years. The dragon fruit was first made available in India in the late 1990s. The top three states for producing dragon fruit in India are Gujarat, Karnataka, and Maharashtra. The largest producer is Gujarat, and the second-largest is Karnataka. Global dragon fruit cultivation is expected to increase ten-fold over the next five years (Kantaria et al., 2024). Currently, it is being cultivated in atleast 22 countries in the tropics including Australia, Cambodia, China, Malaysia, Thailand, Srilanka (Nerd et al, 2002; Nobel and Barerra, 2002).

Dragon fruit is rich in potassium (K), Iron (Fe), sodium (Na), calcium(Ca), other minerals and fiber which are good for health compared to the other fruits (Suryono, 2006). Dragon fruit has obtained attention during last few years among the people in society, mostly in Asian countries, due to its color, nutritional value, and other features (Hoa et al, 2006; Harivaindaran et al., 2008).

It represents a significant source of antioxidants which is a value-added characteristic to any food crop (Rebecca et al., 2010), The red peel of both species as well as the red-purple flesh of H. polyrhizus contain water-soluble betacyanin pigments similar to those found in red beets (Mizrahi, 2015). Dragon fruit contains 0.20-1.04% (Kanjana et al., 2006)pectin, so its jam and jelly usually call for added pectin.

The fruit contains relatively high amount of fiber (2-4%, w/w), potassium (3.2-4g/L) and antioxidants (42.4 ± 0.04mg of gallic acid equivalents/100g of flesh) (Wu et al., 2006).In addition, red pitaya is a good source of praline (1.1-1.6g/L) and this red pitaya also contains considerable amount of essential fatty acid (linoleic acid, 51%) (Ariffin et al., 2009).

In the view of the importance of dragon fruits, the aim of proposed study is todevelop nutritious value-added processed food products with good shelf-life. For this purpose, development of technology for preparation of value-added products from dragon fruit is proposed in this study. In addition, the products will expect to provide a cost-effective way of processing of mature dragon fruit for human consumption. In the proposed research plan, anattempt is made to develop the economically feasible technologies for production of jam

II. MATERIALS AND METHODS

Dragon Fruits (*Hylocereus polyrhizus (Red pulip))* were collected from dragon fruit grower of Chunar, Mirzapur of eastern Uttar Pradesh.

A. *Preparation of Dragon Fruit Jam*

For preparation the jam, fresh, fully ripped but firm dragon fruit without any blemishes or bruises were selected, washed thoroughly to get rid of extraneous matter. Weight of dragon fruits was noted down. The dragon fruits were then cut with a knife and scoop out the pulp. Weight of peel as well as pulp was recorded separately. The pulp was prepared with the help of a Food Processor (USHA, India). The fruit pulp kept in clean bowl. Different batches of dragon fruit were used for each replication. However, the ripeness level for each replication was based on the same peel colour index in order to ensure consistency between the replications.

B. *Technical Work Plan for jam*

Experimental plan for preparation of the dragon fruit jam was followed according to protocol given in details in Table 1.

Table-1: Technical work plan for development of dragon fruit jam

Experimental parameters	levels	Description
Dragon Fruit Pulp	1	1000 g
Sugar levels	2	100 and 50%
Honey levels	2	100 and 50%
Pectin levels	3	0.5, 1.0 and 1.5 %
Citric acid	1	0.5%
Packaging mode	1	Wide mouth glass jars (200 g)
Storage conditions	2	Low temperature 5^o C (refrigerator) and room temperature (ambient)
Storage period	7	0, 30, 60, 90, 120, 150 and 180 days after preparation
Replication	3	Each experiment was replicated thrice
Measuring quality parameters		Sensory - Colour, flavour, taste, body & texture and overall acceptability (Ranganna, 2007) Physico-chemical – Acidity, pH, protein, fat, Total solids, sugars and ash. Microbial – Total Plate Count (SPC), coliform count and yeasts and mould count after 0, 30, 60, 90, 120, 150 and 180 days during storage
Statistical analysis	1	Factorial RBD

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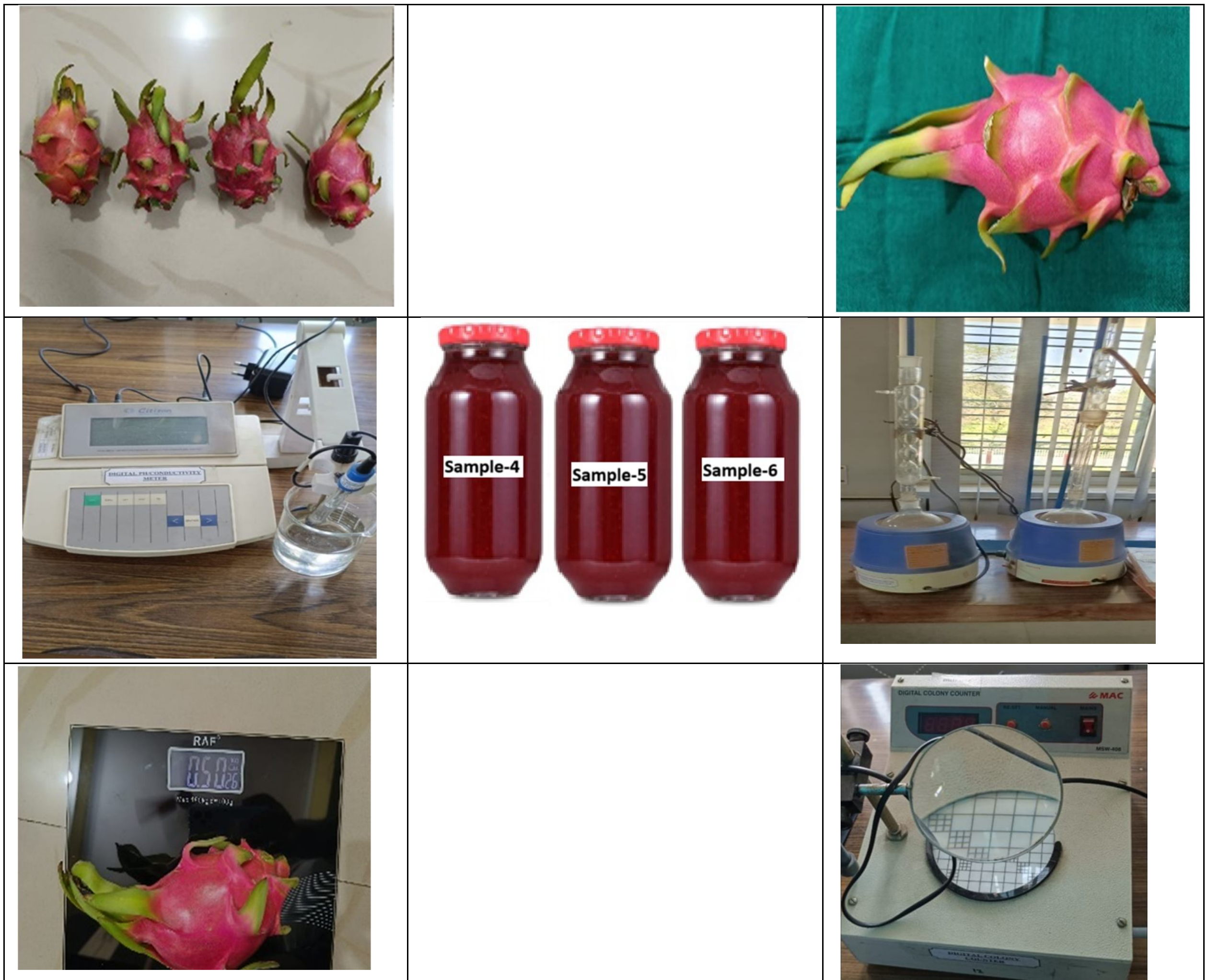

Fig. 1: : Preparation of Dragon Fruit Jam

In view of above descriptions, the salient features of the experimental treatments are given for easy understanding and explicit presentation.

Dragon Fruit Juice Level : 1 (@ 1000 g)
Sugar Levels : 2 (@ 100 and 50%)
Honey Levels : 2 (@ 100 and 50%)
Pectin levels : 3 (@ 0.5. 1.0 and 1.5%)

The details about treatment combinations examined are given here under as.

S_1 : 1000 g DFP + 100% Sugar + 0.5 % Pectin + 0.5% Citric Acid
S_2 : 1000 g DFP + 100% Sugar + 1.0 % Pectin + 0.5% Citric Acid
S_3 : 1000 g DFP + 100% Sugar + 1.5 % Pectin + 0.5% Citric Acid
S_4 : 1000 g DFP + 50% Sugar + 50% Honey + 0.5 % Pectin + 0.5% Citric Acid
S_5 : 1000 g DFP + 50% Sugar + 50% Honey + 1.0 % Pectin + 0.5% Citric Acid
S_6 : 1000 g DFP + 50% Sugar + 50% Honey + 1.5 % Pectin + 0.5% Citric Acid
S_7 : 1000 g DFP + 100% Honey + 0.5 % Pectin + 0.5% Citric Acid
S_8 : 1000 g DFP + 100% Honey + 1.0 % Pectin + 0.5% Citric Acid
S_9 : 1000 g DFP + 100% Honey + 1.5 % Pectin + 0.5% Citric Acid

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Ripe firm dragon fruit
↓
Washing
↓
Peeling
↓
Pulping without Seed
↓
Addition of Sugar/Honey (Add water if necessary)
↓
Addition of pectin solution
↓
Boiling (with continous stirring)
↓
Addition of citric acid
↓
Judging of end product
↓
By further cooking to reach suitable TSS
↓
Filling hot into sterilized glass jars
↓
Capping
↓
Storage (at and low temp. and ambient temp.)

Fig.-2: Flow diagram for the preparation of Dragon Fruit Jam

III. RESULTS AND DISCUSSION

A. *Physico-chemical Analysis of Jam*

Several ingredients are used in the making of dragon fruit jam which affects the end product's nutritional content and quality. There are notable differences in the amount of moisture, acidity, pH, protein, fat, total solids, sugars, ash, carbohydrates and fiber found in dragon fruit jam, according to studies on its physico-chemical characteristics. Although it drops after boiling to produce a thicker consistency, the moisture level normally varies from 35 % to 40 %, indicating the highwater content of dragon fruit. Citric acid, a measure of acidity, typically ranges from 0.2% to 1.0%, with normal values of 0.7%. This helps to preserve the fruit and gives it a tangy taste (Ramli et al., 2018). According to Cheirsilp et al. (2017), dragon fruit jam has a slightly acidic pH of 3.5 to 4.5, which is perfect for gelling with pectin. The normal pH is 4.2. While lipid content is low, usually less than 1%, with values ranging from 0.1% to 0.3% (Ramli et al., 2018), protein content is still low, ranging from 0.5% to 1.5%, with most jam averages about 0.8% (Srisomboon et al., 2014). Sugars and other dissolved solids make up the total solids in dragon fruit jam, which typically vary from 25% to 45% with an average of 40% (Cheirsilp et al., 2017). With concentrations ranging from 30% to 50% and often reaching 42%, sugarsmostly fructose, glucose and sucrose—are a predominant component (Srisomboon et al., 2014). The mineral composition is reflected in the comparatively low ash percentage, which ranges from 0.5% to 1.5%, with one research indicating 1.2% (Ramli et al., 2018). A substantial amount of the composition is composed of carbohydrates, mostly from sugars, with values usually falling between 45% and 60% (Cheirsilp et al., 2017). The jam's modest fiber content, which usually ranges from 3% to 5%, with one research showing around 4%contributes to its texture and health advantages (Sirisomboon et al., 2014). Although these figures represent the overall makeup of dragon fruit jam, they may vary based on the particular recipe, processing techniques and fruit type. Acidity, pH, protein, fat, total solids, sugar and ash content were among the physico-chemical characteristics that were assessed. These parameters were examined both at the beginning and at various points during the storage periods. On the very fist day of sample the various physico-chemical parameters found are listed in table 4.7.

Table 2: Physico-Chemical Parameters of Different Treatments at Day 0

Parameter	S1	S2	S3	S4	S5	S6	S7	S8	S9
Moisture (%)	37.50	37.89	37.83	38.50	38.61	38.44	38.17	38.06	38.11
Acidity (%)	0.45	0.47	0.46	0.50	0.48	0.49	0.50	0.48	0.49
pH	3.78	3.76	3.75	3.80	3.77	3.78	3.80	3.79	3.81
Protein (%)	0.90	0.87	0.89	0.82	0.85	0.83	0.80	0.79	0.78
Fat (%)	0.54	0.58	0.56	0.57	0.58	0.56	0.57	0.54	0.58
Total Solids (%)	26.50	26.80	27.40	25.40	25.70	25.90	24.9	25.20	25.10
Sugars (%)	59.50	59.80	60.20	57.80	58.10	58.50	60.4	60.20	60.30
Ash (%)	1.20	1.18	1.17	1.10	1.12	1.11	1.05	1.07	1.06
Carbohydrates (%)	60.16	59.79	59.83	59.29	59.11	59.34	59.66	59.82	59.75
Fiber (%)	2.10	2.20	2.10	2.40	2.30	2.30	2.10	2.20	2.10

1) Moisture

When assessing a food product's overall quality and stability, moisture content is a crucial factor, particularly in fruit-based formulations like the dragon fruit pulp-based product used in this research. The term "moisture" describes the product's water content, which has a direct impact on its microbiological stability, texture and shelf life. Since water is essential for microbial development, higher moisture levels may result in a softer, more spreadable consistency but also raise the risk of microbial contamination. The study's treatments had varying moisture contents; S4 (50% sugar + 50% honey + 0.5% pectin) had the greatest moisture content, at 38.50%. The main cause of this is the addition of honey, which has a higher water content than granulated sugar (about 17–20% moisture). If honey is not properly kept, its high-water content might make it more prone to spoiling at room temperature. Since sugar has a lower water content than honey, other treatments, including S1 (100% sugar + 0.5% pectin), had a somewhat lower moisture content (37.5%). When creating fruit-based spreads, it is essential to take moisture levels into account since they have a significant impact on the product's overall stability, affecting both its texture and microbiological safety.

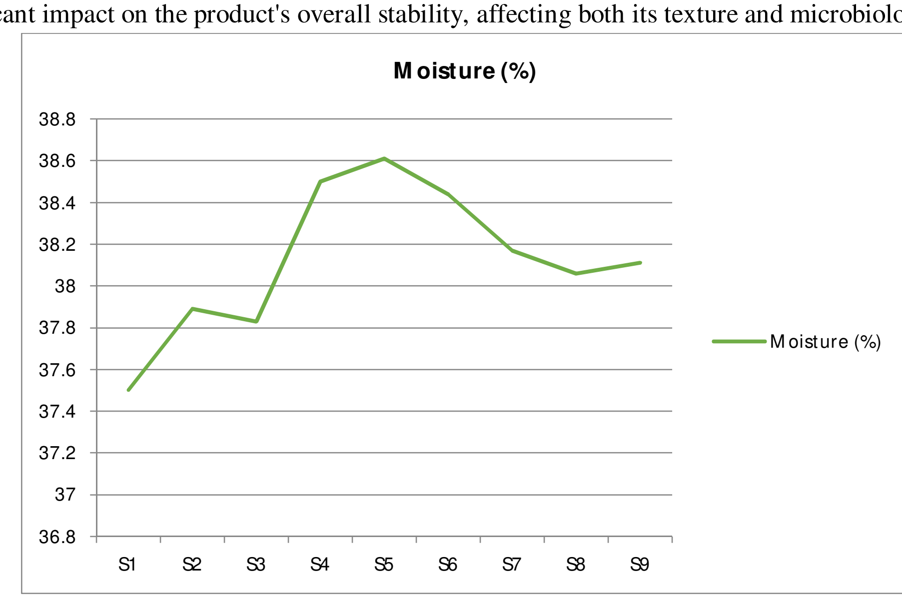

Fig. 3: moisture content of fresh Samples

2) Acidity (%)

The quantity of acidic substances, mostly organic acids like citric, malic and tartaric acids found in food items is referred to as their acidity. For taste balance and preservation acidity is crucial. Fruit-based goods benefit from a little acidic pH because it inhibits the development of dangerous germs, which favor neutral or slightly alkaline environments. By giving the product a tangy taste, citric acid's inclusion in the recipe helps to preserve it along with enhancing its flavor.

The various treatments in the current investigation had acidity levels ranging from 0.45% to 0.50%. Due to the inherent acidity of honey and the extra citric acid added to all formulations, Treatment S4 (50% sugar + 50% honey + 0.5% pectin) had a slightly greater acidity of 0.50%. By bringing a little tartness to balance the sweetness of sugar and honey, more acidity may also enhance the whole sensory experience. The greater acidity in S4 indicates that honey improves its preservation and flavor profile by contributing to a slightly higher acid profile than the pure sugar formulations, even though honey has naturally high sugar content.

3) pH

Considering pH influences both flavor and microbiological stability, it is a crucial metric in food science. Fruit-based goods should have a lower pH (acidic) since this inhibits the development of dangerous microbes and spoiling bacteria. Fruit spreads usually work best in the somewhat acidic pH range of 3.0 to 4.0. Because it protects against microbial development and preserves the fruit's inherent tastes, this pH range is advantageous for both flavor and preservation. In the study pH levels ranged from 3.75 to 3.80, meaning that all of the treatments were slightly acidic—perfect for product preservation. The different component compositions are the cause of the minor pH variations between the treatments. The pH of S7, for example, was marginally higher than that of the sugar-based treatments. This could be because honey's pH is naturally lower than that of granulated sugar solutions. Citric acid (0.5%) was added to all treatments to bring the pH down to a level that is appropriate for microbiological stability and attaining a balanced flavor.

4) Protein (%)

Fruit-based goods' protein content often includes the fruit's own protein content as well as any added substances like pectin or other additives. Even though dragon fruit doesn't have a lot of protein, the end product's protein content may be somewhat changed by the inclusion of pectin and other substances. Although protein is a crucial macronutrient that affects the product's texture and nutritional content, fruit spreads usually have modest levels of it. All treatments in this investigation had comparatively low protein contents, ranging from 0.79% to 0.90%. S1 had the greatest protein level (0.90%), whereas S7had the lowest (0.79%). The natural makeup of the dragon fruit pulp accounts for the little variations in protein concentration, with pectin and honey making very modest contributions. These processes mostly serve to give the product a sweet, spreadable consistency rather than a substantial nutritional protein benefit because of the comparatively low protein level. These figures might however still provide light on the product's overall nutritional balance.

5) Fat (%)

Fruit-based product often has very little fat content particularly those manufactured from low-fat fruits like dragon fruit. Although contribution of fats to the treatments is minimal when compared to that of carbohydrates and sugars. It is mostly caused by the trace quantities of fat found in substances like pectin and honey. There were only slight variations in the fat content amongst the treatments, which varied from 0.54 % to 0.58 %. S1 and S7, for instance contained 0.57% and 0.58% fat, respectively. The composition of honey, which includes trace levels of fat even though it is still regarded as a very low-fat diet, is mostly to blame for this little fluctuation in fat content, which is not substantial. The main function of the fat in these items is to help create the finished product's smooth mouthfeel and texture as well as affect the sensory qualities of the final product.

6) Total Solids (%)

The product's non-water composition, which includes sugars, pectin, fiber and other dissolved materials, is represented by its total solids. The percentage of total solids is significant because it provides information on the quantity of active substances like sugars and pectin, which affect the product's stability and texture. Because sugar and pectin both contribute to the product's solid matter, S3 had the greatest total solids content (27.4%) in this investigation. On the other hand, S7 had the lowest total solids (24.9%), most likely due to the fact that honey adds less solid matter to the product due to its higher water content than sugar. The product's viscosity and stability are mostly determined by its total solids content; a thicker, more stable spread is often the consequence of a larger solid concentration.

7) Sugars (%)

By lowering water activity, sugars, the main sweetening ingredient in fruit-based products also help to preserve the product. The kind and amount of sweeteners utilized in this investigation caused considerable variations in the sugar content. The greatest sugar contents were found in S1 and S3, with S1 having 59.5% sugar and S3 having 60.2%.

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Granulated sugar, which is very concentrated and helps to create a low water activity, was the only source of sweetness used in these formulations, which helped with preservation. Since honey also adds sugars, but in a different way, treatments including honey, such S4, had a somewhat lower sugar concentration (57.8%) than treatments containing just sugar. Because honey contains more moisture than pure sugar, honey-based compositions usually have a lower sugar level. Because it directly affects the product's sweetness and preservation qualities, sugar concentration is an important factor.

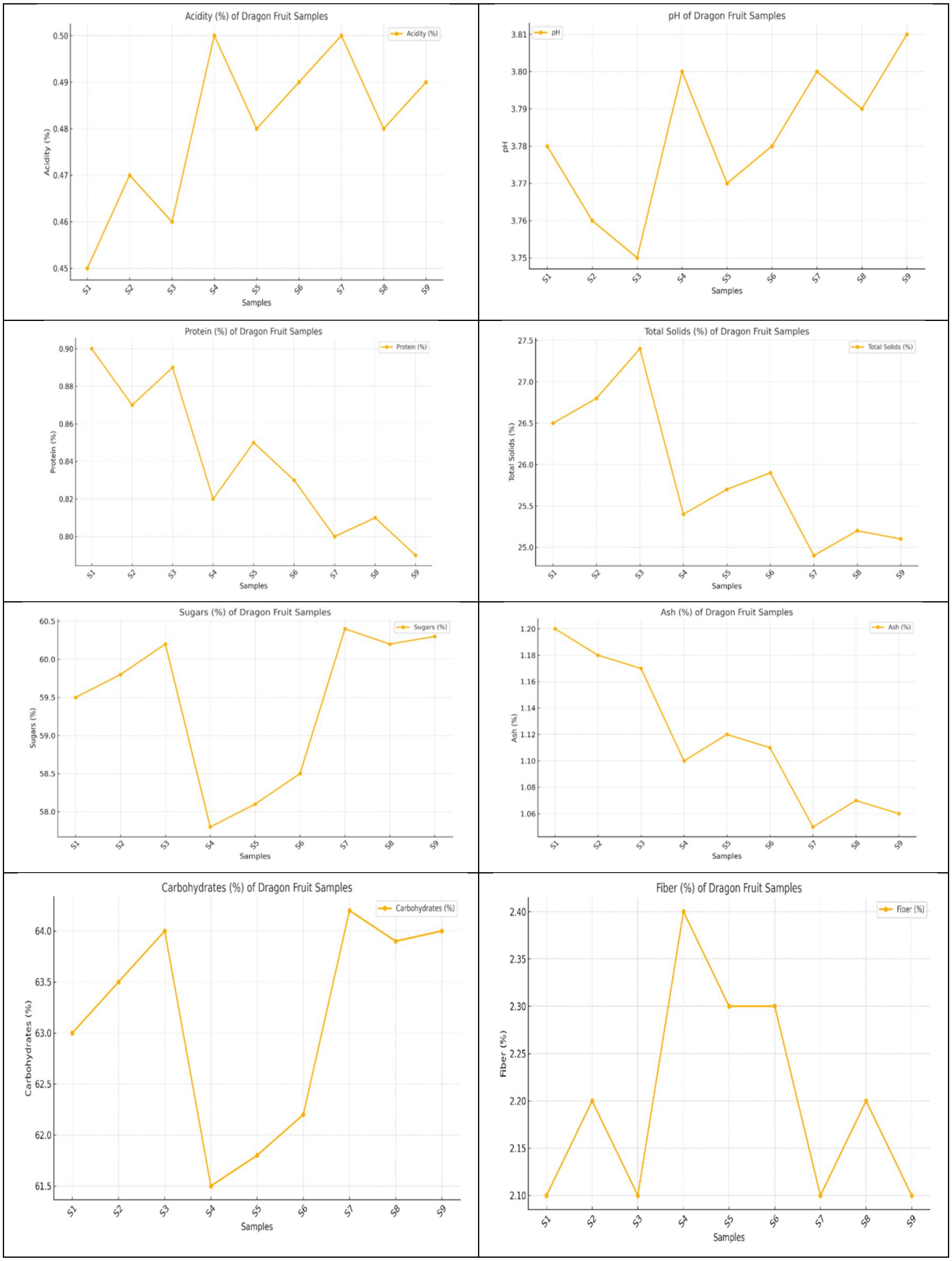

Fig. 4: Physico-chemical analysis of Fresh Samples

8) Ash (%)

The entire mineral content of food items, which includes necessary components like calcium, potassium and magnesium, is represented by the amount of ash. The ash content may nonetheless provide information about the nutritional profile of fruit products, even if they typically contain little minerals. The ash concentration in this investigation varied between 1.05% and 1.20%. Ash concentration ranged from 1.05% for S7 to 1.20% for S1. The inherent minerals in the dragon fruit pulp as well as the additional components like honey and pectin have a significant impact on the amount of ash. The amount of ash in fruit-based spreads indicates the mineral makeup of the food, even if it does not significantly affect its total nutritional worth.

9) Carbohydrates (%)

The primary energy source in fruit-based items is carbohydrates. They consist of fibers, starches and sugars, with sugars being the most common kind. In order to define the product's texture, sweetness and preservation, carbohydrates are essential. This study's carbohydrate content varied between 60.16% and 59.11%. Carbohydrate content was greatest in S1 (64.2%) and lowest in S5. The modest variations in total carbohydrate amount are caused by the various kinds of sweeteners utilized, since honey has a different carbohydrate profile than sugar. Because they affect water activity and texture, carbohydrates are crucial for the product's nutritional value as well as its preservation.

10) Fiber (%)

Dietary fiber, especially soluble fiber, is a crucial ingredient of items made from fruit. Fiber adds to the product's mouthfeel and texture while also aiding in digestion. With values ranging from 2.1% to 2.4%, the fiber content in this research was comparatively constant among treatments. Because honey contains more soluble fibers, treatments like S4 had a slightly greater fiber content (2.4%). Fiber content is a crucial factor since it influences the texture of the product, giving it a more solid mouthfeel in addition to offering health advantages.

B. Microbial Analysis of Jam

Microbial analysis was performed to monitor the shelf life of the products, with focus on total plate count (TPC), coliform count and yeast & mold count. Microbiological analysis is essential for assessing the safety and shelf-life stability of food products. The primary objective of microbiological testing in this study was to evaluate the microbial load of the dragon fruit pulp-based product during storage, specifically focusing on total plate count (TPC), coliform count and yeast and mold count. These parameters provide insights into the effectiveness of the preservation methods (sugar, honey, pectin and citric acid) in inhibiting microbial growth over time.

1) Total Plate Count (TPC)

Total Plate Count is a measure of the overall bacterial load in the product. High TPC values indicate poor microbial quality, while low values suggest effective microbial control. TPC was measured at regular intervals (0, 30, 60, 90 and 120, days) to monitor the microbial stability of the product during storage at both low (5°C) and room (ambient) temperatures.

Observation: At the initial stage (Day 0), all treatments showed relatively not detectable TPC values, indicating that the product was free from significant microbial contamination at the time of preparation.

Table 3: Microbial Counts for Different Treatments

Sample	Microbial type	Fresh 0 days	Storage Period						
			30		60		90		120
			ART	LT (5°C)	ART	LT (5°C)	ART	LT (5°C)	LT (5°C)
S1	Total Plate Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	2.50	TFTC	TFTC
	Coliform Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.20	TFTC	TFTC
	Yeasts & Molds Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	2.85	TFTC	TFTC
	Total Plate Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	2.80	TFTC	TFTC

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S2	Coliform Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.00	TFTC	TFTC
	Yeasts & Molds Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	2.90	TFTC	TFTC
S3	Total Plate Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.10	TFTC	TFTC
	Coliform Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.20	TFTC	TFTC
	Yeasts & Molds Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.00	TFTC	TFTC
S4	Total Plate Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.60	TFTC	TFTC
	Coliform Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.70	TFTC	TFTC
	Yeasts & Molds Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.50	TFTC	TFTC
S5	Total Plate Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.30	TFTC	TFTC
	Coliform Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.60	TFTC	TFTC
	Yeasts & Molds Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.50	TFTC	TFTC
S6	Total Plate Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.40	TFTC	TFTC
	Coliform Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.40	TFTC	TFTC
	Yeasts & Molds Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.20	TFTC	TFTC
S7	Total Plate Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.70	TFTC	TFTC
	Coliform Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.50	TFTC	TFTC
	Yeasts & Molds Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.25	TFTC	TFTC
S8	Total Plate Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	2.80	TFTC	TFTC
	Coliform Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.00	TFTC	TFTC
	Yeasts & Molds Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	2.90	TFTC	TFTC
S9	Total Plate Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.00	TFTC	TFTC
	Coliform Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.20	TFTC	TFTC
	Yeasts & Molds Count (log cfu/g)	TFTC	TFTC	TFTC	TFTC	TFTC	3.10	TFTC	TFTC

*TFPC- Too Few To Count

- As storage progressed, the TPC values increased gradually, with treatments stored at room temperature (S1, S4, and S7) showing higher microbial counts compared to those stored under refrigeration (5°C). After 120 days of storage, treatments like S4 (50% sugar + 50% honey + 0.5% pectin) and S7 (100% honey + 0.5% pectin) exhibited the highest TPC values, while those with 100% sugar (S1–S3) and refrigeration showed lower counts.
- The initial low TPC values suggest that the processing and packaging methods were effective in controlling microbial contamination. However, over time, as the product was stored, the microbial counts increased due to environmental conditions. Storage at room temperature accelerated microbial growth, particularly in treatments containing honey (such as S4 and S7), which may serve as a nutrient source for microorganisms. Honey, while having antimicrobial properties, is not entirely resistant to microbial growth, especially in the presence of moisture. On the other hand, refrigeration slowed down microbial growth, which is evident in the lower TPC values for treatments stored at 5°C. The high sugar content in treatments like S1 and S3 likely acted as a preservative, creating an inhospitable environment for microbial growth.The safe limit of TPC has been reportedin case of milk as 4 log cfu/ml (Frazier, 1995).

2) *Coliform Count*

Coliform bacteria are commonly used as indicators of sanitary quality and potential contamination. Their presence, especially in significant numbers, suggests that the product may be at risk for foodborne pathogens. Coliform count was evaluated at various storage intervals (0, 30, 60, 90 and 120, days).

- Observation: At Day 0, all treatments showed no detectable coliform bacteria, indicating that the products were hygienically prepared and free from contamination. As storage progressed, coliform bacteria were detected in treatments stored at room temperature, particularly in S4 (50% sugar + 50% honey + 0.5% pectin) and S7 (100% honey + 0.5% pectin), with a marked increase in coliform levels by Day 120. Conversely, treatments stored at 5°C showed no significant increase in coliform count, maintaining their microbial safety throughout the storage period.
- The absence of coliform bacteria at Day 0 suggests that the hygiene during preparation and packaging was adequate. The increase in coliform count over time, particularly in room-temperature-stored treatments, is a clear indication that storage conditions played a major role in the growth of these bacteria. Honey, despite its natural antimicrobial properties, contains some moisture and can act as a medium for microbial growth if not adequately preserved. The increased coliform count in honey-based treatments (S4, S7, and S9) over time might also be attributed to the higher water activity in these products, which creates a more favorable environment for bacterial growth. The refrigeration of products, on the other hand, effectively inhibited the growth of coliforms, as cooler temperatures generally slow down microbial proliferation.

3) *Yeast and Mold Count*

Yeasts and molds are important indicators of spoilage and fungal contamination in food products. Their presence can affect the taste, texture and safety of the product. In this study, the yeast and mold count was measured at the same storage intervals (0, 30, 60, 90 and 120, days).

- Observation: At Day 0, yeast and mold counts were negligible in all treatments, reflecting the effectiveness of the initial sanitation and preparation processes. However, by Day 180, yeast and mold counts were higher in treatments stored at room temperature, particularly in those with higher water activity, such as S4 (50% sugar + 50% honey + 0.5% pectin) and S7 (100% honey + 0.5% pectin). Refrigerated treatments maintained very low yeast and mold counts throughout the study, showing minimal microbial growth under these conditions.
- With situations with increased moisture content and poor storage conditions, yeasts and molds are more prone to grow. The somewhat increased moisture content of honey, when combined with room temperature storage, created an environment that was conducive to fungal development, resulting in comparatively higher yeast and mold counts in the honey-based treatments (S4, S7 and S9). When kept at room temperature, honey's natural sugar content may serve as a source of nutrients for yeasts. On the other hand, by reducing their development and metabolic activity, refrigeration (5°C) assisted in maintaining lower levels of mold and yeast. The low water activity and high sugar content in the S1, S2 andS3 treatments, especially those with higher sugar and pectin content, likely provided an inhospitable environment for yeasts and molds, contributing to their minimal growth over time.

The microbiological analysis revealed several key findings regarding the microbial stability of the dragon fruit pulp-based product during storage:

1. Storage Temperature Effect: Microbial growth (TPC, coliforms, yeasts and molds) was greater in treatments kept at ambient temperature than in those kept in a refrigerator. This emphasizes how crucial cold storage is to extending the product's shelf life and guaranteeing its microbiological safety.
2. Impact of Sweeteners: In comparison to sugar-based treatments (S1, S2, S3), honey-based treatments (S4, S5, S6, S7, S8, S9) showed increased microbial counts, particularly in the coliform and yeast and mold categories. Even while honey has inherent antibacterial qualities, certain germs may still thrive due to its increased moisture content and food profile, particularly when stored at room temperature.

4) *Pectin and Preservation*

The product’s overall stability was aided by pectin, but the storage environment and the kind of sweetener used had a greater impact on microbial development. Because the greater sugar content probably decreased the water activity, which limited microbial development, the combination of pectin and high sugar levels in treatments like S1, S2 and S3 created a more conducive environment for preservation.

IV. SUMMARY AND CONCLUSION

The experimental design involved a total of nine treatments for dragon fruits pulp jam (DFP).

A. DFP Jam Treatments

- S_1 : 1000 g DFP + 100% Sugar + 0.5 % Pectin + 0.5% Citric Acid (Control)
- S_2 : 1000 g DFP + 100% Sugar + 1.0 % Pectin + 0.5% Citric Acid
- S_3 : 1000 g DFP + 100% Sugar + 1.5 % Pectin + 0.5% Citric Acid
- S_4 : 1000 g DFP + 50% Sugar + 50% Honey + 0.5 % Pectin + 0.5% Citric Acid
- S_5 : 1000 g DFP + 50% Sugar + 50% Honey + 1.0 % Pectin + 0.5% Citric Acid
- S_6 : 1000 g DFP + 50% Sugar + 50% Honey + 1.5 % Pectin + 0.5% Citric Acid
- S_7 : 1000 g DFP + 100% Honey + 0.5 % Pectin + 0.5% Citric Acid
- S_8 : 1000 g DFP + 100% Honey + 1.0 % Pectin + 0.5% Citric Acid
- S_9 : 1000 g DFP + 100% Honey + 1.5 % Pectin + 0.5% Citric Acid

Sensory analysis played a crucial role in determining consumer preferences for the three products. DFJ Jam formulations with higher sugar content were firmer and sweeter, while honey-based formulations were preferred for their smoother texture and more complex flavor.

B. Impact of Sugar and Honey on DFJ

For DFJ Jam, the study found that higher sugar concentrations (750g) produced firmer jams with a more traditional texture and sweetness, which are characteristics typically favored by many consumers. However, as the formulations incorporated more honey (100g and 200g), the jams became softer, smoother, and less sticky, offering a distinct mouthfeel. The presence of honey in the jam formulations not only reduced the sugar content but also improved the overall flavor complexity, creating a more balanced and natural sweetness. These findings are aligned with current trends in the food industry, where there is a growing interest in reducing the amount of refined sugar in products without sacrificing taste.

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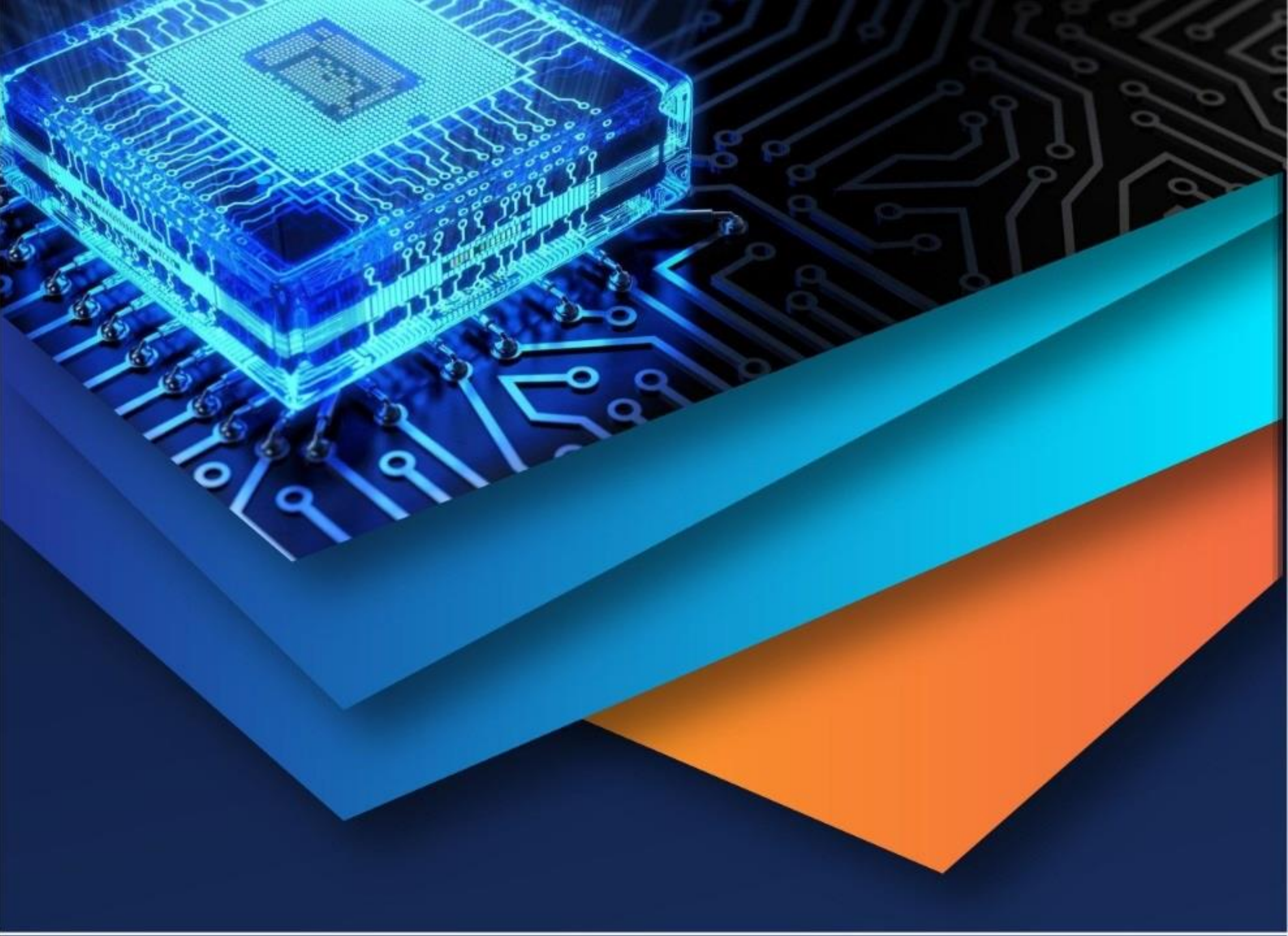

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