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ANALISIS UMUR SIMPAN *SALAD DRESSING* BERBASIS *MAYONNAISE* MENGGUNAKAN KEMASAN POLYETHYLENE TEREPHTHALATE (PET)

The analysis of mayonnaise-based salad dressing shelf life using polyethylene terephthalate (PET) packaging

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Abstrak
Indonesia menjadi produsen minyak sawit terbesar dunia. Minyak kelapa sawit dan minyak nabati lainnya memiliki kandungan omega-3 yang tinggi, yang sudah dikenal sebagai prekursor sistem kognitif dan dapat menghambat pertumbuhan stunting. Salad dressing merupakan salah satu produk makanan yang menggunakan minyak nabati. Pengaruh oksidasi dalam berbagai jenis dan formulasi minyak ditentukan dengan nilai bilangan peroksida (PV). PV diperoleh dengan metode titrasi dan pengamatan stabilitas secara visual. Sebanyak 5 jenis minyak digunakan dalam formulasi produk ini, yaitu minyak kedelai, bunga matahari, kanola, kelapa, dan virgin coconut oil. Produk dibuat dengan menggunakan susu kedelai dan xanthan gum sebagai pengemulsi dan penstabil. Kemasan PET digunakan dan diamati selama 56 hari pengamatan untuk setiap 7 hari. Data dihitung menggunakan metode ASLT dengan pendekatan Arrhenius. Hasil penelitian menunjukkan semakin banyak xanthan gum yang ditambahkan akan membuat sampel memiliki stabilitas emulsi yang baik. Salad dressing dalam penelitian ini memiliki umur simpan paling lama yaitu 132 hari (minyak canola, suhu 25°C). Umur simpan terpendek adalah 46 hari (minyak kedelai, suhu 45°C).

Kata Kunci: ASLT, Minyak Nabati, Oksidasi, *Salad Dressing*

Abstract
Indonesia is one of the countries that have a high percentage of stunting and malnutrition among children. Therefore, Indonesia became the world's largest palm oil producer. Palm oil and other vegetable oils have high amounts of omega-3, which is already known as the precursor of the cognitive system and can inhibit stunting growth. Salad dressing is one of the food products which uses vegetable oil. The effect of oxidation in various oil and formulations were determined. PV was obtained by titration method and visual observation of stability. About 5 types of oils were used in this product formulation, i.e soybean, sunflower, canola, coconut, and virgin coconut oil. Products were made using soybean milk and xanthan gum as emulsifiers and stabilizers. PET packaging was observed within 56 days of observation for every 7th day. The data was then calculated using ASLT method with the Arrhenius approach. The results showed that more xanthan gum added will make the sample have a good emulsion stability. Salad dressing had the longest shelf life of 132 days (using canola oil at 25°C). The shortest shelf life of salad dressing is 46 days (using soybean oil at 45°C).

Keywords: ASLT, Oxidation, Salad Dressing, Vegetable Oil

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INTRODUCTION

Worldwide food patterns have altered as a result of globalization and lifestyle changes. Most individuals start to concern about healthy lifestyles because of having access to limitless information via unrestricted internet connections. However, according to data from the Indonesian Research Report Ministry of Health 2018, it was discovered that 10.2% of children are undernourished, 17.7% of children suffer from malnutrition, and one-third of children have stunted growth. According to the minimum acceptable value set by the World Health Organization (WHO) for child nutrition, Indonesia

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has a high proportion of children who are stunting and malnutrition. Children being stunted is a problem for public health worldwide. Morbidity and death rates may rise as a result of this disorder (Jutomo et al., 2020). Children's malnutrition and poverty can both contribute to stunting.

The USDA Foreign Agricultural Service reports that Indonesia now produces the most palm oil globally. Between 1980 and 2016, oil palm plantations in Indonesia expended. Meanwhile, the total production of Crude Palm Oil (CPO) increased from 700.000 tons in 1980 to 33.5 million tons in 2016. The rapid growth of CPO in Indonesian production has changed the country's position in the world's palm oil market, which can replace Malaysia's position in 2016 and share reach 54% in the world CPO production. According to information from the Indonesian Central Statistics Agency (BPS), the average annual use of palm cooking oil in 2018 was 8.72 kg/cap/year. CPO production in Indonesia reach up to 44.8 million ton in 2020 (Rokhman et al., 2020). Palm oil is an edible vegetable oil high in saturated fats and free of trans fats. Palm oil (PO) or Crude Palm Oil (CPO) is obtained from the flesh of the fruit and Palm Kernel Oil (PKO) is produced by extracting the oil from the internal seed (Kernel).

In recent years, the consumption of vegetable oils has been growing rapidly due to the important constituent and essential components of the human diet. Vegetable oils were extracted from seeds or oleaginous fruit. The most consumed edible vegetable oils are palm, sunflower, soybean, rapeseed, canola, corn, and grapeseed oil (Martín-Torres et al., 2022). Vegetable oils contain vitamin E, vitamin K, calcium, iron, phosphorous, potassium and other minerals, and also fatty acids are the important raw materials of salad dressing (Yin et al., 2022).

The most abundant Fatty Acid in vegetable oils is Polyunsaturated Fatty Acid (PUFA). α-linolenic (ALA, 18:3, n-3) and linoleic acid (LA, 18:2, n-6) are a fundamental PUFAs that have been considered as functional food and nutraceuticals for reducing the risk of serious diseases (Orsavova et al., 2015). The high unsaturated fatty acids contained in the oil will increase lipid oxidation during storage (El-Waseif et al., 2022).

Jutomo *et al* (2020) conducted research on children under five with stunting and gave the result that omega-3 fatty acids can significantly increase the height of children under five with stunting. Omega-3 fatty acids at an early age can accelerate bone growth and improve bone quality. Other studies also mention the relationship between stunting and low serum omega-3 fatty acids through metabolomics studies (Semba et al., 2017). Supplementation of omega-3 fatty acids in stunting children can significantly reduce exposure to the frequency of illness (Jutomo et al., 2020). This condition showed that omega-3 plays an important role in children's growth and health. Omega-3 also supports the cognitive system of children.

Based on the data from USDA, about 20% of individuals in the U.S. consumed one or more salads in a day (Sebastian et al., 2018). The highest percentage is people above 40 years old at 26%. Salad is a fresh cut of vegetables or fruits with selected mayonnaise-based salad dressing. Mayonnaise and salad dressing are fast becoming popular condiments and are identified as the source of many essential vitamins and high antioxidants (Bandy et al., 2019).

The commercial salad dressings consist of fresh egg yolk, which is used as emulsifier. At room temperature, salad dressing has 6 to 12 months of shelf life (Ayu et al., 2020). The high fat and low pH of salad dressing support the inhibition of microorganisms and can be saved at room temperature (Mirzanajafi-Zanjani et al., 2019).

One of the important parameters in salad dressing products is shelf life due to the susceptible of lipids to oxidize. The oxidation process can be affected by the interaction between ingredients and the place of oxidation occured (Gorji et al., 2016). Peroxide Value (PV) can be used to measure the oxidation of the product.

Emulsion-type of salad dressing will have a shelf life of the ranges from 6 to 12 months at room temperature and can be increased by inhibiting the oxidation process (Aksoy et al., 2022). Oxidation can be caused by the composition of salad dressing, temperature, and packaging of the product. The impact of external factors such as hydrolytic, microbiological, and oxidative processes may depend on the type of packaging (Alekseenko et al., 2022). One of the plastic polymer packaging is Polyethylene Terephthalate (PET) which is a group of polyesters. PET has good properties, such as recyclable and unbreakable, so it lead to the broad distribution as food and beverages packaging. This research aims to analyze the

stability and oxidative of various vegetable oils based on salad dressing composition.

This research was conducted to determine the shelf life of salad dressing products using Accelerated Shelf-Life Testing (ASLT) with the Arrhenius approach. PV data was collected every week of observation. The stability of the product will also be tested using visual observation. Variation in the use of oil in this study was compared to determine the most stable product (soybean, sunflower, canola, coconut, and virgin coconut oil) using Polyethylene Terephthalate (PET) packaging.

In order to establish the shelf life of those items as functional products, this research aims to understand the stability and oxidation process of various oils based on salad dressing composition.

MATERIALS AND METHODS

Materials

This research used various vegetable oils such as soybean, sunflower, canola, coconut, and virgin coconut oil (commercial product, Indonesia). All formulations consist of soy milk, xanthan gum, water, vinegar, salt, and sugar. The shelf-life product was then determined using the titration method by $Na_2S_2O_3$ solution (Merck, Germany).

Sample Preparation

About five different salad dressings were prepared using vegetable oil, soy milk, xanthan gum, water, vinegar, salt, and sugar. Materials were mixed until smooth. There were 5 formulations (A, B, C, D, E) with different oil compositions, i.e soybean, sunflower, canola, coconut, and virgin coconut oil (Table 1). All samples were titrated by $Na_2S_2O_3$ for peroxide value analysis.

Pasteurization

Each salad dressing formulation was packaged into 27 PET packaging (Semarang, Indonesia) that will later be stored in 3 different temperatures for peroxide value and emulsion stability analysis. Pasteurization was done using a water bath at 65°C for 30 minutes. The samples were pasteurized, allowed to cool in the open air, and then stored at three different temperatures. For 9 weeks of analysis, each sample was kept in a room with temperature of 25, 35, and 45° C.

Table 1. Salad dressing formulation

Materials	composition (%)				
	A	B	C	D	E
Soybean oil	44	-	-	-	-
Sunflower oil	-	44	-	-	-
Canola oil	-	-	44	-	-
Coconut oil	-	-	-	44	-
Virgin coconut oil	-	-	-	-	44
Xanthan gum	0.7	0.7	0.7	0.9	0.9
Sugar	7	7	7	7	7
Water	36	36	36	36	36
Vinegar	0.5	0.5	0.5	0.5	0.5
Soy milk	10	10	10	10	10

Emulsion Stability Analysis

About 5 ml of samples were taken from the storage and put into a centrifugation tube (Hettich, Germany). The sample was centrifuged for 25 minutes at 3500 rpm. The separated sample is then taken using a pipette and then measured by measuring cylinder. The percentage of emulsion stability was calculated using tormulation:

$$\frac{(v0 - v1)}{v0}\ x\ 100\%$$

v_0 = the volume of sample (ml)
v_1 = the separated volume (ml)

Peroxide Value Analysis

The lipid from each sample was extracted by mixing 2g of the sample with 30 ml of acetic acid: chloroform (3:2) (Merck, Germany) mixed for 1 minute. The mixture was then filtered using a paper filter into an Erlenmeyer flask. The sample in the Erlenmeyer flask is then mixed with 1 ml saturated KI solution prepared by mixing pure KI into 50 ml boiled aquadest until the color becomes stable. After that, the sample is mixed with 30 ml aquadest and shaken for 1 minute. The sample was then colorized with 0.5ml 1% starch solution and then titrated by 0.01 N $Na_2S_2O_3$ until the solution became clear. The peroxide value was calculated using this equation:

$$\frac{S\ x\ M\ x\ 1000}{g\ sampel}$$

S = ml $Na_2S_2O_3$ used for titration
M = $Na_2S_2O_3$ molarity

Shelf-Life Analysis

The emulsion stability and peroxide value analysis were conducted every 7 days for 56

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days with 3 replications. The data was analyzed using the Accelerated Shelf-Life Testing principle based on the Arrhenius equation. When a product is stored at a temperature higher than normal condition, the Arrhenius model predicts acceleration of product spoilage (Hayati et al., 2022)

RESULTS AND DISCUSSION

Oil, egg yolk, acidulants, and starch are the typical composition of salad dressings. About 50% of calories from fat can be found in salad dressing products. A healthier product is needed to replace the composition of salad dressing without decreasing the quality of products. This research was conducted using variety of oils and supported with xanthan gum as an emulsifier to replaced egg yolk. Variety of oils responsible for the unique properties that can significantly affecting the composition and properties of a salad dressing (Hayashi, 2023).

Emulsifier is needed by salad dressings formulations to be stable (Abedinzadeh et al., 2016). This stability of the product plays an important role in enhancing the quality of salad dressing. The shelf life of salad dressings depends on temperature, storage conditions, and the type of oil. Acid conditions are generally applied to avoid spoiling. In acid pH, the bacterial growth will be stopped. This led to the stable condition to keep product have longer shelf life. This product contained 0.5% of vinegar.

Effect of Storage Temperature on The Stability of Salad Dressing

Salad dressings were stored at different temperatures of 25, 35, and 45°C. All formulations have high stability at room temperature (25°C). However, the stability percentage decreased with the prolongation of storage time, and generally decrease in 42 days after storage (Figure 1). At the same optimal condition (25°C) and longest storage (56 days). The A formulation still had a higher stability (98%) compared to the other formulations. And the lowest value was E formulation (82%). The result could be due to the A formulation had 0.7% of xanthan gum while E had 0.9%. Xanthan gum has a specific character to bind water molecules. The more xanthan gum is added, the more water will bind. In low concentrations, xanthan gum can increase the viscosity of the water phase. The D and E formulations have high xanthan gum composition (0.9%), this made the D and E products stable at the beginning of storage.

The high temperature caused more oil droplet movement, increased flocculation, and faster breakdown of protein content (Rahmati et al., 2018). Emulsion became unstable due to the heating process. This condition can be found in all formulations of salad dressing (Figure 1).

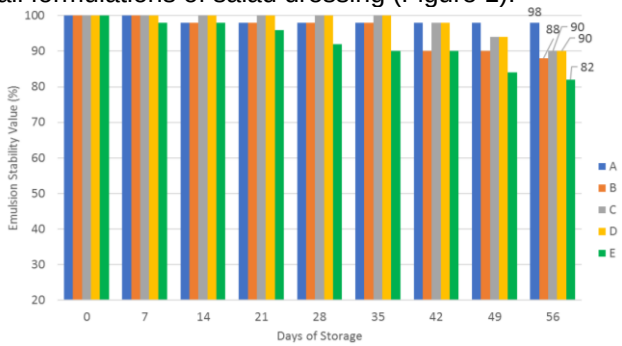
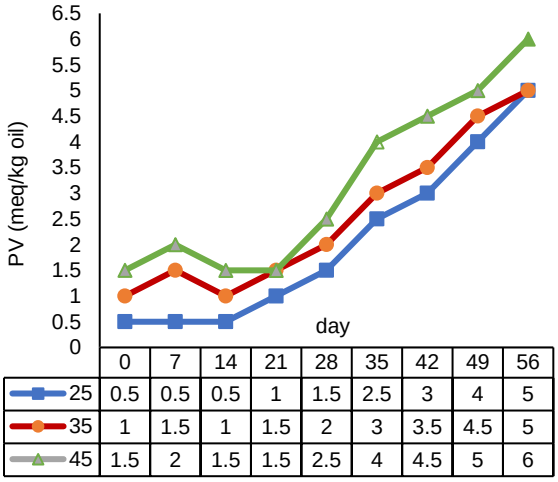


Figure 1. Salad dressing stability in 25°C of storage



	0	7	14	21	28	35	42	49	56
25	0.5	0.5	0.5	1	1.5	2.5	3	4	5
35	1	1.5	1	1.5	2	3	3.5	4.5	5
45	1.5	2	1.5	1.5	2.5	4	4.5	5	6

Figure 2. Stability of A formulation in various temperatures

The Effect of The Type of Oil on The Oxidation of Salad Dressing Products

One of the measurements for salad dressing product quality is Peroxide Value (PV). PV is used to determine the rancidity of salad dressing, which has a fatty acid component dominantly from oil material. As presented in Figure 3, after 56 days of storage, all of the formulations had an increase in PV. According to Dastgerdi (2019), the PV of mayonnaise exceeding 5 meq/kg oil is not acceptable because it shows that

mayonnaise has been damaged (Ahmadi-Dastgerdi, 2019). All products had below 5 meq/mg oil of PV. After 56 days of storage, the higher values of PV were found in the A (soybean) and B (sunflower) formulations. Soybean and sunflower oil had a higher Poly Unsaturated Fatty Acid (PUFA) than others. Soybean contains 57.5 %, while sunflower oil has 59.5% of PUFA. Fatty Acid in the form of an unsaturated structure will easily become an oxidized product due to the unstable character of its structure (Ghorbani Gorji et al., 2016).

Lipid oxidation in oil-in-water emulsion is taking place at the surface of the oil droplets, due to the interaction between lipid hydroperoxides (first product of oxidation) that is commonly cause the oxidative instability (Paraskevopoulou et al., 2007)

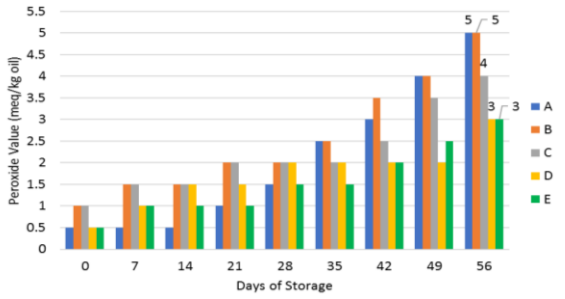


Figure 3. Peroxide value of salad dressing at optimum temperature storage (25^{o}C)

Shelf Life of Salad Dressing Products

Salad dressing packaging contributes to the shelf life of product. This research was conducted using Polyethylene Terephthalate (PET) packaging material which has a high gas barrier property but limited capability to the water vapor transmission. It is caused by the poor ability of PET to hold water vapor. Determination of the shelf life of salad dressings is carried out using the Accelerated Shelf-Life method Testing (ASLT) with a semi-empirical approach using the Arrhenius equation. The Arrhenius equation is used to predict the speed of damage when stored at extreme temperatures. In this study, chemical reactions were observed to determine the shelf life of salad dressings is fat oxidation which is measured by calculating the PV value. The result at 25^{o} C condition showed that the A formulation had the shortest shelf life than others, followed by the B formulation (Table 2). The longest shelf life was D formulation. This result is analogous to the PV value.

Table 2. Shelf life of salad dressing formulation product

Temperature (^{o}C)	shelf life (day)				
	A	B	C	D	E
25	50	59	83	132	109
35	47	51	67	90	90
45	46	45	62	71	66

CONCLUSION

Mayonnaise-based salad dressing using PET packaging has a long shelf life. The A formulation has highest stability and low PV at room temperature (25^{o}C). Meanwhile, the E formulation has the longest (109 days) shelf life when kept in a room temperature.

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