Effect of packaging type on the quality of red ginger soft-candy

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Abstract. Red ginger is a rhizome containing *polyphenols*, *curcumin*, polysaccharides, essential oils, *gingerol*, and *shogaol*, known for their antioxidant and anti-inflammatory effects. The numerous advantages of red ginger have led to its expanded use, leading to the availability of several processed red ginger products in the market, such as red ginger. Research on how packaging, temperature, and storage duration impact the quality of red ginger jelly sweets is still limited. This study investigates how packaging type affects the quality of red ginger jelly sweets during preservation. The experiment entailed storing red ginger jelly sweets in different packaging and analyzing the subsequent quality alterations. The research findings indicate that the quality of red ginger jelly candy led to higher water content, total acid, reduced sugar content, and total microorganisms. The pH, texture, antioxidant activity, and sensory qualities of red ginger jelly sweets all decreased. The research findings indicate that the most effective packing material is polypropylene plastic which inhibits the rate of deterioration of moisture, texture, and reducing sugar of red ginger jelly candy.

1 Introduction

Red ginger is one type of rhizome that is widely used as a natural raw material for the food, cosmetic, and pharmaceutical industries. Red ginger contains various active compounds such as polyphenols, curcumin, gingerol, essential oils, and polysaccharides. Gingerol and shagol contained in ginger have been shown to have functional activities such as antioxidant and anti-inflammatory [1,2]. In addition, the active components of ginger are also widely used in pharmacology such as drugs for cholesterol, ulcers, tumors, atherosclerosis, digestive disorders, diabetes, and cardiovascular diseases [3]. The various benefits of red ginger have made the consumption of red ginger even higher. As a result, various processed red ginger products such as seasonings, syrups, candies, and dry powders began to appear in the market. One of the processed red ginger products that can be made is candy.

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Candy is a widely consumed snack item, particularly among the younger population. Commonly found in public circulation are both hard and soft candies. Jelly confectionery is an instance of a soft candy. Jelly candy is confectionery composed of fruit puree, sugar, or other sweetening agents combined with a variety of gelling agents to achieve an elastic and chewy consistency [4]. Red ginger can be incorporated into jelly confection formulas as a means of augmenting their nutritional content. This is due to the fact that red ginger's constituents are extremely healthful [5].

The quality of jelly candy is influenced by proper processing, packaging, and storage. The packaging process and storage conditions are important factors that must be considered during the storage period of a food product. Packaging is one of the ways that is done so that food quality can be maintained within the desired period [6]. Research the type of packaging used must be able to protect the product from contamination. If the packaging is not appropriate, then the packaging will be a source of contaminants for jelly candy products. Some jelly candy packaging on the market are PP (polypropylene) plastic packaging, aluminum foil packaging, and glass jar packaging. Currently, there is no research on the effect of these types of packaging on jelly candy, especially red ginger jelly candy.

In addition, the duration of storage has an impact on product quality; as the storage period extends, there is an observed escalation in the rate of quality deterioration. This is susceptible to microbial and other influences. Numerous studies have been conducted on the production of red ginger jelly candies. Nevertheless, research examining the impact of packaging on the quality of red ginger jelly candies remains extremely few. In light of this, this research aimed to ascertain the impact of packaging type on the quality of red ginger jelly candies throughout the storage period.

2 Material and Methods

2.1 Materials and chemicals

The materials used in this study were red ginger (Zingiber officinale var. Rubrum), carrageenan, sucrose, fructose syrup (HFS 50%), citric acid, distilled water, buffer pH 4 and buffer pH 7, D-Glucose Anhydrous (Chemical Pure), sodium potassium tartrate (Pudak Sci), sodium hydroxide (NaOH) (Merck Supelco; Chemical Pure), 0.01 N iodine solution, methanol (Smartlab), phenolphthalein indicator, 3,5-diniterosalicylic acid (DNS) (Himedia), 1% amylum solution, 2,2- diphenyl-1-picrylhydrazyl (DPPH) (Himedia), methanol, 0.1 N iodine solution, PCA medium (Merck KGaA), polypropylene (PP) packaging, glass jar packaging, and filter paper.

2.2 Preparation of red ginger juice

The red ginger is first sorted, and then the rhizomes of the red ginger are peeled and cleaned using flowing water. Subsequently, the ginger rhizomes were sliced into small pieces and blended with water to ginger ratio was 1:1 (b/v). The red ginger pulp is filtered by straining it through a filter cloth to separate the juice from the pulp, resulting in the extraction of red ginger juice.

2.3 Preparation of red ginger jelly candy

The production of jelly candy, as described by Bactiar et al. [4], involves dissolving 7.50 grams of carrageenan in 41.50 ml of red ginger juice in a separate container. Subsequently, the two solutions were combined and subjected to heating at approximately 70°C for a

duration of 5 minutes. Next, 13.70 grams of sucrose and 37 ml of fructose syrup were added into the mixture while continuously stirring until it thickened and reached a temperature of approximately 90-100°C. After that, the temperature was reduced to around 70°C and an amount of 0.30 grams of citric acid was put in. The mixture was then transferred to a pan and covered with aluminum foil, followed by cooling at room temperature for an hour. Following that, the jelly candy was enveloped with plastic wrap and placed in the refrigerator for 24 hours at 5°C. Afterwards, allow it to sit at room temperature for an hour, and proceed to slice it in accordance with the dimensions 2x2 cm.

2.4 Packaging and storage

The red ginger jelly candy was packaged and stored based on the treatment it received. This treatment involved using two forms of packaging: glass jars and polypropylene (PP) plastic. The candy was stored at room temperature, around 30°C, while ensuring it was not exposed to sunlight. Water content [7], pH [8], total acid [9], texture [9], reducing sugar [10], and antioxidant activity [11], were conducted on each treatment on day 0, 5, 10, and 15 of storage.

2.5 Data analysis

This research will be analyzed using a completely randomized design (CRD) with 3 factorial treatments and 3 replicates. If the results obtained are significantly different, the analysis will be proceeded by doing the Least Significant Difference (LSD) test. The data collected in this study were analyzed using the Microsoft Excel software.

3 Results and Discussion

3.1 Water content

The water content of a food product is a crucial factor in assessing its quality and its ability to withstand any damage. Microorganisms utilize the water present in food items to sustain their biological activities during physicochemical processes. Food products with a high water content are susceptible to harm caused by microbial metabolic activity. Lowering the moisture level in food ingredients is carried out to hinder the proliferation of microbes, hence extending the shelf life of the food ingredients [12].

According to the observation, the water content of red ginger jelly candy had an average value ranging from 15.93% to 40.43%. The analysis of variance revealed that the treatment of packaging type had a significant impact (Sig. 0.000) at the 5% level ($P < 0.05$) on the water content of red ginger jelly candy. The analysis of variance revealed a substantial impact of the packing treatment on the water content of red ginger jelly candy. Figure 1 displays the findings from the analysis of the water content of red ginger jelly candy when subjected to various packing methods.

Figure 1 demonstrates that red ginger jelly candy, when packaged in glass jars, has the highest average water content of 35.23%, which is significantly different from the average water content of 23.08% in the control group (without packaging). The results indicate that the utilization of glass jar packaging yields the highest mean water content value in comparison to PP packaging and no packaging. This is determined by the permeability of the container. The permeability of packaging is directly linked to the rate at which water vapor is transmitted. A package with a lower water vapor transmission rate allows less water vapor to pass through its material. The water vapor permeability of glass jar packaging is lower

than that of PP plastic packaging, indicating that the glass jar packaging is capable of preserving the moisture content of the red ginger jelly candy it contains. Nevertheless, the moisture content of red ginger jelly candy, which was packaged in glass jars for this investigation, exhibited a significant increase after storage. The presence of a cavity in the screw cap of the glass jar packaging allows for the ingress of external air into the packing. According to Atmini's research [9], glass jar packaging, although it should be airtight, actually has higher moisture content compared to other types of packing since the lid of the glass jar does not have a proper seal. Furthermore, the substantial moisture content in glass jar packing might be attributed to the significant headspace and surface area of the packaging. The water content of the red ginger jelly candy generated in this study surpassed the maximum limit of 20% set by the SNI quality standard for water content in red ginger jelly candy. Nevertheless, the moisture content acquired aligns with the moisture content of semi-wet materials, falling within the range of 10-40% [13]. The elevated water content in jelly sweets can result from the constituents employed during its production. According to Sundari et al. [14], there is a direct relationship between the water content of the materials utilized and the overall water content.

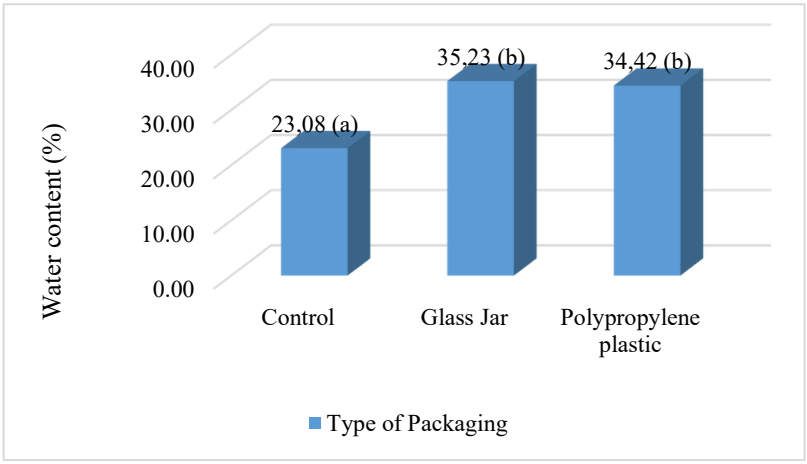

Fig.1. Effect of packaging type on the moisture content of red ginger jelly candy.

3.2 pH

Measuring the degree of acidity of a product involves conducting a test to ascertain its pH level. The level of acidity is also correlated with the safety and duration of storage of the product. The pH value is a crucial determinant of product quality. The acidic nature of red ginger jelly candy goods can be attributed to the use of raw materials such as red ginger, which has inherent acidity, and the inclusion of citric acid. The average pH of red ginger jelly sweets ranged from 3.48 to 4.36, as determined through observation.

The analysis of variance revealed that the type of packaging form had a significant influence (Sig. 0.000) at the 5% level ($P < 0.05$) on the degree of acidity (pH) of red ginger jelly candy. The analysis of variance revealed a notable impact of the packaging type on the acidity level (pH) of red ginger jelly sweets. Figure 2 displays the findings from the analysis of the pH level of red ginger jelly sweets when subjected to various packing methods. The water content of a food product is a crucial factor in assessing its quality and its ability to withstand any damage. Microorganisms utilize the water present in food items to sustain their biological activities during physicochemical processes. Food products with a high water content are susceptible to harm caused by microbial metabolic activity. Lowering the

moisture level in food ingredients is carried out to hinder the proliferation of microbes, hence extending the shelf life of the food ingredients [12].

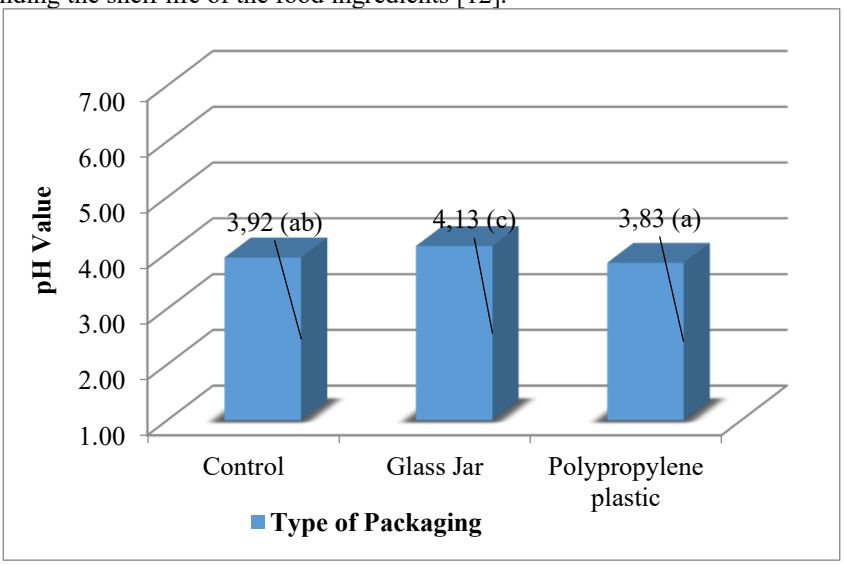

Fig.2. Effect of packaging type on the pH value of red ginger jelly candy.

The pH value of red ginger jelly sweets may be observed in Figure 2, which demonstrates a notable disparity between glass jar packaging and polypropylene (PP) plastic packaging. The average pH value in polypropylene (PP) plastic packaging is 3.83. In contrast, the average pH value of red ginger jelly sweets in glass jar packaging is 4.13, making it the packaging treatment with the highest pH value. The red ginger jelly candy, when not packaged, has a pH value of 3.92. The graph demonstrates that the use of glass jar packaging for storing red ginger jelly candy resulted in the highest average pH value compared to other packaging methods. This pertains to the water content found in red ginger jelly candy, which is higher in glass jar packaging due to the presence of a cavity in the screw cover. This allows air from outside the packaging to enter, causing the organic acids to dissolve in the water. Nevertheless, the red ginger jelly candy's pH value remains acidic as it falls below 7, which is the neutral range. The acidic nature of red ginger jelly candy is attributed to its primary component, red ginger juice, which is rich in organic acids. Furthermore, red ginger contains phenol chemicals that can release protons (H^+) in a solution. As a result, when tested with a pH meter, the higher concentration of H^+ will yield a lower pH value, indicating acidity. Incorporating additional substances such as carrageenan and citric acid leads to an elevation in the overall titratable acid levels, resulting in the product exhibiting a low pH value (acidic) [15].

3.3 Total titratable acid

The measurement of total titratable acid is a criteria used to determine the acid content present in the product. The concentration of titrated acid is directly correlated with the pH value, meaning that as the concentration of titrated acid increases, the pH value decreases, indicating acidity [16]. The addition of red ginger juice will result in an elevation of the overall titratable acid content in jelly candy. The reason for this is that red ginger juice contains organic acids. The addition of other components, such as citric acid, leads to an elevation in the overall titratable acid level. Furthermore, the concentration of total titratable acid in jelly candy will also rise if the amount of water in the ingredients utilized is limited.

The data indicates that the mean total titratable acid content of red ginger jelly candy varied between 0.06% and 0.20%. The analysis of variance revealed significant findings for the treatment of packaging type (Sig. 0.000) at the 5% level (P <0.05) on the total titratable acid of red ginger jelly candy. Figure 3 displays the outcomes of the analysis conducted on the total titratable acid of red ginger jelly candy when subjected to various packaging methods.

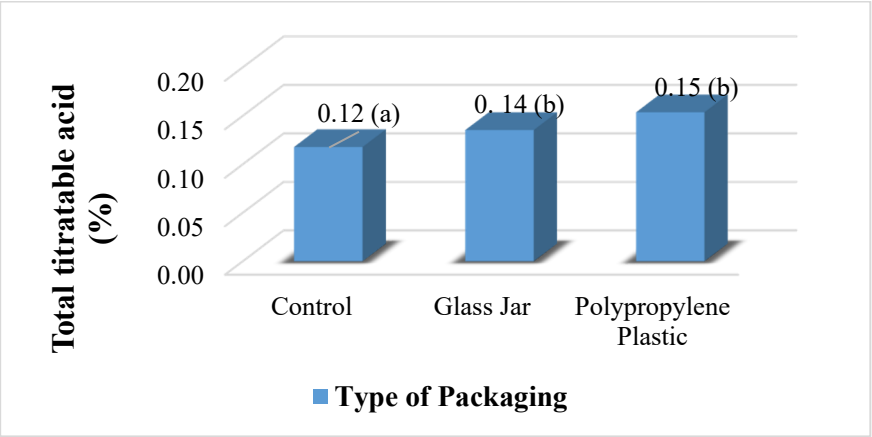

Fig.3. Effect of packaging type on total titratable acid of red ginger jelly candy.

Figure 3 demonstrates that red ginger jelly candy stored in polypropylene (PP) packaging has the highest average total titratable acid value of 0.15%, which is significantly different from the control group of unpackaged red ginger jelly candy with an average total titratable acid value of 0.12%. The product is packaged in glass jars and has an average total titratable acid content of 0.13%. The results indicate that red ginger jelly candy stored in polypropylene packaging have the greatest average total titratable acid content. The variation in the overall titratable acid concentration among various packaging types can be attributed to the differing penetration capabilities of each packing material [17]. The low value of total titratable acid can be attributed to factors such as exposure to high temperatures, packaging that is resistant to high temperatures, and an increase in water content [9]. The glass jar packaging resulted in the maximum water content, which had an impact on the acidity of the red ginger jelly candy being packaged. This is due to the direct relationship between water content and the solubility of ascorbic acid. As the water content increases, a greater amount of ascorbic acid can dissolve in the water. Nevertheless, the red ginger jelly candy remains categorized as acidic. The acidity of red ginger jelly candy is caused by the primary ingredient, red ginger juice, which contains organic acids [15]. Furthermore, the use of citric acid during the production of red ginger jelly candy can impact the overall level of titratable acid. Citric acid serves as an acidity regulator in this process [18].

3.4 Texture

Texture is one of the parameters in determining the characteristics of jelly candy. The texture of jelly candy in general is chewy due to the addition of gelling agents such as carrageenan [19]. The principle of texture testing is that the higher the value obtained, the higher the level of chewiness of the jelly candy texture produced (the harder). A good jelly candy texture is not too brittle and not hard. The texture is produced by using the right concentration of sugar syrup and sucrose. In addition, a good texture is also obtained by adding enough pectin as a hydrocolloid component.

The observation indicates that the red ginger jelly candy's average texture (hardness) ranges from 1.96 to 5.06 kg/f. The analysis of variance revealed significant results (Sig. 0.000) at the 5% level (P <0.05) for the effects of packaging type. Figure 4 displays the outcomes of the analysis conducted on the texture of red ginger jelly candy when subjected to various packaging methods.

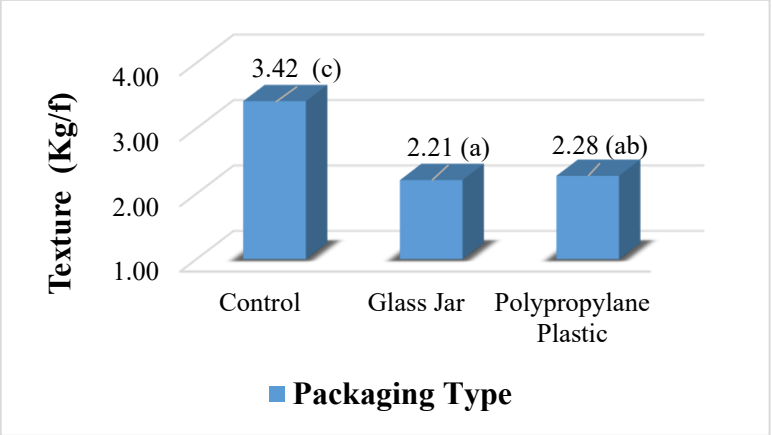

Fig.4. Effect of packaging type on the texture of red ginger jelly candy.

The texture of red ginger jelly candy stored with different types of packaging is depicted in Figure 4. The control group, which did not have any packaging, exhibited the highest level of hardness at 3.42 kg/f. This value was significantly different from the hardness levels observed in the other two packaging types: glass jar packaging (2.21 kg/f) and polypropylene plastic packaging (2.28 kg/f). The variation in the hardness of red ginger jelly candy among the three treatment types is attributed to disparities in the water content present in the manufactured candy. The water content testing results indicate that red ginger jelly candy, when packaged in a glass jar, has a high water content of 35.23%. In comparison, the control sample (without packaging) has a water content of 23.08%. Consequently, the hardness level of the control (unpacked) surpasses that of the glass jar packing and polypropylene packaging. Furthermore, the rise in the hardness level seen in the control group (can be attributed to the loss of weight in the red ginger jelly candy. Weight loss can result from temperature and humidity conditions, as well as metabolic activities that remove water and other organic elements from the product [20].

3.5 Reducing sugar

Reducing sugars are a category of carbohydrates that can decrease the electron-receiving properties of compounds. The determining factor for the reducing capabilities of a dietary item is the presence or absence of reactive free hydroxyl (OH) groups [21]. Reduced sugar functions as a reducing agent due to the presence of an aldehyde group (-CHO) or a free ketone group (-CO-). Furthermore, reducing sugars function as potent reducing agents by transferring electrons to various molecules, causing their oxidation [22]. Reducing sugars encompass various forms, including monosaccharides like glucose, fructose, and galactose, as well as disaccharides such as maltose and lactose [23].

The research findings show that the red ginger jelly candy's average reduction sugar ranges from 17.73 to 25.87%. The analysis of variance revealed that the packaging type had a statistically significant influence (Sig. 0.000) at the 5% level (P <0.05) on the reduction of sugar in red ginger jelly candy. Figure 5 displays the results of the analysis conducted on the reduction of sugar in red ginger jelly candy, comparing different methods of packaging.

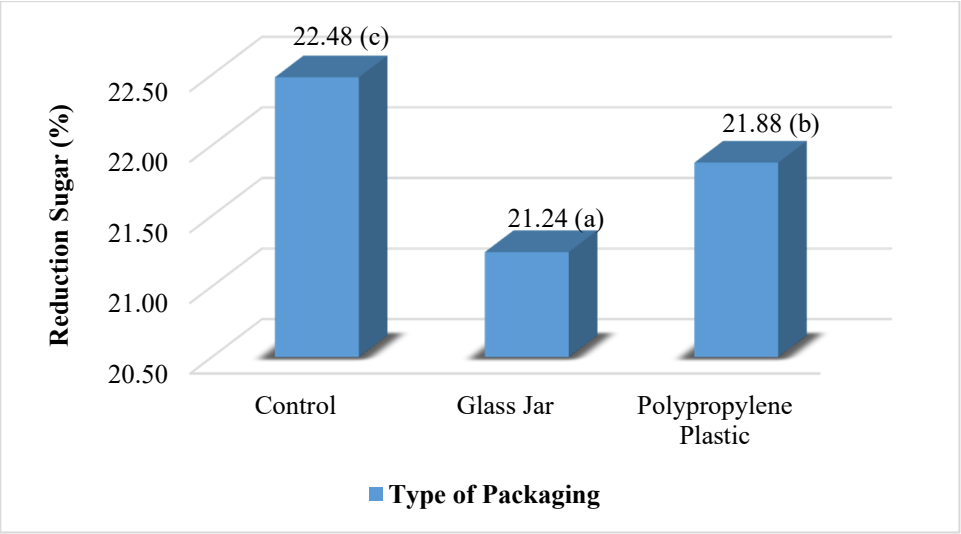

Fig.5. Effect of packaging type on reducing sugar of red ginger jelly candy.

Figure 5 illustrates the impact of different types of packaging on the reducing sugar content of red ginger jelly candy. The control group, which had no packaging, had the highest reducing in sugar content at 22.48%. This value was significantly different from the average reducing sugar content of 21.24% for the glass jar packaging and 21.88% for the polypropylene plastic packaging. These results indicate that the red ginger jelly candy created has a reducing sugar level that complies with the standards set by SNI 3547:2:2008 for soft candy. According to the standard, the maximum allowed reducing sugar content is 25%. Winarno [24] states that the high-reducing sugar is a result of the decomposition of sucrose into glucose and fructose produced by acid. Under acidic circumstances, sucrose can undergo hydrolysis to become inverted sugar [25].

3.6 Antioxidant activity

Antioxidants are substances that can attach to and neutralize free radicals and highly reactive molecules, hence preventing oxidation reactions [26]. Antioxidant compounds have two primary functions. The first function is to supply hydrogen atoms to radicals. The second function is to reduce the rate of autooxidation by converting radical molecules into a more stable form, using mechanisms that are different from breaking the autooxidation chain [27]. The antioxidant activity is affected by various elements, including temperature, oxygen, the concentration of antioxidants, the lipid content, and the components of food such as water and protein [28]. Antioxidants are naturally occurring substances found in food that help prevent damage to lipids or oils caused by oxidation processes. Antioxidants function as agents that mitigate the impact of processes within the body by diminishing the presence of free radicals and inhibiting the generation of radicals. Antioxidants are categorized into three groups based on their method of action: primary antioxidants (enzymatic antioxidants), secondary antioxidants (exogenous or non-enzymatic antioxidants), and tertiary antioxidants [29].

The average antioxidant activity of red ginger jelly candy was found to range from 24.17 to 46.01%. The analysis of variance revealed that the packaging type had a significant impact (Sig. 0.000) on the antioxidant activity of red ginger jelly candy at a 5% significance leve

l (P <0.05). Figure 6 displays the findings of the antioxidant activity investigation of red ginger jelly candy when treated with various forms of packaging.

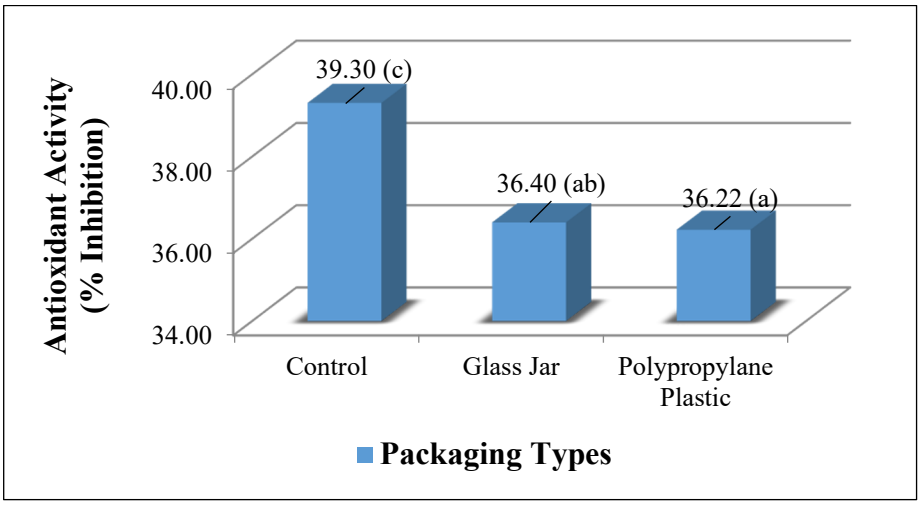

Fig.6. Effect of packaging type on antioxidant activity of red ginger jelly candy.

The antioxidant activity of red ginger jelly candy was assessed using different types of packaging. Figure 6 illustrates the results, showing that the control group (without packaging) had the highest antioxidant activity at a concentration of 25,000 ppm, with a value of 39.30%. This value was significantly higher than the average antioxidant activity of 36.40% observed in the glass jar packaging group and the average antioxidant activity of 36.22% observed in the polypropylene plastic packaging group. According to the acquired data, it is evident that the red ginger jelly sweet has a low antioxidant activity. Antioxidant activity as high if it can suppress the production of free radicals by more than 80%, moderate if it can inhibit 50-80%, and weak if it can inhibit less than 50% [30]. The diminished antioxidant capacity of red ginger jelly sweets may be attributed to the inclusion of additives such as sugar and carrageenan. The presence of components like sugar and gelling agents in the product is responsible for its inadequate antioxidant action [31]. Furthermore, an increase in the amount of sugar supplied leads to a decrease in antioxidant activity. This is because the sugar contains methylation groups and reduced hydrogen atoms, which act as hydrogen donors to free radicals and hence limit the antioxidant activity. The glass and polypropylene plastic packaging exhibited minimal antioxidant activity in this investigation. This may be attributed to the infiltration of moisture and oxygen into the packing, leading to storage-related issues. Glass packaging exhibits a low permeability, enabling it to effectively resist the ingress of moisture and oxygen from the external environment [32]. Nevertheless, in this investigation, the absence of a screw cap on the glass jar packaging allowed air from the external environment to enter the packing through the opening, resulting in the evaporation of antioxidant activity. Furthermore, the glass jar and polypropylene plastic container has a transparent hue, facilitating the unhindered transmission of light into the product, hence causing the degradation of the antioxidant activity content. This aligns with the findings of Pelealu et al. [33]that the decline in antioxidant activity can be attributed to the impact of light, specifically its wavelength, which has the ability to enhance molecular electronics. As a result, the bioactive compounds present in the product absorb significant amounts of energy, leading to the degradation of the antioxidant components.

4 Conclusion

In this investigation, it was shown that the most suitable packaging for preserving the quality of red ginger jelly candy is made of polypropylene (PP) plastic. The packaging had a moisture content of 34.42%, a texture of 2.28 Kg/f, and a reducing sugar content of 21.88%. Then proceeded with the use of glass jar paskaging.

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