



# Evaluation Of Different Packaging Materials for Perishable Fruits (Guava)

Snigdharani Behera<sup>1</sup>, P.Harini<sup>2</sup>, Sameer K Barik<sup>1</sup>, Shantanu Bhattacharyya<sup>1\*</sup>Pratibha Rani Deep

1. Department of Zoology, School of Applied Science, Centurion University of Technology and Management · Odisha India
2. Department of Agriculture, School of Agriculture and Bioengineering, Centurion University of Technology and Management · Odisha India

**Abstract:** Evaluation of the Suitable Packaging material for the preservation and Extending the Shelf life of Perishable fruits like Guava. Three Packaging Material: Ziplock, Silver foil and Vacuum packages was assessed Across 3 temperature: Room temperature, Refrigerator, Freezer. Over a defined period daily monitoring of Key parameters: pH, TSS, Pectin, Antioxidant, Weight loss and Sensory attributes (Appearance, Texture, Taste and Smell) was conducted. Results demonstrate a progressive deterioration in Guava over time, marked by increasing in the level of pH and TSS, and decrease in the pectin level and Antioxidant content. Among these the Silver foil emerged as the most effective and suitable packaging material as it provide Air space for Guava to maintaining its overall quality, Freshness and sensory attributes particularly stored in Refrigerated condition. Freezer storage also proved beneficial for extending the shelf life but it may effect the texture of guava due to occurrence of chilling injuries. Ziplock bags exhibited as moderate usability while Vacuum packages are unsuitable for Guava because its adverse reaction on texture and quality that it needs air for its respiration. These findings underscore the importance of selecting appropriate packaging materials customize the requirements of the Fruit sample. This study contributes valuable insights in to optimizing packaging and storage practices to enhance the Shelf life and to maintain the quality of the perishable fruits. By providing evidence based on recommendations, it aids in the development of improved packaging solutions, beneficial for both Consumers and Food manufacturers in ensuring Product Quality and Safety.

**Keywords:** Perishable fruits, Guavas, Packaging material, Preservation

## 1.INTRODUCTION: -

India produces about 46 million tones of fruits in the World and become the largest producer of fruits with a Global share over 10% perishable fruits, a delightful yet delicate part of our diet. Face a constant battle against spoilage. From Farm to Table these vibrant treasures require careful handling and protection to retain their Freshness, Flavour and Nutritional value. This is where innovative packaging material step in, playing a crucial role in their journey.

### **1.1Perishable Fruits:-**

Perishable Fruits are highly susceptible to spoilage during transportation and storage , necessitating effective packaging solution to maintain freshness and maximize marketability. The selection of appropriate packaging material plays acritical role in preserving fruit quality, minimizing food waste and meeting consumer preferences. They are typically high in moisture content and respiration rate, which contributes to their spoilage. Some example of perishable fruits include:

- Berries (strawberries, raspberries, blueberries, etc.)
- Stone fruits (peaches, plums, nectarines, cherries, etc.)
- Tropical fruits (mangoes, papayas, pineapples etc.)
- Melons (watermelon, cantaloupe, honeydew, etc.)
- Citrus fruits (oranges, grapefruits, lemons, limes, etc.)

## 1.2 Packaging Materials: -

The effect of Packaging material on fruit quality attributes such as appearance, texture and flavour and nutritional content. Comparative analysis are conducted to evaluate the efficacy of various packaging solutions in delaying fruit ripening, reducing microbial growth and extending shelf life.

In addition to performance consideration, the study explores emerging trends and innovations in fruit packaging, including sustainable alternatives such as biodegradable films, compostable trays, and bio-based polymers. The potential environmental impact and cost effectiveness of these materials are also discussed, along with challenges and limitations in their implementations.

Over-all this research provides valuable insights in to the evaluation of different packaging materials for perishable fruits, offering recommendations for stakeholders in he fresh produce industry to optimize packaging practices, enhance fruit quality and improve sustainability across the supplied chain.

### **Packaging plays a crucial role in safeguarding the quality and extending the shelf life of perishable fruits.**

1. Minimizes physical damage
2. Controls Moisture Loss
3. Regulates Gas Exchange
4. Protects from Light Exposure
5. Reduces Contamination
6. Enhances Shelf Life

### **Type of packaging material significantly impacts the shelf life and quality of perishable fruits. Here's a breakdown of the pros and cons of common options:**

#### 1. Ziplock Bags:

##### Pros:

- Inexpensive and readily available
- Transparent for easy product visualization
- Resealable for partial consumption

##### Cons:

- Highly permeable to moisture and gases like ethylene (fruit ripening agent)
- Offers little to no physical protection against crushing

#### 2. Silver Foil:

##### Pros:

- Good barrier to light and moisture, slowing ripening process
- Offers some protection from physical damage

**Cons:**

- Can puncture easily, compromising barrier properties
- Not transparent, making product inspection difficult
- Not resealable

**3. Vacuum Packaging:****Pros:**

- Excellent barrier to moisture, oxygen, and ethylene, maximizing shelf life
- Reduces fruit dehydration and shriveling
- Can conform to the shape of the fruit, minimizing damage

**Cons:**

- Most expensive option
- Requires specialized equipment for sealing
- Not resealable
- Can crush delicate fruits if not done properly

**1.3 Guava:-**

Guava (*Psidium guajava* L) is a commercial fruit crop in many Tropical and Sub-tropical countries all over of the world. Fruits are a rich source of Vitamins, Minerals, Fiber and Dietary antioxidants. The most important post-harvest limitations of guava fruit are high Perishability and Susceptibility to physical damage, frost damage, disease and pests. Guava is a popular edible fruit that is an excellent source of anti-oxidants, vitamins (especially vitamin c) and minerals. Guava is tremendously successfully grown all over India and it contributes 0.4% of total fruit production. After post-harvest the most important limitations of Guava is its susceptibility to physical damage, high perishability, frost damage, disease and pests. The climatic nature of Guava is that it can be consumed up to 3-4 days after post-harvest as it can be stored at ambient temperature (28-30). The major changes that take place during storage include weight loss due to loss of moisture, changes in colour due to degradation of chlorophyll, changes in texture and also loss of nutritional value.

**1.3.1. Physiology of Guava fruit:-**

Flowering and fruiting on the Guava plant occur throughout the year in the tropical and sub-tropical areas. The growth of Guava fruit can be divided into 3 distinct phases-

- Fast phase- It takes place just after anthesis for 45-60 days.
- Slow growth rate phase- This phase is characterised by hardening and maturation of seeds for 30-60 days.
- Exponential phase- In this phase the fruit attains its maturity and the time period is 30-60 days.

Maturity is the stage of development, at this stage is acceptable to consumers as it supplies all the quality attributes such as appearance (colour, shape, size), firmness and nutrition value. Generally guava harvests on 120-150 days during spring season and in winter it is harvested on 90-150 days. Guava has 4 maturity indices such as:-

- Mature green
- Turning green
- Ripe
- Over-ripe

### 1.3.2. Perishability and storage Life challenges:-

Guava is pre-dominantly considered as climatic fruit but there are some varieties of Guava that they show non-climatic behaviour. Guava has higher perishability due to its critical factors present in it. During pre-harvest and post-harvest it undergo different physiological changes that speed up their respiration rate, ripening process, ethylene production and deterioration effects.

### 1.3.3. Rate of Respiration:-

The respiration process of Guava has a biological system that enables the guava to live even after harvest. From metabolic energy that derived primarily during the respiration process. Respiration is occurs in the tissues of fruits, It is a catabolic process that broken the complex macro biomolecules like carbohydrates, proteins and fats in to small molecules such as carbon dioxide( $\text{CO}_2$ ) and water ( $\text{H}_2\text{O}$ ). For instance-Glucose  $\text{C}_6\text{H}_{12}\text{O}_6$

### 1.3.4. Nutritional Status of Guava:-

Table 1.2: Guava is an excellent source of proteins, minerals and vitamins and other compounds.

Name	Content
Carbohydrate	9.1-17mg
Protein	0.1-0.5 g
Phosphorous	0.30-0.70mg
Fat	0.43-0.7mg
Iron	200-400IV
Calories	77-86 g
Carotene	0.046mg
Moisture	2.8-5.5g
Crude Fiber	0.9-1.0g
Calcium	17.8-30mg
Ash	9.5-10.0mg
Thiamine	0.0.3-0.04mg
Riboflavin	0.6-1.068mg
Vitamin B3	35 IV
Vitamin G4	36-50mg
Niacin	40IV

### 1.3.5.Ethonomedical Uses:-

Table no 1.3: Guava have Ethnomedical uses. It plays a role in traditional system of medicine. It is an important herbal medicine for Diarrhoea and Dysentery. Traditional Chinese system used Guava to treat many diseases.

Plant part	compound	Ethnomedical use
Skin	Phenolic compound	Helps in the improvement of food absorption.
Pulp	$\beta$ -carotene, $\beta$ -cryptoxanthine, Ascorbic acid, Carotecoids	Anti-hyperglycemic, Anti-oxidant, Anti-neoplastic
Seed	Phenolic compound Glycosoids, Carotenoids	Anti-microbial activity
Leaves	Phenolic compound, Gallic acid, Rutin, Isoflavonoids, Catechin	Anti-inflammatory, Anti-Cancer, Anti- microbial, Anti- oxidant, Anti-hyperglycemic.
Bark	Phenolic compounds	Strong Anti-bacterial activity, Anti-diarrhoeal activity, stomachache.

### 1.3.6. Pharmacological Effect:-

Different parts of Guava used for various pharmaceutical activity. Such as;

#### 1. Anti-oxidant activity:-

The presence of phenolic compounds like taxifolin, ferulic acid is responsible for anti-oxidant role in guava. The major compounds responsible for the anti-oxidant properties of Guava are Rutin, Catchin, Kaemferol, quercitrin, hesperetin, quercetin and apigenin are revealed by high performance liquid chromatography analysis. The significance of such anti-oxidant compounds in Guava that it helps in minimizing the harmful effects of free radicals and also helpful for decrease the degenerative diseases such as brain dysfunction, inflammation, cancer, heart disease, arteriosclerosis and arthritis.

#### 2. Anti-microbial activity:-

The essential oils of Guava act as strong anti-microbial properties against Escherichia coli, Streptococcus faecalis, staphylococcus aureus and Bascillus subtilis and helps in minimizing microbial infection like urinary tract infections, Septicemia, Pneumonia, Meningitis and Gastritis.

#### 3. Anti-diabetic activity:-

In several studies it has been reported that the compounds like flavonoids and polysaccharides present in Guava reported as anti-diabetic potential because the Guaijaverin and avicularin has significant role for the development of  $\beta$ -cells of pancreatic islets. Hence it has significant role in increasing insulin level and reduced blood glucose level.

## 2. OBJECTIVE OF THE PRESENT WORK:-

1. To evaluate different packaging materials

2. To study shelf-life of perishable fruits
3. To study physicochemical properties of perishable fruits
4. To study different storage temperature

### **3.MATERIALS AND METHODS:-**

The present study “Evaluation of different Packaging Material for Perishable Fruits” was conducted on Food Science and Agriculture laboratory of M.S.S.S.O.A Centurion University Of Technology and Management, Paralakhemundi, Odisha in the month March 2024. The present day was conducted to determine the physico-chemical properties of food, shelf-life of perishable fruits and effect of different packaging materials on fruits and to determine the storage temperature of fruit samples.

#### **3.1Instruments and Equipment used:-**

1. Digital pH Meter
2. Vacuum packaging and Sealing Machine
3. Hand Sealer
4. Mortar and Pestle
5. Zip lock Bags
6. Silver foil Bags
7. Vacuum packaging Bags
8. Spectrophotometer
9. Test tubes
10. Funnels
11. Weighing Machine

#### **3.2Procedure:-**

To study the different packaging material and to evaluate the physio- chemical properties of Guava and its shelf life extension. For the study Local varieties of Guava was taken from the market of Paralakhemundi, Odisha market for the research purpose 3 different varieties of packaging material such as Ziplock (zl), Silver foil (sf) and Vacuum (vc) was taken. Firstly Guava was washed using distilled water to remove the contaminants, dirt, pesticides and micro-organisms that are present on the surface of the fruit. Then it was sliced in to uniform size with the help of knife for the shelflife study. In total the packaging material such as Ziplock, Silver foil and Vacuum was taken in quantity of 3 for each baggage material for different temperature condition. In each of this packet we put approximately 100gm of Guava slices. After that the package material containing the slice of Guava was stored at different temperature condition such as Room temperature (RT), Refrigerator (RF) and Freezer(F). After-that the packages were left for 24 hours without any disturbance. From the 2<sup>nd</sup> day onward different physio-chemical and sensory attribute (hedonic test) of the Guava with different storage temperature condition was studied and the observation was recorded up to 10<sup>th</sup> day. On the other hand 0<sup>th</sup> day, 7<sup>th</sup> day and 10<sup>th</sup> day the anti-oxidant and pectin test was conducted.

#### **3.3Physicochemical analysis of Guava:-**

##### **3.3.1. Determination of pH:-**

The pH of the Guava sample was analysed by the use of digital pH meter was calibrated using distilled water of pH 7.0 at room temperature. The Guava sample from different packaging with different temperature condition was taken and crushed to extracted juice by the help of Mortar and Pestle. Then the pH meter electrode was placed inside the juice and then stabilize reading was taken directly on the pH meter.

##### **3.3.2.Determination of Total Soluble Solids(TSS):-**

For the TSS determination a hand-held Refractometer was taken and calibrated with distilled water. Then 1-2 drops of Guava juice from different sample was dropped on the clean surface of the refractometer. Three reading was taken as final in 0Brix.

### 3.3.3.Determination of colour:-

The colour parameter of the Guava sample was measured using a online app colour picker. Before measurement, the Guava samples were placed evenly on a white background to ensure stable lighting conditions. LAB values represent the colour properties of each sample as obtained using a colour picker application. Three measurements were performed for each sample and the average LAB value was recorded for analysis. The LAB colour space provides information about the brightness (L), blue-red (A) and blue-yellow (B) of the sample, allowing quantitative assessment of colour changes over time. Colour changing value or  $\Delta E$  value can be calculated by using the following formula

$$\Delta E = \sqrt{(L_{ref} - L_{sam})^2 + (a_{ref} - a_{sam})^2 + (b_{ref} - b_{sam})^2}$$

*ref: Reference. sam: Sample*

### 3.3.4. Determination of Anti-oxidant:-

The anti-oxidant analysis of Guava juice was conducted on 0<sup>th</sup> day, 7<sup>th</sup> day and 10<sup>th</sup> day of storage interval. About 0.5ml of Guava juice sample of different packaging material with different temperature condition was taken and mixed with 5ml of distilled water. From which 2ml was taken and mixed with 2ml of DPPH solution. Then the mixture is poured in to separate test tubes. Then the tubes containing mixture were incubated for 30 minutes at room temperature in the dark. After that the optical density  $A = \pi r^2$  was measured by the use of UV spectrophotometer at 517nm. The Spectrophotometer using DPPH solution as a reference. The following formula is used to calculate the percentage of antioxidant

$$\% \text{ of antioxidant activity} = [(Ac - As) \div Ac] \times 100$$

where: Ac=Control reaction absorbance; As=Testing specimen absorbance

### 3.3.5. Determination of Pectin:-

To the determination of Pectin 1ml of Guava juice was taken in different test tubes. Then 1ml of Ethanol was added in to test tubes containing fruit juice and left it for around 30 minutes. The presence of pectin was confirmed by the formation of gelatinous mass at the top of the sample. Then the dried pectin value of different Guava sample was measured with the help of weighing machine.

### 3.3.6. Determination of weight:-

The weight of the Guava sample of different packaging materials with different temperature condition was measured by the help of weighing machine.

### 3.3.7.Sensory Evaluation:-

The sensory evaluation of different Guava sample was subjected to sensory evaluation i.e. Appearance, odour, texture and taste. The evaluation was conducted on the basis of nine point hedonic rating scale, where;

9= Like extremely

8= Like very much

7=Like moderately

6=Like slightly

5=Neither like nor dislike

4=Dislike

3=Dislike moderately

2=Dislike very much

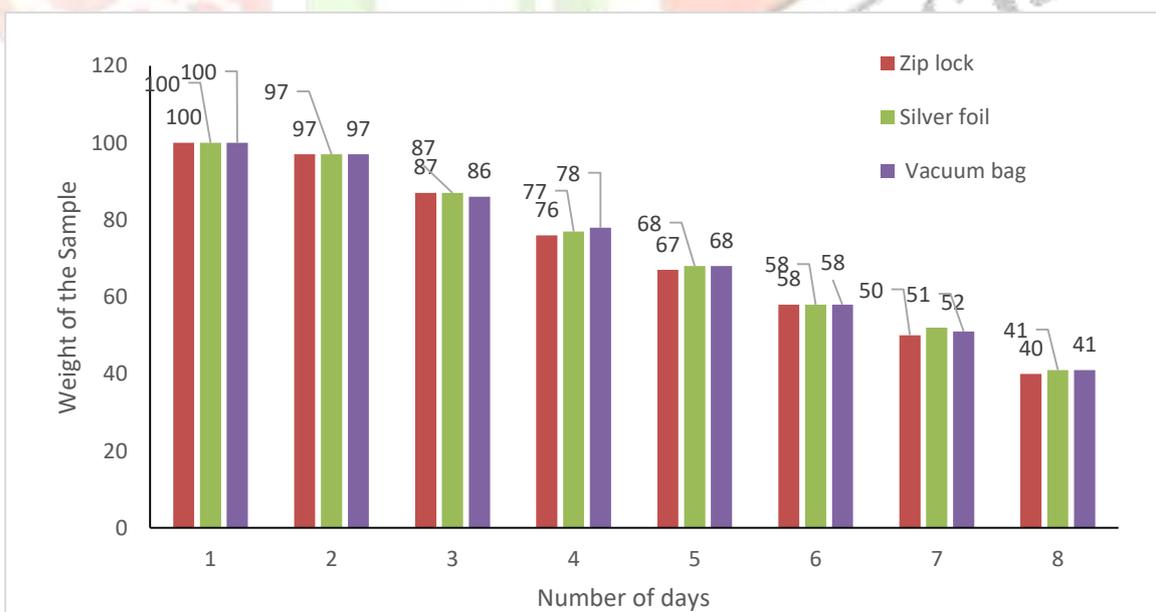
1=Dislike extremely

**4.RESULT AND DISCUSSION:**

The present study entitled “Evaluation of different packaging materials of perishable fruits” was conducted on Food science and Agriculture Laboratory of M.S.S.O.A Centurion University of Technology and Management, Paralakhemundi, Odisha to study the effectiveness of different packaging materials in extending the shelf-life of Guavas focusing on physicochemical parameters and sensory evaluation.

Table 4.1 Determination of Weight loss Of The Sample Across Different Packaging Material At Different Temperature Condition

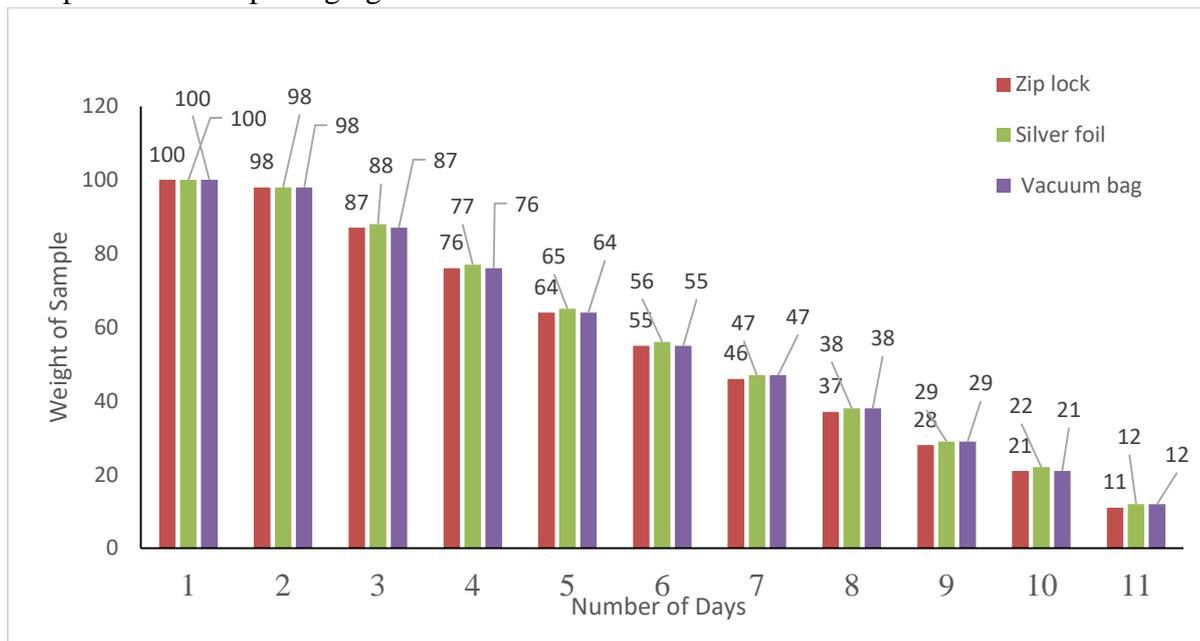
DETERMINATION OF WEIGHT									
At Room Temperature Condition (RT)				At Refrigerator Condition (R)			At Freezer Condition (F)		
No of days	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag
0	100	100	100	100	100	100	100	100	100
1	97	97	97	98	98	98	98	98	98
2	87	87	86	87	88	87	88	89	88
3	76	77	78	76	77	76	79	80	79
4	67	68	68	64	65	64	70	71	71
5	58	58	58	55	56	55	61	62	62
6	50	52	51	46	47	47	52	53	52
7	40	41	41	37	38	38	43	44	43
8	Decay	Decay	Decay	28	29	29	34	35	34
9	Decay	Decay	Decay	21	22	21	24	25	25
10	Decay	Decay	Decay	11	12	12	12	13	13



**Fig 4.1.1 Determination of Weight At Room Temperature**

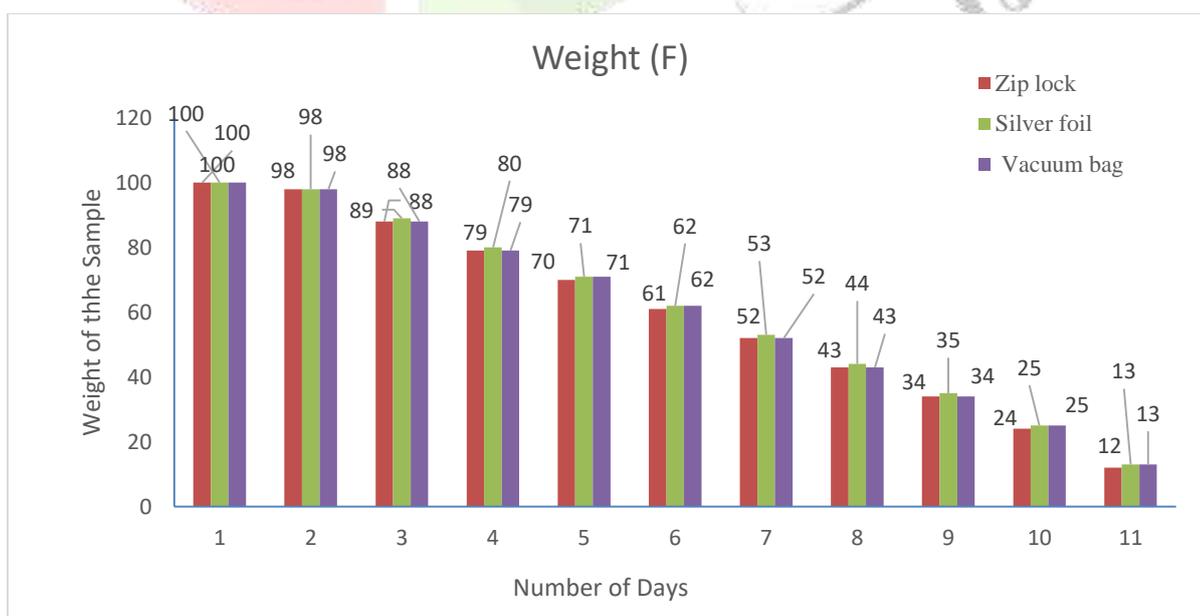
Fig 4.1.1 showing weight loss was observed in all samples over 10 days period at room temperature conditions. The permeability of zip lock bags allows oxygen to penetrate, accelerating enzymatic reactions and microbial growth. Enzymatic activities such as polyphenol oxidase and peroxidase catalyze the oxidation

of phenolic compounds present in the pulp of Guava, leads to more weight loss as compared to silver foil and vacuum bag. Ziplock bag offers some protection compared to Vacuum bag, slowing down enzymatic and microbial activity and reducing weight loss, but not entirely decay. Silver foil experience the least weight loss due to superior barrier properties of the material, but some levels of decay still occurs. The presence of oxygen and residual enzymatic activity leads to gradual weight loss over time, albeit at a slower rate compared to other packaging materials.



**Fig 4.1.2 Determination of Weight At Refrigerator condition**

Fig 4.1.2 showing weight loss was observed in all samples over 10 days period at refrigerator conditions. Cooler temperature slow down enzymatic activity, reducing but not eliminating weight loss. The permeability of the Vacuum bag still allows some moisture loss, contributing to weight loss. Similarly Ziplock packages in the refrigerator slows down decay but does not provide sufficient protection to prevent weight loss entirely. Despite the superior barrier properties of silver foil, some moisture loss and enzymatic activity still occur in refrigerator. While the rate of weight loss is slower compared to other packaging materials, prolonged storage eventually leads to deterioration and decay of the fruit.



**Fig 4.1.3 Determination of Weight At Freezer Condition**

Fig 4.1.3 showing weight loss was observed in all samples over 10 days period at Freezer conditions. In the freezer minimal weight loss is observed in Guava sample stored in zip lock bag, indicating effective preservation. The low temperature slows down metabolic processes and reduce moisture loss, maintaining

fruit weight. Despite decay observed in Guava stored in vacuum packaging, weight loss may have been minimal initially. However, decay over time could contribute to increased weight loss as the fruit deteriorates. Silver foil experiences minimal weight loss in the freezer, reflecting superior preservation. The barrier properties of silver foil reduce moisture loss, maintaining fruit weight over time.

Table 4.2 Determination of pH Of The Sample Across Different Packaging Material At Different Temperature Condition

DETERMINATION OF pH									
At Room Temperature Condition (RT)			At Refrigerator Condition (R)			At Freezer Condition (F)			
No of days	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag
0	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07	7.07
1	6.8	6.9	6.9	6.8	6.9	6.8	6.7	6.8	6.8
2	6.6	6.7	6.6	6.4	6.5	6.4	6.4	6.5	6.4
3	6.5	6.6	6.4	6.0	6.1	6.1	6.0	6.1	6.0
4	5.9	6.0	5.9	5.7	5.8	5.7	5.6	5.7	5.6
5	5.0	5.2	5.1	5.3	5.4	5.3	5.2	5.3	5.2
6	4.7	4.8	4.7	4.7	4.8	4.7	4.7	4.8	4.7
7	4.1	4.3	4.2	4.2	4.4	4.3	4.2	4.3	4.2
8	Decay	Decay	Decay	3.8	4.0	3.9	4.0	4.1	4.0
9	Decay	Decay	Decay	3.6	3.8	3.7	3.4	3.6	3.5
10	Decay	Decay	Decay	3.4	3.6	3.5	3.2	3.4	3.4

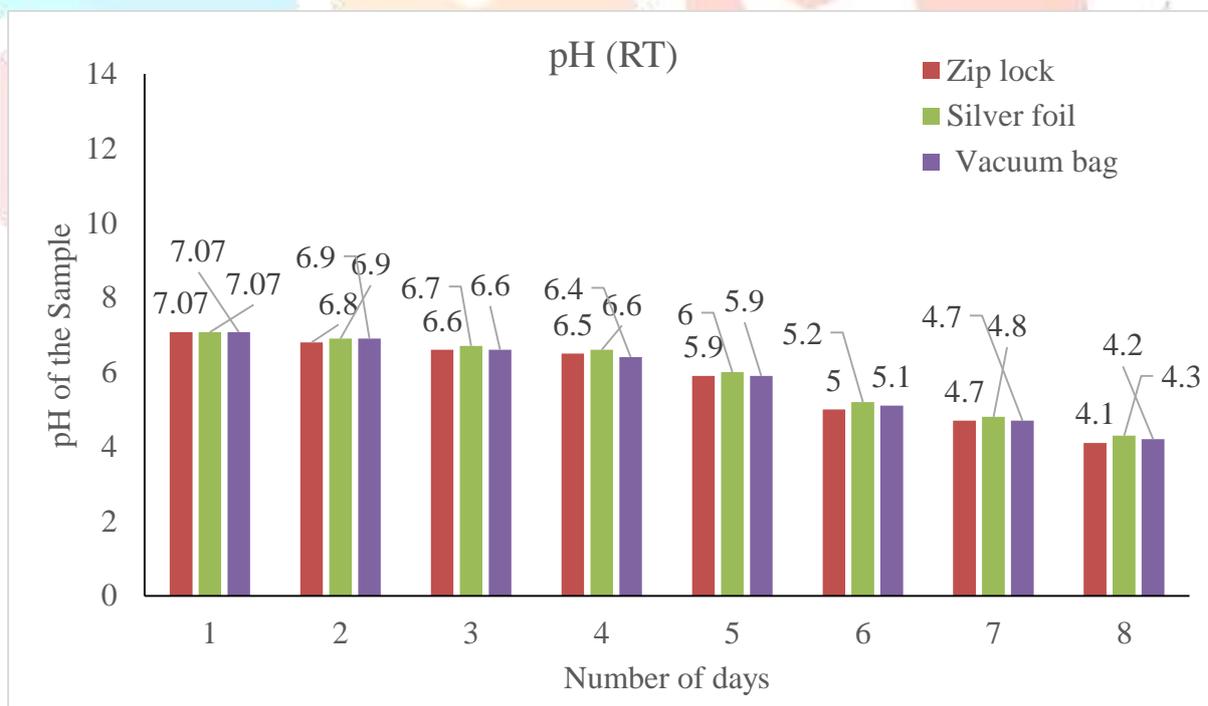
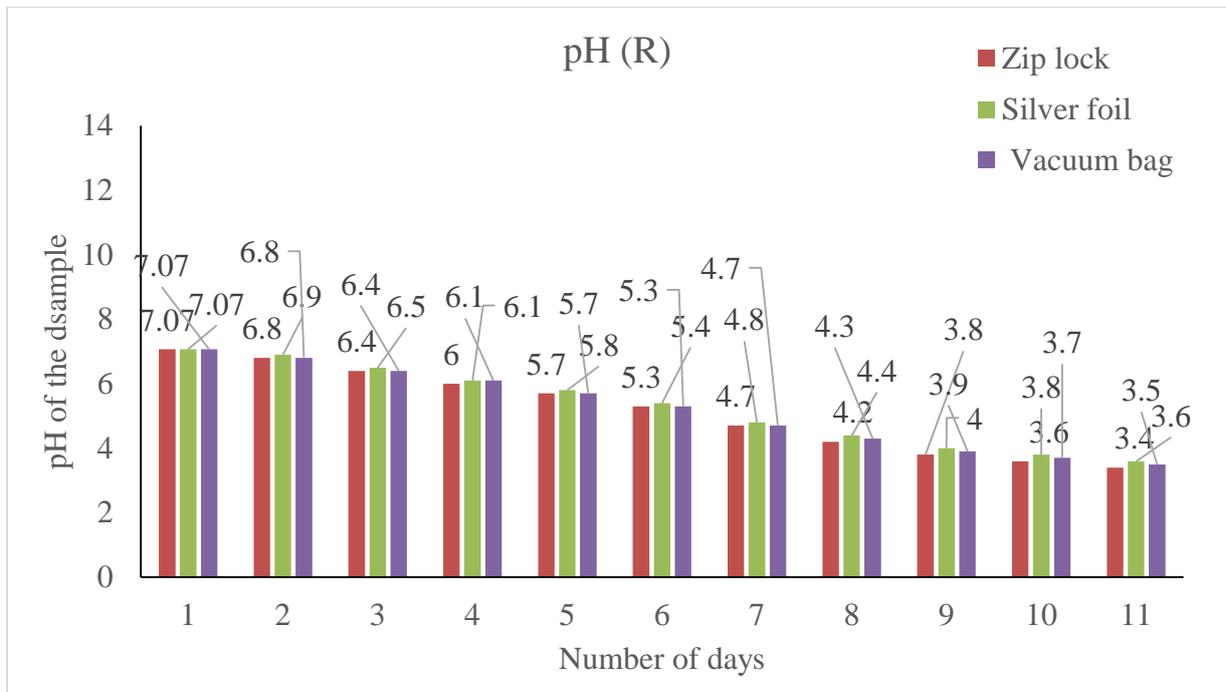


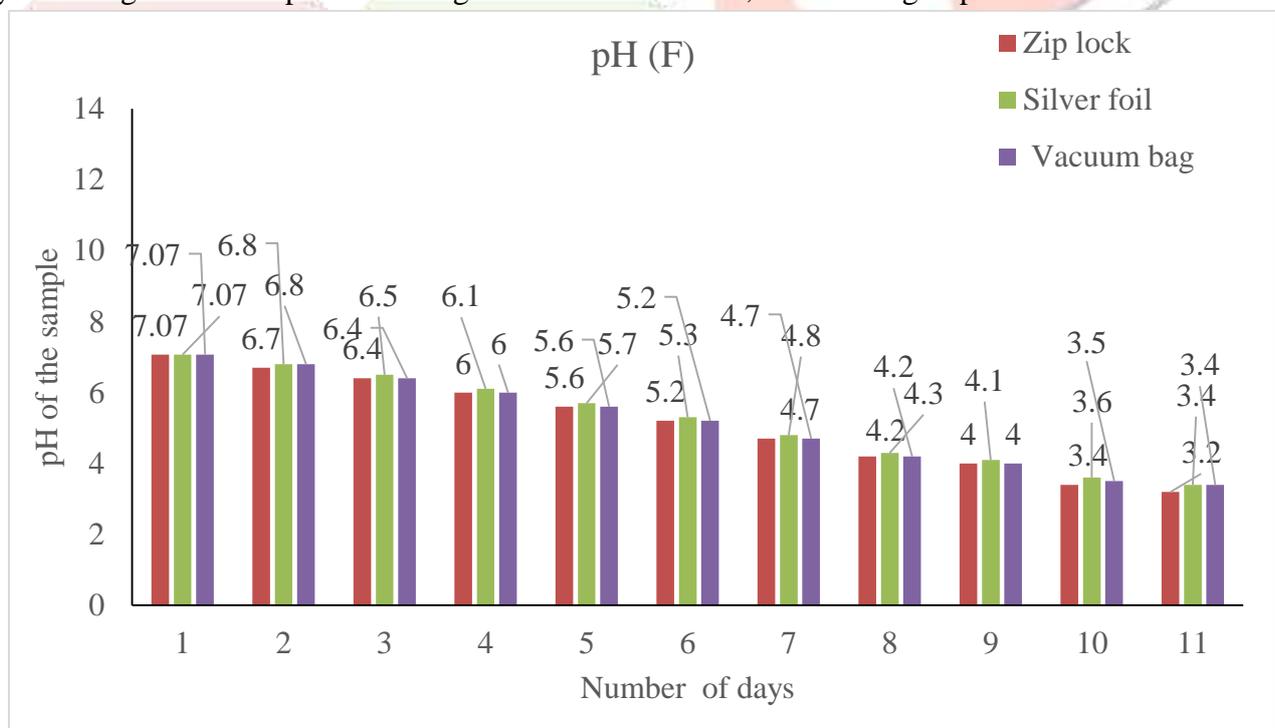
Fig 4.2.1 Determination of pH At Room Temperature

Fig 4.2.1 showing a gradual decrease in pH levels was observed in all samples over 10 days period at room temperature. Enzymatic activities in zip lock bags lead to a decrease in pH over time, as pectin degradation releases acidic components into the fruits, accelerating decay. Ziplock packaging slow down enzymatic activity compared to Vacuum bag, resulting in a slower decrease in pH over time. Despite the barrier properties of silver foil, enzymatic degradation of pectin and organic acids persists, leading to a gradual decrease in pH over time. This enzymatic activity contributes to the decay of the fruit despite the protective packaging.



**Fig 4.2.2 Determination of pH At Refrigerator Condition**

Fig 4.2.2 showing a gradual decrease in pH levels was observed in all samples over 10 days period at refrigerator condition. Cooler temperature slow down enzymatic reactions but do not entirely prevent pH decrease in Vacuum bag, as enzymatic activity persists, albeit at a reduced rate. Similarly Ziplock packaging slows down pH decrease compared to Vacuum packaging but does not provide complete protection against enzymatic degradation. While silver foil provides better preservation compared to other packaging materials, enzymatic degradation of pectin and organic acids still occurs, contributing to pH decrease and fruit decay.



**Fig 4.2.3 Determination of pH At Freezer condition**

Fig 4.2.3 showing a gradual decrease in pH levels was observed in all samples over 10 days period. The pH of Guavas stored in zip lock bag remain slowly decrease, indicating minimal degradation of organic acids. In vacuum packaging decay of sample is observed may have contributed to changes in pH over time. Microbial growth and enzymatic reactions could have altered the acidity of the fruit, leading to fluctuations

in pH. Silver foil maintains a stable pH in the freezer, indicating effective preservation. The barrier properties of silver foil inhibit microbial growth and enzymatic activity, preserving the acidity of the fruit.

Table 4.3 Determination of TSS Of The Sample Across Different Packaging Material At Different Temperature Condition

DETERMINATION OF TSS									
At Room Temperature Condition (RT)			At Refrigerator Condition (R)			At Freezer Condition (F)			
No of days	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag
0	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
1	6.3	6.4	6.3	6.2	6.3	6.3	6.1	6.3	6.2
2	6.5	6.7	6.6	6.6	6.7	6.4	6.5	6.7	6.4
3	6.7	6.8	6.7	6.9	6.8	6.7	6.9	6.8	6.6
4	6.9	7.0	6.9	7.0	7.0	6.9	7.0	7.0	6.9
5	7.2	7.4	7.1	7.2	7.3	7.4	7.2	7.3	7.4
6	7.5	7.7	7.6	7.5	7.8	7.6	7.4	7.5	7.6
7	8.3	8.7	8.5	8.7	8.9	8.8	8.7	8.8	8.7
8	Decay	Decay	Decay	9.7	9.8	9.5	9.4	9.9	9.5
9	Decay	Decay	Decay	10.5	10.8	10.7	10.5	10.7	10.4
10	Decay	Decay	Decay	11.2	11.5	11.3	11.2	11.4	11.3

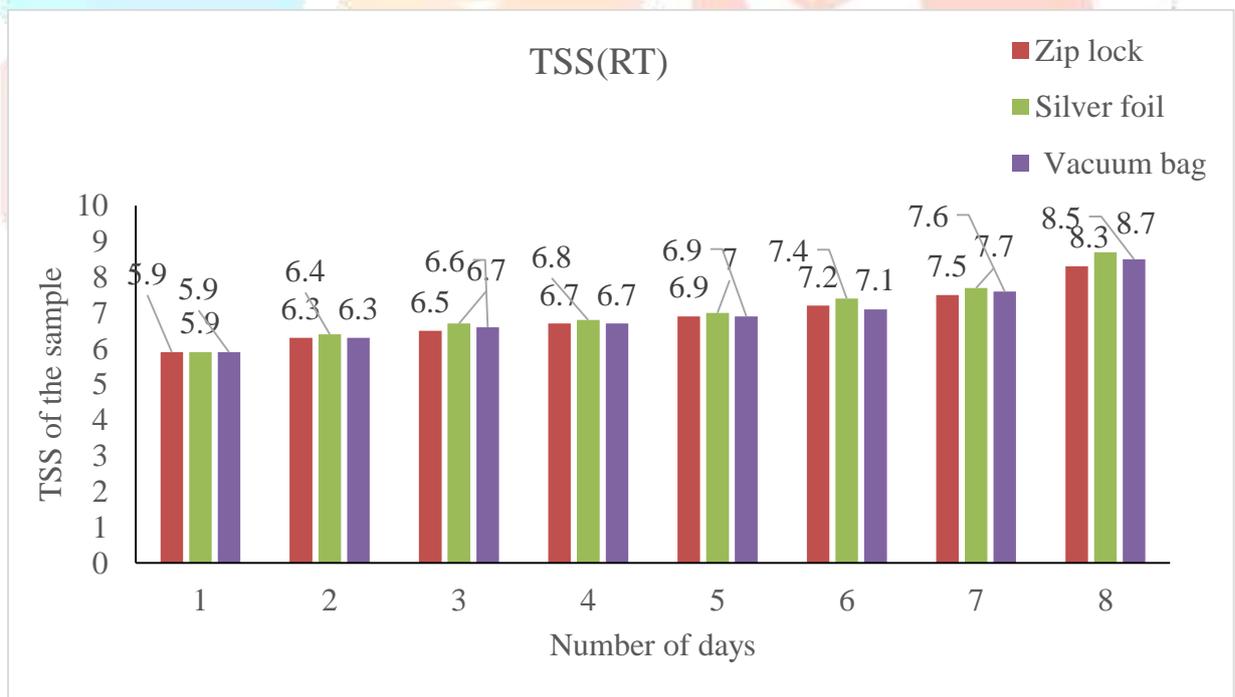
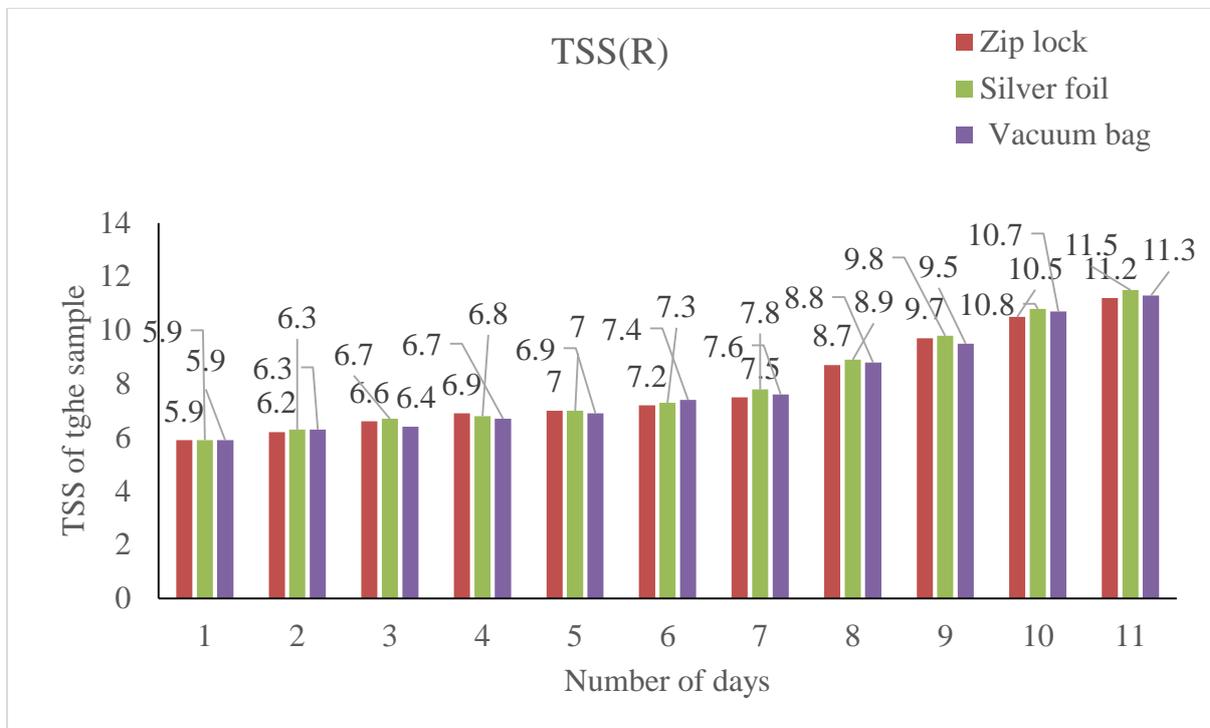


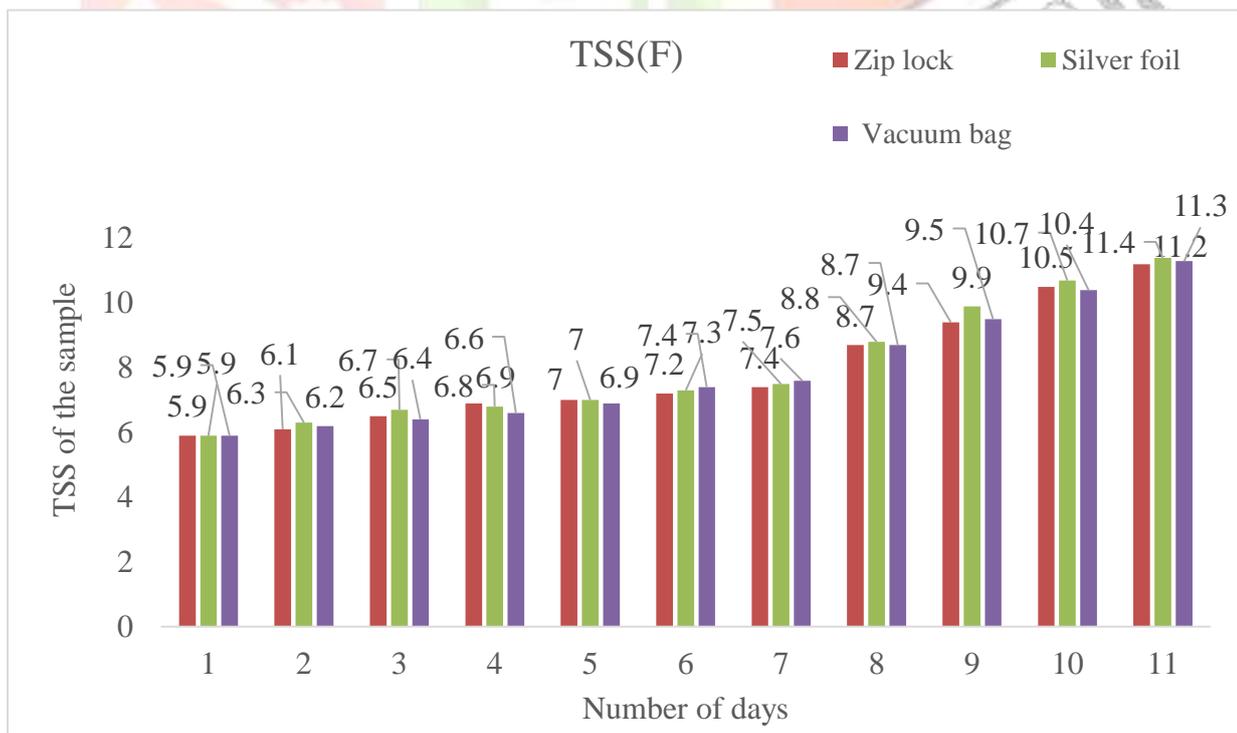
Fig 4.3.1 Determination of TSS At Room Temperature condition

Fig 4.3.1 represents Total Soluble Solids (TSS) levels increase in all samples over 10 days period. In zip lock bag enzymatic activity, such as alpha- amylase and invertase, catalyzes the breakdown of starches and sugars into soluble forms, leading to an increase in TSS levels over time. The permeability of zip lock bags accelerates this process. Ziplock packaging slows down enzymatic activity compared to Vacuum bags, resulting in a slower increase in TSS levels but not preventing it entirely. Guavas stored in silver foil experiences minimal increase in TSS levels due to the barrier properties of the material, but some levels of decay still occurs.



**Fig 4.3.2 Determination of TSS At Refrigerator Condition**

Fig 4.3.2 represents Total Soluble Solid (TSS) levels increase in all samples over 10 days period at refrigerator conditions. In zip lock bag despite cooler temperature, enzymatic reactions persists, leading to gradual increase in TSS levels over time as starches and sugar continue to break down into soluble forms. Ziplock packaging in the refrigerator slows down the increase in TSS levels compared to Vacuum bag but does not entirely prevent it. Silver foil provides superior preservation, minimizing the increase in TSS levels compared to other packaging materials due to the inhibition of enzymatic activity, but decay of samples still occur.



**Fig 4.3.3 Determination of TSS At Freezer Condition**

DETERMINATION OF COLOUR									
At Room Temperature Condition (RT)			At Refrigerator Condition (R)			At Freezer Condition (F)			
No of days	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag
0	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12
1	5.31	4.41	5.94	4.21	3.21	3.87	4.13	3.78	4.13
2	6.73	5.63	6.26	4.21	4.31	4.43	5.33	4.14	4.65
3	7.82	7.14	7.86	4.98	4.44	5.14	4.76	4.78	5.32
4	9.42	8.38	10.21	5.53	5.21	5.67	5.31	5.23	6.91
5	10.54	10.21	11.45	6.44	6.52	6.66	6.26	5.92	7.54
6	11.87	11.65	12.32	7.23	6.87	7.64	7.32	6.97	8.76
7	12.84	12.37	13.65	8.32	7.74	8.89	8.34	7.65	9.67
8	Decay	Decay	Decay	9.24	8.45	9.21	9.78	8.34	10.74
9	Decay	Decay	Decay	10.14	9.12	10.54	10.54	9.75	11.76
10	Decay	Decay	Decay	10.45	9.86	11.43	11.21	10.43	12.36

Fig 4.3.3 represents Total Soluble Solids (TSS) levels increase in all samples over 10 days period. In freezing temperature the Vacuum bag effectively preserves fruit quality, leading to minimal increases in TSS levels over time. Enzymatic activity is inhibited, resulting in slower breakdown of starches and sugars into soluble forms. In Ziplock packaging TSS level gradually increases over time, leading to decay of Guava samples. The Ziplock sealed have promoted anaerobic microbial growth, contributing to decay and TSS increases. Silver foil experiences the best preservation with minimal increases in TSS levels. The superior barrier properties of silver foil effectively inhibit enzymatic activity and preserve fruit quality.

- Table 4.4 Determination of Colour Of The Sample Across Different Packaging Material At Different Temperature Condition

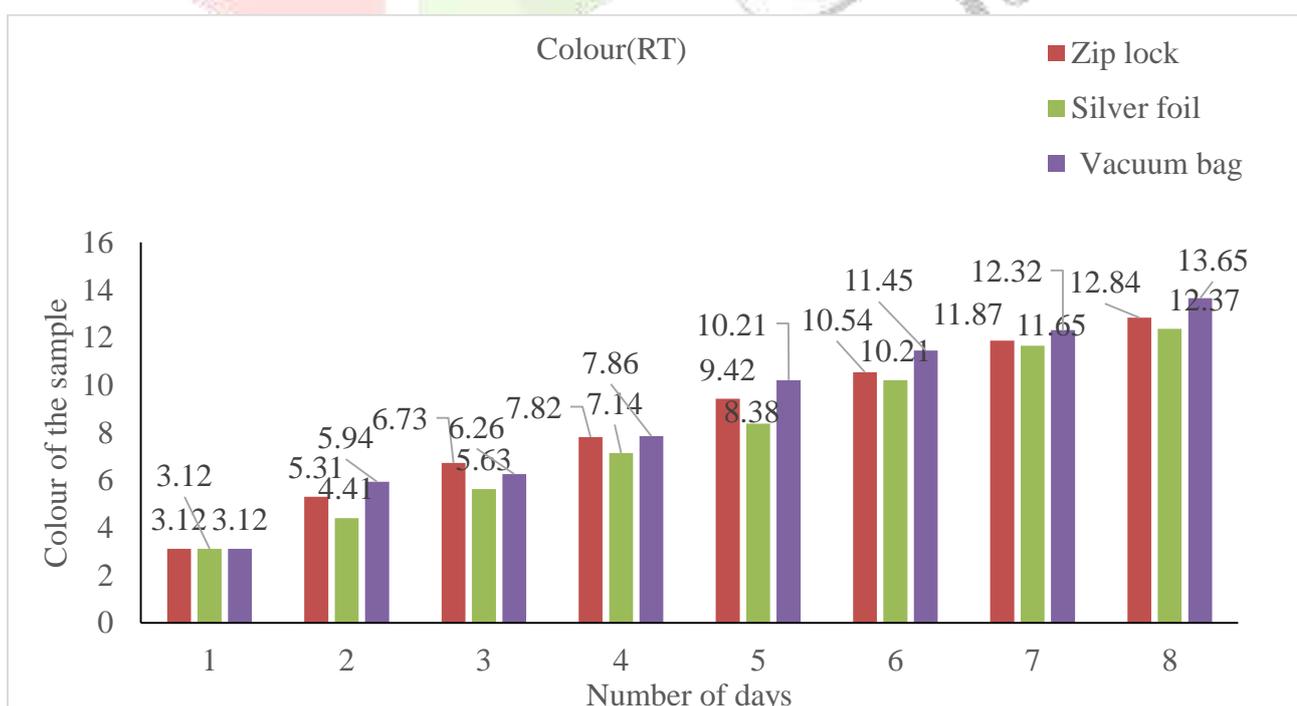
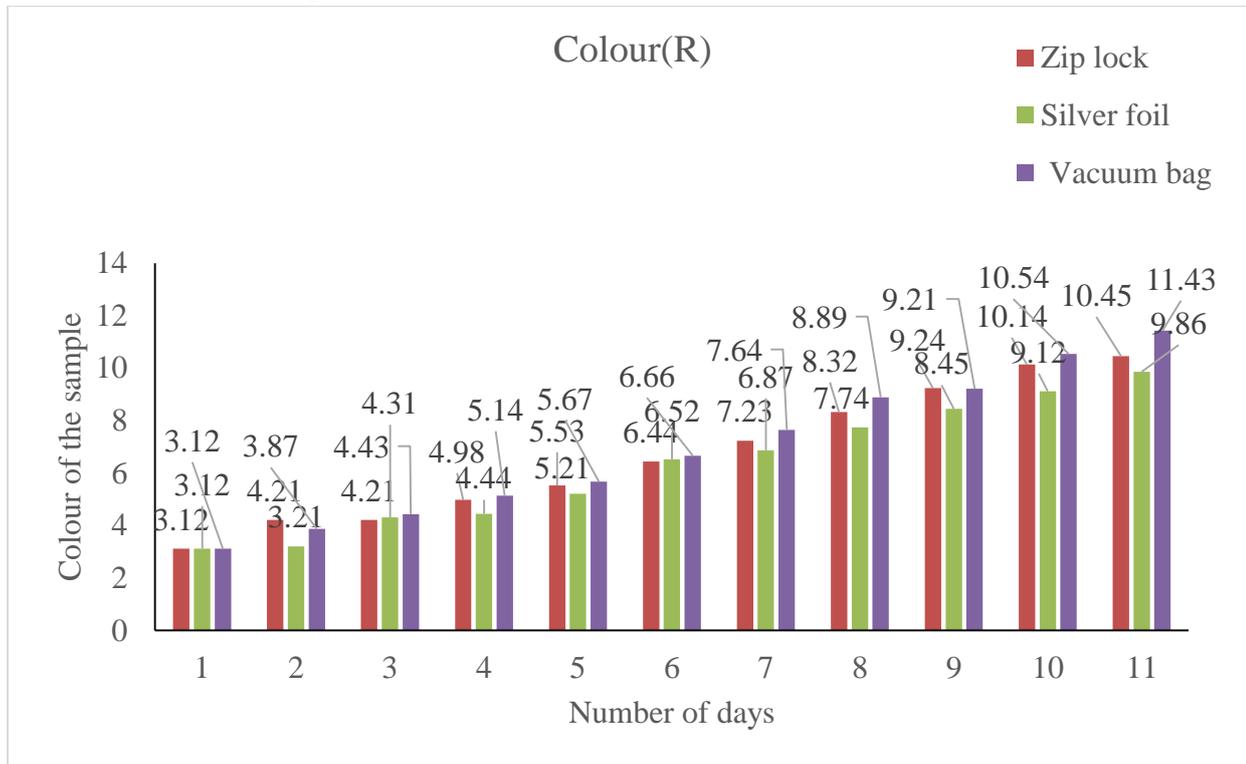


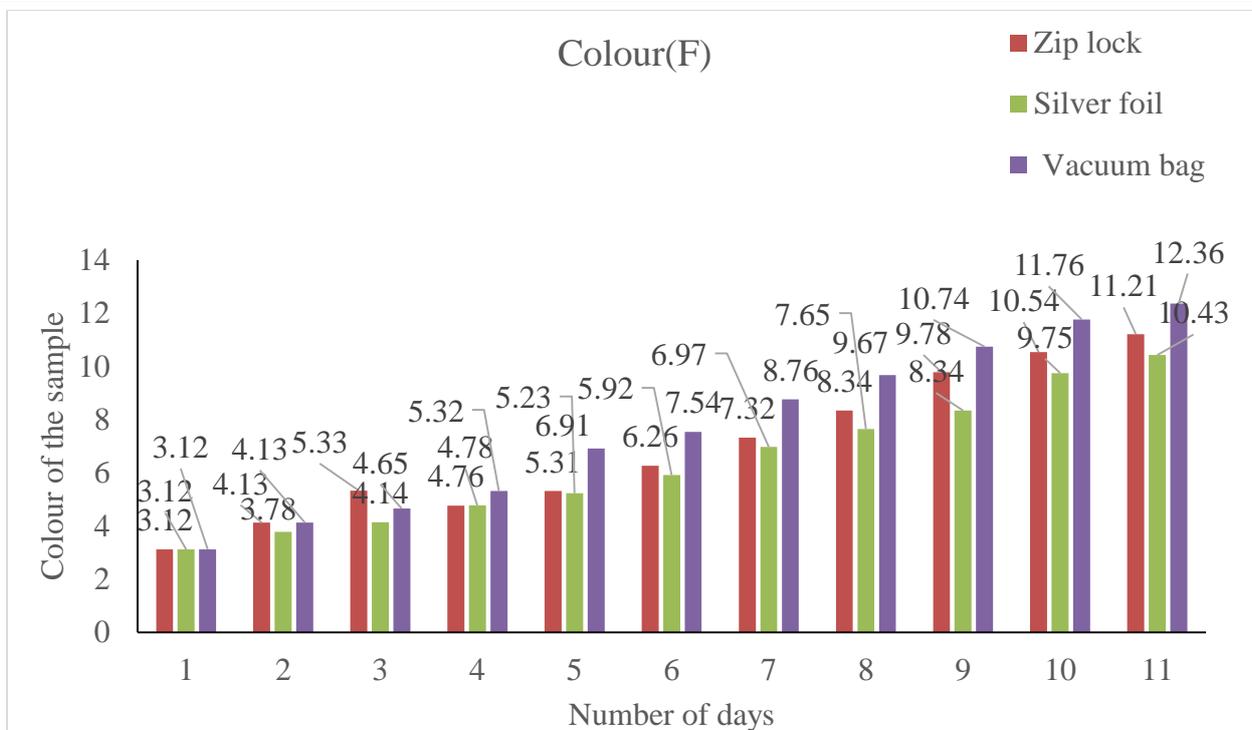
Fig 4.4.1 Determination of colour At Room temperature condition

Fig 4.4.1 represents colour analysis using a colour picker tool revealed changes in the colour intensity of Guava samples over the 10 days period at room temperature. The day-by-day increase in colour can be attributed to several factors. As Guava ripen, their colour naturally deepens due to the accumulation of carotenoid pigments. In zip lock bag oxygen permeability accelerates oxidative processes, leading to increase in colour intensity such as browning over time due to enzymatic reactions and lipid oxidation. Vacuum packaging slows down oxidative process in room temperature as compared to zip lock bag, resulting in slower increase in colour intensity but not preventing them entirely. Guava slices stored in silver foil experience minimal increase in colour intensity due to the barrier properties of the material but still decay is observed in Guava samples.



**Fig 4.4.2 Determination of colour At Refrigerator Condition**

Fig 4.4.2 represents colour analysis using a colour picker tool revealed changes in the colour intensity of Guava samples over the 10 days period at refrigerator conditions. Cooler temperature slows down oxidation, but some colour changes still occur over time due to enzymatic and oxidative process in zip lock bag. Vacuum packaging also slows down colour changes compared to zip lock bag but does not entirely prevent them, leads to decay of orange samples. Silver foil provides superior preservation, minimizing in increase of colour intensity, but here also decay of Guava sample is observed due to fluctuation in temperature.

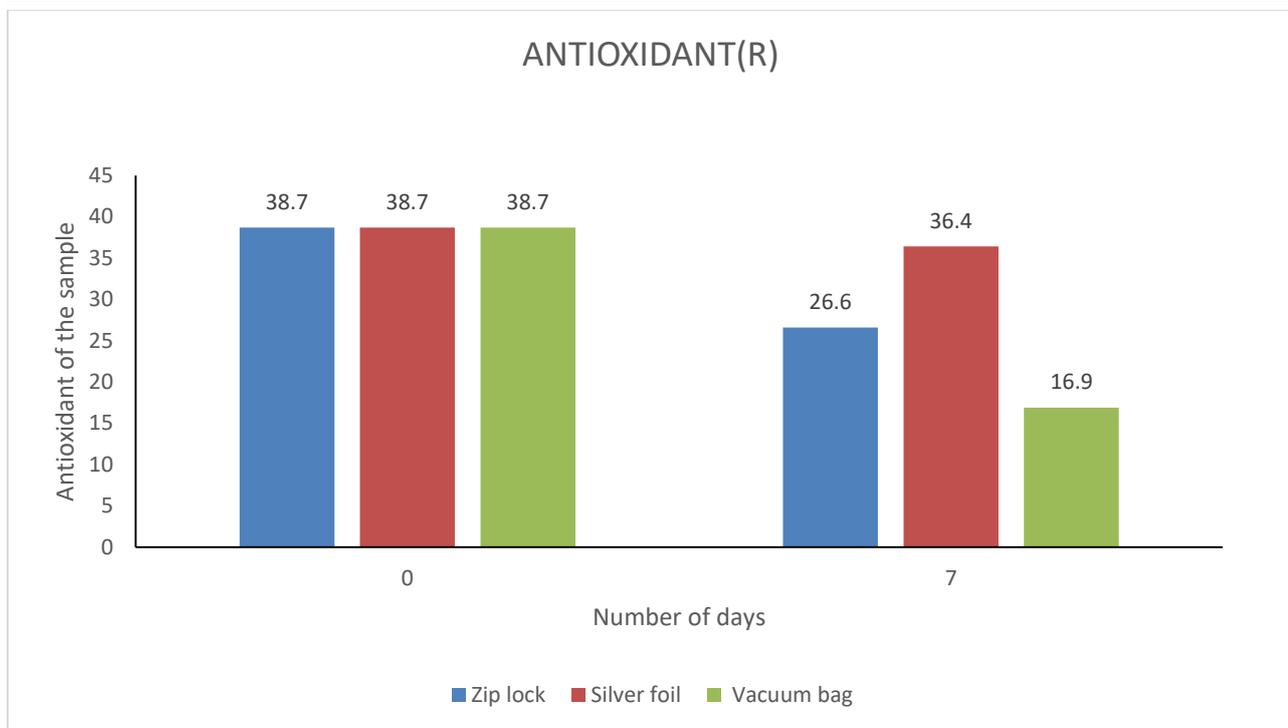


**Fig 4.4.3 Determination of colour At Freezer Condition**

Fig 4.4.3 represents increases of colour intensity of Guava samples over 10 days period at freezer conditions. Colour changes were minimal in Guavas stored in zip lock bag, indicating effective preservation of fruit colour. The lower temperature slows down oxidation and enzymatic processes preserving fruit quality. In vacuum packaging the intensity of colour increases gradually due to oxidative processes, leading to decay of Guava slices. Guava stored in silver foil in the freezer exhibit minimal colour changes, indicating superior preservation. The barrier properties of silver foil prevent enzymatic browning, preserving fruit colour effectively.

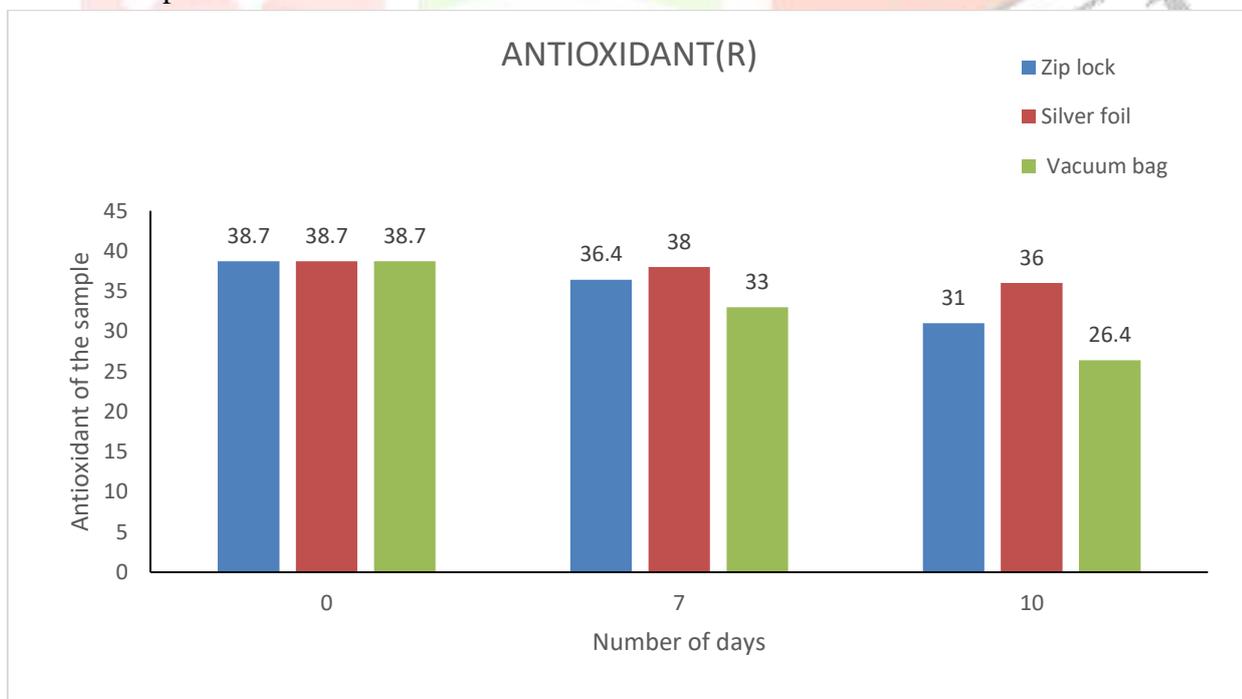
- Table 4.5 Determination of Antioxidant Of The Sample Across Different Packaging Material At Different Temperature Condition

DETERMINATION OF ANTIOXIDANT (%)									
At Room Temperature Condition (RT)			At Refrigerator Condition (R)			At Freezer Condition (F)			
No of days	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag
0	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
7	26.6	36.4	16.9	36.4	38	33	33.4	38	31
10	Decay	Decay	Decay	31	36	26.4	16.9	21.3	14.6



**Fig 4.5.1 Determination of Antioxidant At Room Temperature**

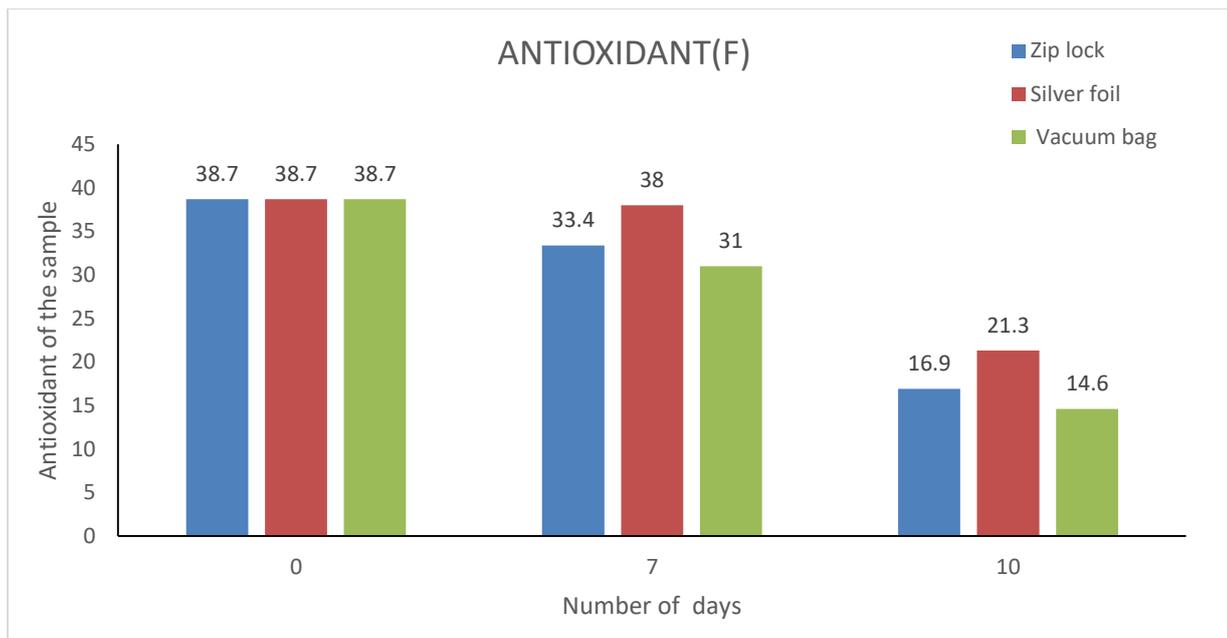
Fig 4.5.1 represents initially Guava sample exhibited at high levels of Antioxidant on day 0. At Room temperature the antioxidant activity of Guava stored in Room Temperature gradually decline over time due to oxidative processes. Exposure to oxygen and Ambient temperature can accelerate the degradation of antioxidant compounds present in the fruit slices. Guava stored in Ziplock experience relatively preserved antioxidant activity as compared to the Vacuum packaging. Vacuum sealed environment reduces oxygen exposure, slowing down oxidative reaction and preserving antioxidant compound. Silver foil packaging offers superior preservation of antioxidant activity at Room Temperature but still decay of sample is observed at room temperature.



**Fig 4.5.2 Determination of Antioxidant At Refrigerator condition**

Fig 4.5.2 represents in Refrigerator, Antioxidant activity in Guava stored in Ziplock bags not gradually decrease. The lower Temperature slowdown oxidative reactions, helping to preserve antioxidant compounds in the fruit for a longer period. In Vacuum packaging the antioxidant activity decline due to oxidative damage

leads to decay of Guava slices. Silver foil packaging maintains high antioxidant activity in the Refrigerator. The barrier properties of Silver foil effectively prevent oxygen exposure.

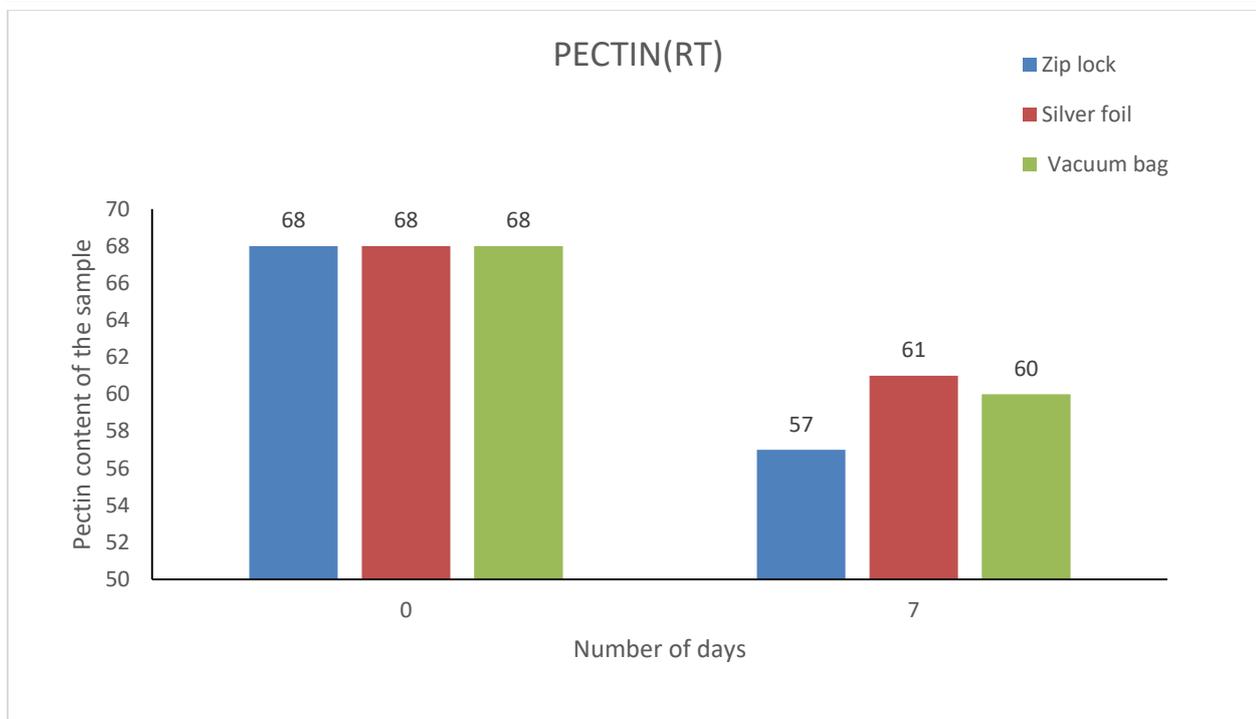


**Fig 4.5.3 Determination of Antioxidant at Freezer Condition**

Fig 4.5.3 represents the Antioxidant activity of Guava stored in Freezer. The stored samples of Ziplock bags not gradually decrease, indicating preservation of Antioxidant compounds. Freezing temperature slows down the oxidative processes, preserving the Antioxidant capacity of fruit. Decay observed in the samples which are stored in Vacuum packages, Freezer leads to a decline in antioxidant activity over time. Degradation of Antioxidant compounds due to microbial growth or enzymatic reactions could contribute to reduced Antioxidant activity. Guava that was stored in Silver foil maintain Antioxidant activity in the freezer, demonstrating effective preservation. The barrier properties of Silver foil inhibit oxidative processes, preserving the Antioxidant capacity of the Fruit.

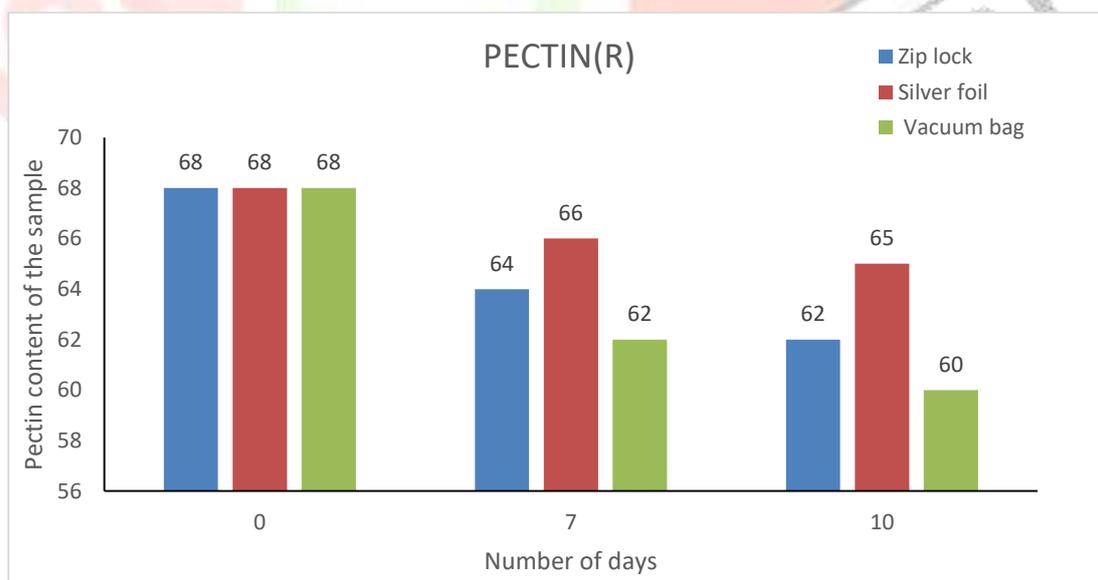
**Table 4.6 Determination of Pectin Of The Sample Across Different Packaging Material At Different Temperature Condition**

DETERMINATION OF PECTIN (%)									
At Room Temperature Condition (RT)				At Refrigerator Condition (R)			At Freezer Condition (F)		
No of days	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag
0	68	68	68	68	68	68	68	68	68
7	57	61	60	64	66	62	63	65	61
10	Decay	Decay	Decay	62	65	60	61	64	60



**Fig 4.6.1 Determination of Pectin content At Room temperature condition**

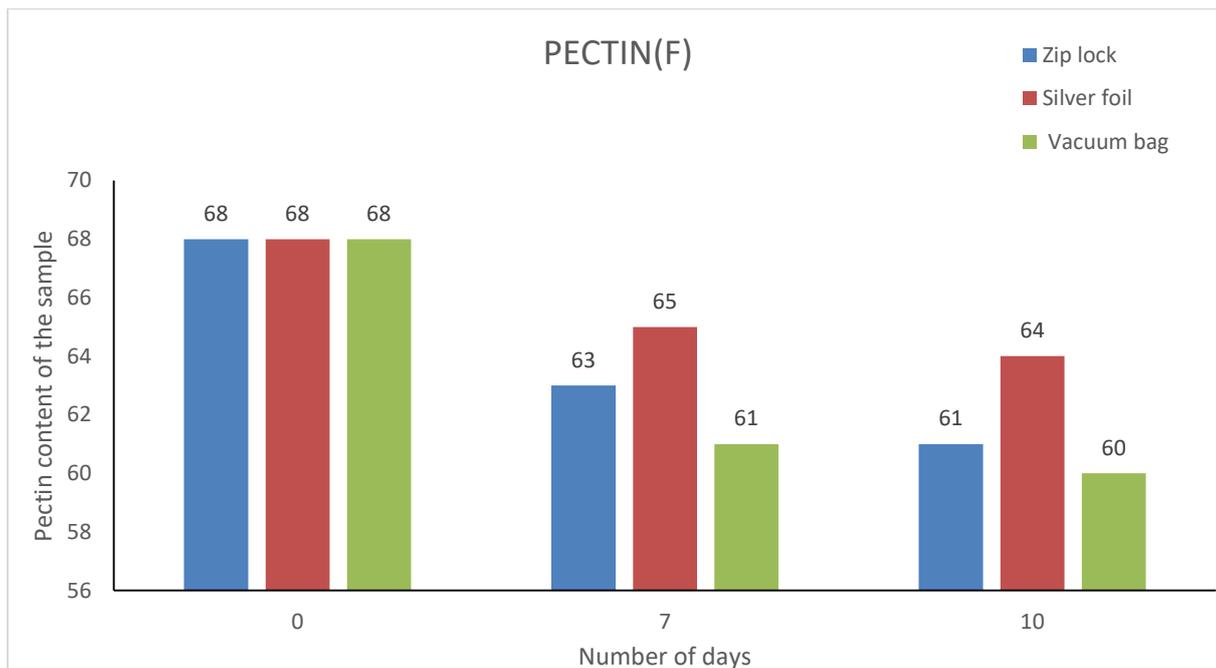
Fig 4.6.1 showing pectin content in Guava slices stored in zip lock bags at room temperature may gradually decrease over time due to enzymatic activity and moisture loss. Room temperature conditions accelerate enzymatic reactions, leading to the breakdown of cell wall components and reduction in pectin content. Vacuum packaging helps slow down the degradation of pectin content in oranges stored at room temperature compared to zip lock bags. The vacuum-sealed reduces exposure to enzymes and moisture, preserving the structural integrity of the fruit and its pectin content to some extent. Guava samples stored in silver foil packaging maintain higher pectin content at room temperature. The barrier properties of silver foil effectively inhibit enzymatic activity but still decay of samples observed in Silver foil.



**Fig 4.6.2 Determination of pectin At Refrigerator condition**

Fig 4.6.2 showing in the refrigerator, pectin content in Guava samples stored in zip lock bags experiences minimal degradation compared to room temperature conditions. The cooler temperature slows down enzymatic activity, preserving the structural integrity of the fruit and its pectin content over time. Guava slices stored in vacuum packaging in the refrigerator exhibit preserved pectin content similar to zip lock bags. The refrigerated further inhibits enzymatic reactions, maintaining the structural integrity of the fruit and its

pectin content but still decay occurs in vacuum packaging. Silver foil packaging maintains high pectin content in the refrigerator. The barrier properties of silver foil effectively block moisture and oxygen, ensuring superior preservation of cell wall components but still decay of samples observed in silver foil.

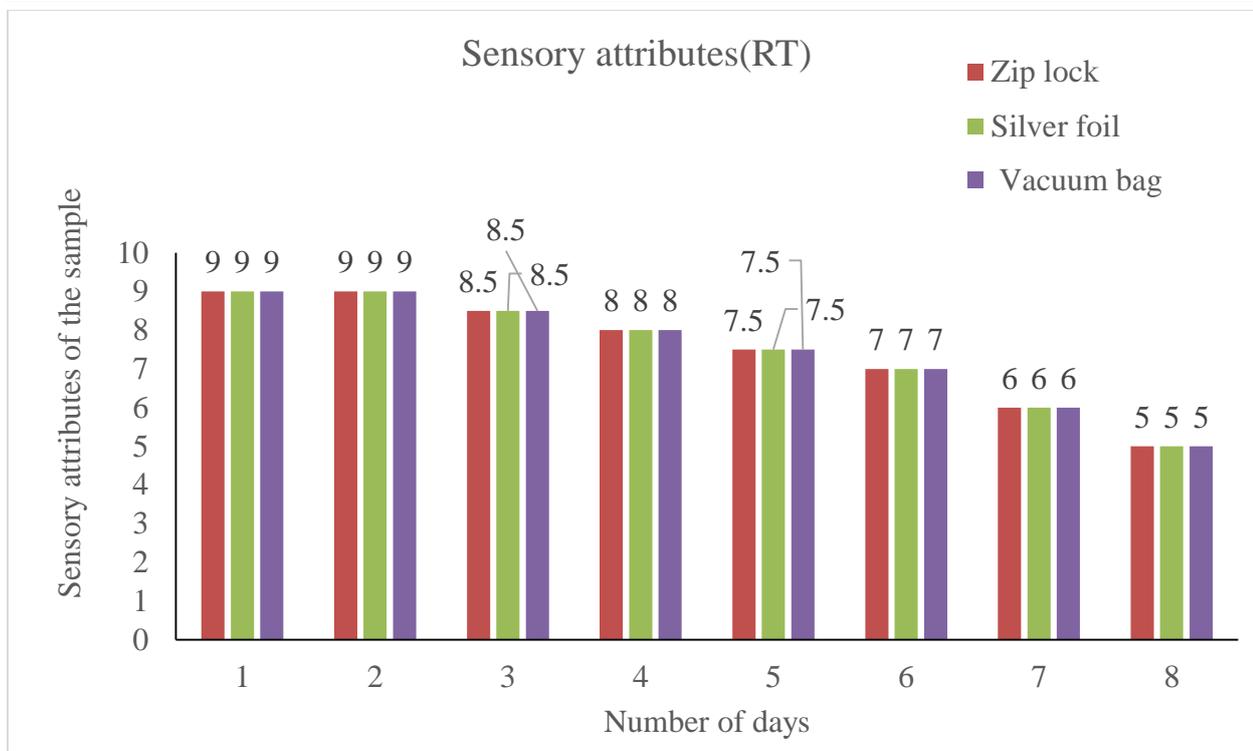


**Fig 4.6.3 Determination of Pectin At Freezer Condition**

Fig 4.6.3 showing pectin content is not much decreases in Guava stored in zip lock bags in the freezer, indicating minimal degradation of cell wall components. Freezing temperatures slow down enzymatic activity, preserving the structural integrity of the fruit. In vacuum packaging gradual decrease of pectin is observed due to the breakdown of cell wall components and reduction in pectin content leads to decay of Guava samples. Guavas stored in silver foil maintain pectin content in the freezer, reflecting effective preservation. The barrier properties of silver foil inhibit enzymatic activity, preserving the structure of the fruit and its pectin content.

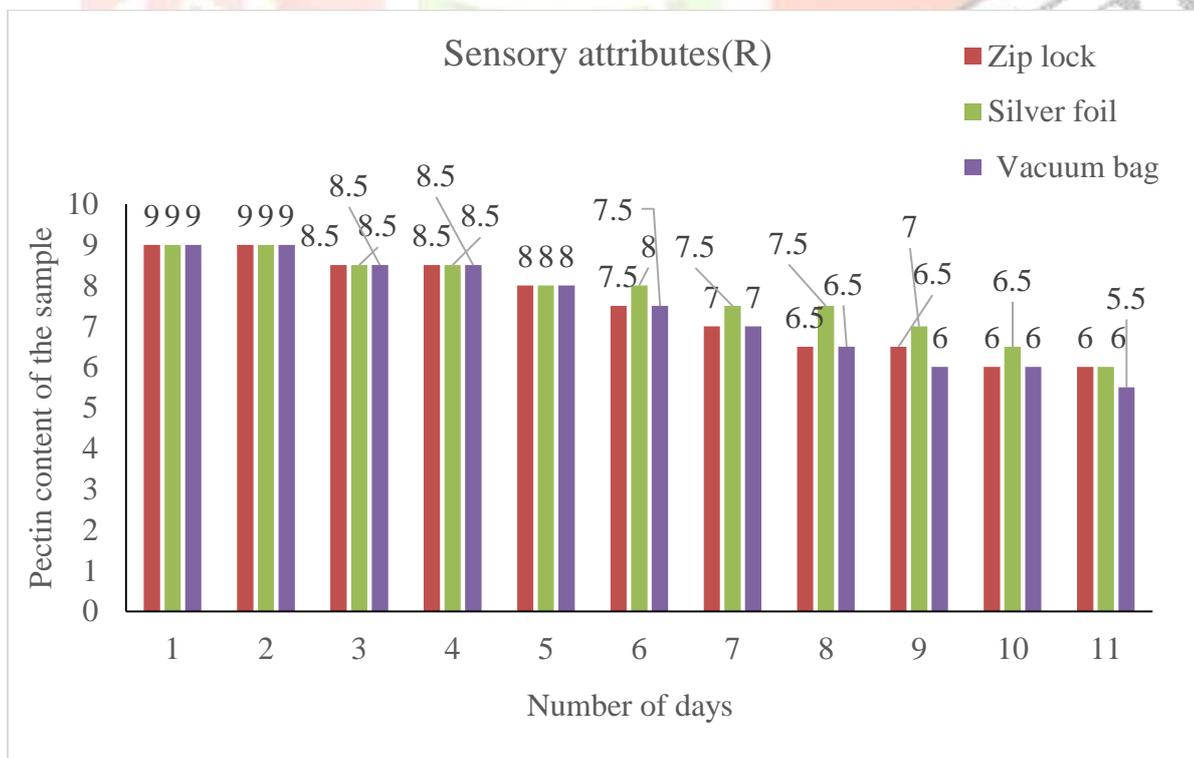
**Table 4.7 Determination of Sensory Attributes Of The Sample Across Different Packaging Material At Different Temperature Condition**

DETERMINATION OF SENSORY ATTRIBUTES									
At Room Temperature Condition (RT)				At Refrigerator Condition (R)			At Freezer Condition (F)		
No of days	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag	Ziplock	Silver foil	Vacuum bag
0	9	9	9	9	9	9	9	9	9
1	9	9	9	9	9	9	9	9	9
2	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
3	8	8	8	8.5	8.5	8.5	8	8.5	8
4	7.5	7.5	7.5	8	8	8	8	8	8
5	7	7	7	7.5	8	7.5	7.5	7.5	7.5
6	6	6	6	7	7.5	7	7	7.5	7
7	5	5	5	6.5	7.5	6.5	7	7	6.5
8	Decay	Decay	Decay	6.5	7	6	6.5	6.5	6
9	Decay	Decay	Decay	6	6.5	6	6.5	6.5	6
10	Decay	Decay	Decay	6	6	5.5	6	6	5.5



**Fig 4.7.1 Determination of Sensory attributes at Room temperature condition**

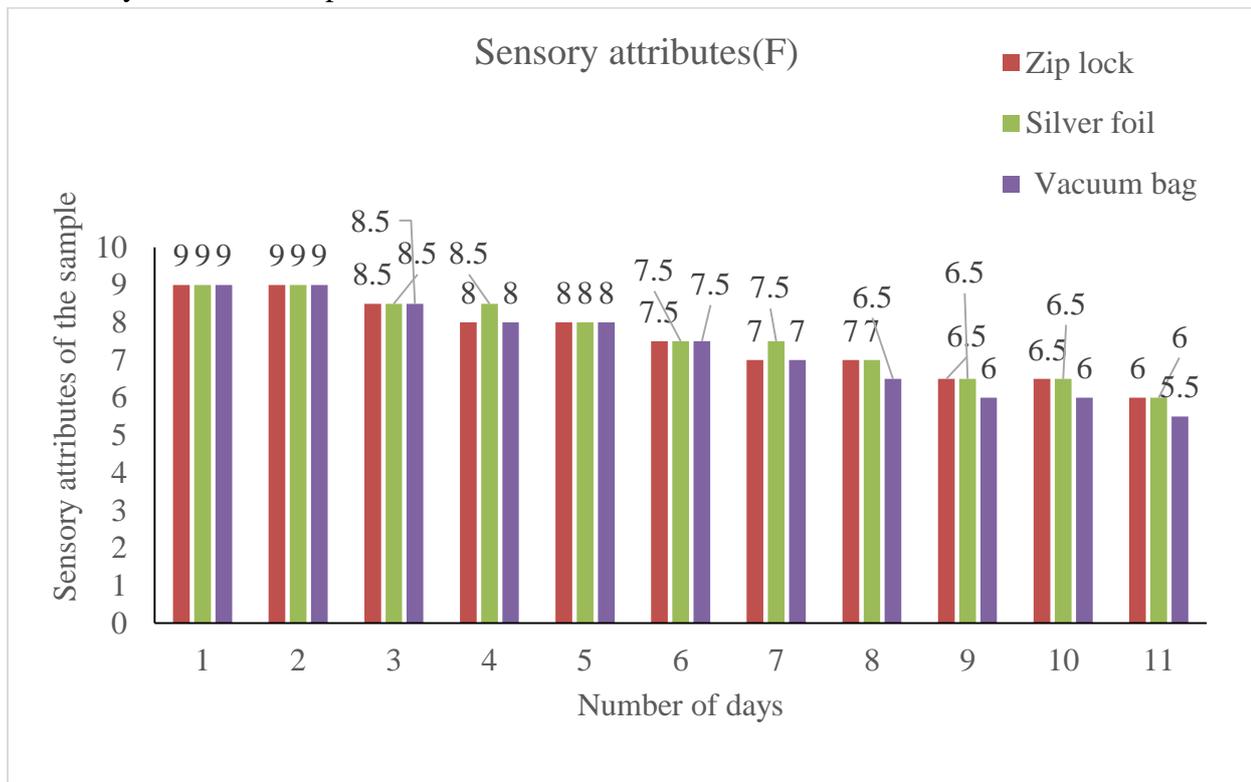
Fig 4.7.1 represents overall acceptability of Guava slices stored in zip lock bags at room temperature may decline over time as sensory attributes deteriorate. Exposure to ambient conditions accelerates deterioration in texture, appearance, aroma, and taste, leading to decreased overall acceptability. Guava stored in Ziplock packaging maintain acceptable sensory quality at room temperature compared to zip lock bags. The Ziplock helps slow down deterioration in sensory attributes, prolonging overall acceptability to some extent. Vacuum packaging preserves high overall acceptability of Guava at room temperature. The barrier properties of silver foil effectively protect against external factors, maintaining sensory quality but still decay of samples observed in Silver foil.



**Fig 4.7.2 Determination of Sensory attributes at Refrigerator Condition**

Fig 4.7.2 represents in the refrigerator, Guava stored in Vacuum packages maintain acceptable sensory quality compared to room temperature conditions. The cooler temperature slows down deterioration in

sensory attributes, prolonging overall acceptability of the fruit. Guava slices stored in Ziplock packaging in the refrigerator exhibit preserved sensory quality. The refrigerated environment further inhibits deterioration in sensory attributes, ensuring maintained overall acceptability but still decay of samples occurs in Ziplock packaging bag. Silver foil packaging maintains high overall acceptability of oranges in the refrigerator but still decay of Guava sample occur in Silver foil.



**Fig 4.7.3 Determination of Sensory attributes at Freezer Condition**

Fig 4.7.3 represents overall acceptability good in Guava slices which stored in zip lock bags in the freezer, indicating good sensory quality. The low temperatures slow down deterioration, preserving texture, appearance, aroma, and taste. Despite decay observed in oranges stored in vacuum packaging in the freezer, initial sensory evaluations may have indicated acceptable quality. However, decay over time could lead to decreased overall acceptability as sensory attributes deteriorate. Guava stored in silver foil maintain high overall acceptability in the freezer, reflecting superior preservation. The barrier properties of silver foil maintain sensory quality, ensuring a positive eating experience.

## 5.CONCLUSION:

In this study the quality and shelf life of Guava slices were examined along with the effects of Various packaging materials: Ziplock, Silver foil and Vacuum packages and Storage conditions: Room temperature, Refrigerator and Freezer. Everyday throughout the experiment, The key parameters were recorded including pH, TSS, Antioxidant content, level of pectin, Weight reduction and Sensory attributes like Appearance, Texture, Smell, and Taste.

The observed Parameters gradually changed, as indicated by the data, suggesting that Guava slices gradually deteriorated Over time. More specially it was shown that there was a decrease in Pectin levels and an increase in pH and TSS levels. These modifications highlight how crucial it is to preserve fruit freshness and nutritional value through appropriate packing and storage setting. Of all the packaging materials that were examined, silver foil turned out to be the best choice for keeping guava slices fresh, especially when kept in a refrigerator. This result emphasizes how well silver foil works to maintain the fruit's overall quality and sensory qualities. It was also discovered that freezing temperatures were effective in prolonging the shelf life of guava slices, but there were minor differences in their sensory qualities. On the other hand, vacuum packing was found to be unfit for guava slices since it negatively affected the texture and general quality of the product. In comparison, Ziplock packaging showed a reasonable level of use. These results highlight how crucial it is to use packaging materials that are suitable for the particular requirements of the crop.

**6.ACKNOWLEDGEMENT:** Authors are Acknowledge to Centurion University of Technology and management to carry out the research work

## 7.REFERENCES

- [1] Afrin, T., Husna, N. A., Hossain, M. M., Iqbal, A., & Karmoker, P. (2022). Efficacy of Packaging on the Quality and Shelf Life of Guava (*Psidium Guajava*). *European Journal of Agriculture and Food Sciences*, 4(5), 7-12.
- [2] Assous, M. T. M., El-Waseif, K. H. M., & Zaki, S. M. (2012). Influence of combined osmotic dehydration and air drying on the quality of guava slices. *Egyptian Journal of Agricultural Sciences*, 63(3), 275-285.
- [3] BAGADA, P. J., GOYAL, S. R., & DWIVEDI, D. K. Standardization of Packaging Technology of Fresh And Processed Guava Fruits. *Advances*, 1988.
- [4] Brown, B. I., & Wills, R. B. H. (1983). Post-harvest changes in guava fruit of different maturity. *Scientia Horticulturae*, 19(3-4), 237-243.
- [5] Gill, K. B. S. (2016, November). Techniques for extending shelf life of guava fruits: a review. In *International Symposia on Tropical and Temperate Horticulture-ISTTH2016 1205* (pp. 959-969)
- [6] Goyal, H., Sharma, C. K., & Sharma, P. K. (2023). Study on effect of different packaging materials on quality of guava (*psidium guajava* l.) To extend shelf life. *Plant Archives* (09725210), 23(2).
- [7] Inam-ur-Raheem, M., Huma, N., Anjum, F. M., & Malik, A. U. (2013). Effect of calcium chloride and calcium lactate on quality and shelf-life of fresh-cut guava slices. *Pakistan Journal of Agricultural Sciences*, 50(3), 427-431.
- [8] Jiménez-Escrig, A., Rincón, M., Pulido, R., & Saura-Calixto, F. (2001). Guava fruit (*Psidium guajava* L.) as a new source of antioxidant dietary fiber. *Journal of Agricultural and food Chemistry*, 49(11), 5489-5493.
- [9] Kumari, J., & Pooja. (2023). Optimisation of edible coating conditions using statistical Response Surface Methodology for shelf life extension of fresh-cut guava. *Acta Alimentaria*, 52(2), 163-176.
- [10] Lima, M. S., Pires, E. M. F., Maciel, M. I. S., & Oliveira, V. A. (2010). Quality of minimally processed guava with different types of cut, sanitification and packing. *Food Science and Technology*, 30, 79-87.
- [11] Miano, T. F., Jokhio, J. A., & Miano, T. F. (2010). Effect of different packaging materials and storage conditions on physicochemical characteristics of guava var Allahabadi. *J. Agrofor. Environ*, 4(2), 33-36.
- [12] Omayio, D. G., Abong, G. O., Okoth, M. W., Gachuri, C. K., & Mwang'ombe, A. W. (2019). Current status of guava (*Psidium Guajava* L.) production, utilization, processing and preservation in Kenya: a review.
- [13] Parihar, P., & Kumar, S. (2007). Shelf life studies on guava fruits under different packaging materials. *Indian Journal of Agricultural Biochemistry*, 20(1), 27-29.
- [14] Sagar, V. R., & Suresh Kumar, P. (2005, December). Processing of guava in the form of dehydrated slices and leather. In *I International Guava Symposium 735* (pp. 579-589).
- [15] Sahoo, N. R., Panda, M. K., Bal, L. M., Pal, U. S., & Sahoo, D. (2015). Comparative study of MAP and shrink wrap packaging techniques for shelf life extension of fresh guava. *Scientia Horticulturae*, 182, 1-7.
- [16] Singh, S. P. (2011). Guava (*Psidium guajava* L.). *Postharvest biology and technology of tropical and subtropical fruits*, 213-246e.
- [17] Suresh Kumar, P., & Sagar, V. R. (2016). Effect of packaging materials and storage temperature on quality of osmo-vac dehydrated guava slices during storage. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 86, 869-876.
- [18] Yadav, A., Kumar, N., Upadhyay, A., Fawole, O. A., Mahawar, M. K., Jalgaonkar, K., ... & Mekhemar, M. (2022). Recent advances in novel packaging technologies for shelf-life extension of guava fruits for retaining health benefits for longer duration. *Plants*, 11(4), 547.

- [19] Yin, S. S. (2010). Effects of different packaging films on the quality retention of fresh-cut guavas (*Psidium guajava* L.).
- [20] Yusof, S., & Mohamed, S. (1987). Physico-chemical changes in guava (*Psidium guajava* L.) during development and maturation. *Journal of the Science of Food and Agriculture*, 38(1), 31-39.

