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Characteristics of Soy-Based Kefir with the Addition of Ajwa Date Juice

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ABSTRACT

Soybeans and their derivatives, such as soy milk, have attracted researchers' attention due to their nutritional value—particularly the presence of bioactive compounds and associated health benefits—and their potential for use in fermented non-dairy products like kefir. However, soybean kefir often has lower sensory acceptability, particularly in taste, which can be improved by adding ajwa date juice. This study evaluated the effects of different concentrations of ajwa date juice (30%, 35%, 40%, 45%, and 50%) on the physical, chemical, microbiological, antioxidant, and sensory characteristics of soybean kefir. A completely randomized design with five treatments and three replications was applied, followed by Duncan's Multiple Range Test when significant differences were observed. The addition of ajwa date juice significantly affected ($\alpha = 0.05$) physical properties, pH, total titratable acidity, protein content, microbiological quality, hedonic attributes (texture, aroma, and taste), and sensory scores. The 45% ajwa date juice treatment produced the best overall quality by improving the characteristic sour taste of soybean kefir, with results comparable to the 50% treatment. The selected kefir exhibited an antioxidant activity (IC_{50}) of 7,917.29 ppm and a total flavonoid content of 0.3138 mg QE/g, indicating the presence of bioactive compounds despite relatively weak antioxidant activity.

1. INTRODUCTION

Soybean (*Glycine max*) is a legume with excellent nutritional value, characterized by high protein content (40%, with good digestibility), 20% fat, 34% carbohydrates (primarily oligosaccharides with prebiotic potential, such as raffinose and stachyose), and 5% minerals (Kim, 2021). Soybeans and their derivatives, such as soy milk, have attracted researchers' attention due to their nutritional value, particularly regarding the presence of bioactive compounds and their associated health benefits (Kim, 2021). Soy intake has been linked to various health outcomes; for instance, the low incidence of cardiovascular disease and cancer observed in Asian populations aligns with their levels of soy consumption (Egea *et al.,* 2021). Soy extract also holds potential for use in producing fermented, non-animal-based dairy alternatives, such as kefir. The choice of soy extract as a raw material for kefir production is also attributed to its relatively comprehensive nutritional profile, which includes fat, carbohydrates, calcium, phosphorus, iron, vitamins A, B1, and B2, and isoflavones. Isoflavones possess properties that help prevent cancer and coronary heart disease (Anggraini & Suryani, 2019).

Kefir is produced from milk by adding kefir grains which serve as a starter culture composed of various lactic acid bacteria (LAB) and yeasts followed by a fermentation of approximately 24 h at room temperature. Kefir grains can grow in sugar solutions and fruit juices (Tzavaras *et al.,* 2022). The kefir starter grains consist of *Lactobacillus kefiri* and species from the genera *Leuconostoc*, *Lactococcus*, and *Acetobacter* growing in association. The grains also contain lactose-fermenting yeasts, such as *Kluyveromyces marxianus*, and non-lactose-fermenting yeasts, such as *Saccharomyces exiguus* (CODEX, 2003). Kefir grains can grow on substrates such as sucrose, honey, fruit and

vegetable juices, and water-soluble plant extracts, acting as a starter culture (Fiorda *et al.,* 2017). The composition of kefir includes protein (3.50%), moisture (89.50%), fat (1.50%), lactose (4.50%), ash (0.60%), alcohol (0.50–2.50%), and lactic acid (0.80–1.10%), along with carbon dioxide, acetaldehyde, and diacetyl, resulting in a pH of 4.60. Lactic acid and alcohol levels are influenced by the lactose content of the raw material, the fermentation duration, and the type of starter used (Susilo *et al.,* 2023). Kefir offers numerous health benefits. The microorganisms present in kefir produce vitamins, minerals, and essential amino acids that aid in homeostasis, hydrolyze lactose, and degrade proteins, resulting in a highly nutritious and easily digestible food product. Kefir offers benefits such as antioxidant, antibacterial, anti-hypercholesterolemic, anti-carcinogenic, and anti-tumor properties, as well as galactosidase activity (Pertiwi *et al.,* 2023). However, kefir production has predominantly relied on cow's milk. This has driven demand for non-animal milk alternatives an area that has not yet been extensively explored. Soy milk is a suitable raw material for kefir production, as it has low natural sugar content and is lactose-free.

Dates (*Phoenix dactylifera* L.) have emerged as a potential ingredient for producing probiotic beverages such as kefir, as their sweetness can balance the inherent acidity of kefir. The Ajwa date is one variety that possesses these characteristics; it contains 77% sugar (0.5% sucrose, 34.5% glucose, and 25.6% fructose) and 3% minerals. Ajwa dates have the highest mineral content compared to other date varieties, which typically contain only 1.5–2.7% minerals (Khalid *et al.,* 2017). The sugar and fiber content in dates can act as prebiotics natural compounds that serve as a food or energy source for the growth of bacteria or probiotics during kefir production. The fermentation process plays a crucial role in the ability of lactic acid bacteria to metabolize the lactose present in milk. Consequently, the energy derived from the dates is expected to stimulate the growth of lactic acid bacteria, leading to a decrease in pH and an optimal yeast count in the kefir product (Nabila *et al.,* 2023). This aligns with findings by (Nabila *et al.,* 2023), which indicate that the addition of 30% Ajwa date extract influences the pH, total lactic acid bacteria count, and total yeast count in kefir products. Based on the aforementioned studies, it can be concluded that the addition of Ajwa date extract to fermented products can influence their quality characteristics. However, those studies were limited to the use of animal-based milk as the raw material. The proposed study hypothesizes that adding Ajwa date extract can improve the quality of soy milk kefir as an alternative non-animal dairy product.

This research aims to increase knowledge about the potential of soybean extract for processing into a fermented milk product, as well as to determine the quality characteristics of soy-based kefir with the addition of Ajwa date juice. This research will also help to enhance the utility of soy kefir, which can have health benefits and be beneficial for those with lactose intolerance.

2. MATERIALS AND METHODS

2.1. Time and Location of Study

The research was conducted at the Food Processing, Chemistry, and Microbiology Laboratory of Sahid University and the Biotechnology Laboratory of the Faculty of Agricultural Technology, Bogor Agricultural Institute. The study period was from July 2025 to January 2026.

2.2. Tools and Materials

The tools included soy makers (Soseki), blender (Miyako), filter cloth, pan, stove (Hitachi), covered container, plastic spoon, UV-Vis Spectrophotometer (Cecil 1000 series), Soxhlet apparatus, Reflux, centrifuge, viscometer (Brookfield), pH meter (Jenway), refractometer (Atago), vortex (Thermolyne), colony counter, laminar air flow, fume hood, incubator (WTC Binder), heating mantle, analytical balance (Osuka), Kjeldahl flask, fat flask, burette (Duran), chemical glassware (Pyrex), volume pipette (Iwaki), micro pipette, dropper pipette, petri dish, test tube, and bunsen.

The materials included Anjasmoro variety soybeans, ajwa dates, water, kefir grains, 0.1 N NaOH (Smartlab), HgO, K_2SO_4, concentrated H_2SO_4, H_3BO_3, NaOH-$Na_2S_2O_3$, 0.02 N HCl, n-hexane, physiological NaCl (Merck), DPPH (Sigma), $AlCl_3$ (SAP Chemicals), 5% CH_3COOH (Smartlab), ethanol (Merck), pH 4 and 7 buffers (Smartlab), PP indicator (Merck), quercetin (Sigma), MRSA media (Man Rogosa Sharpe Agar) (Himedia), PDA media (Potato Dextrose Agar) (Himedia), cartridges, filter paper, and distilled water.

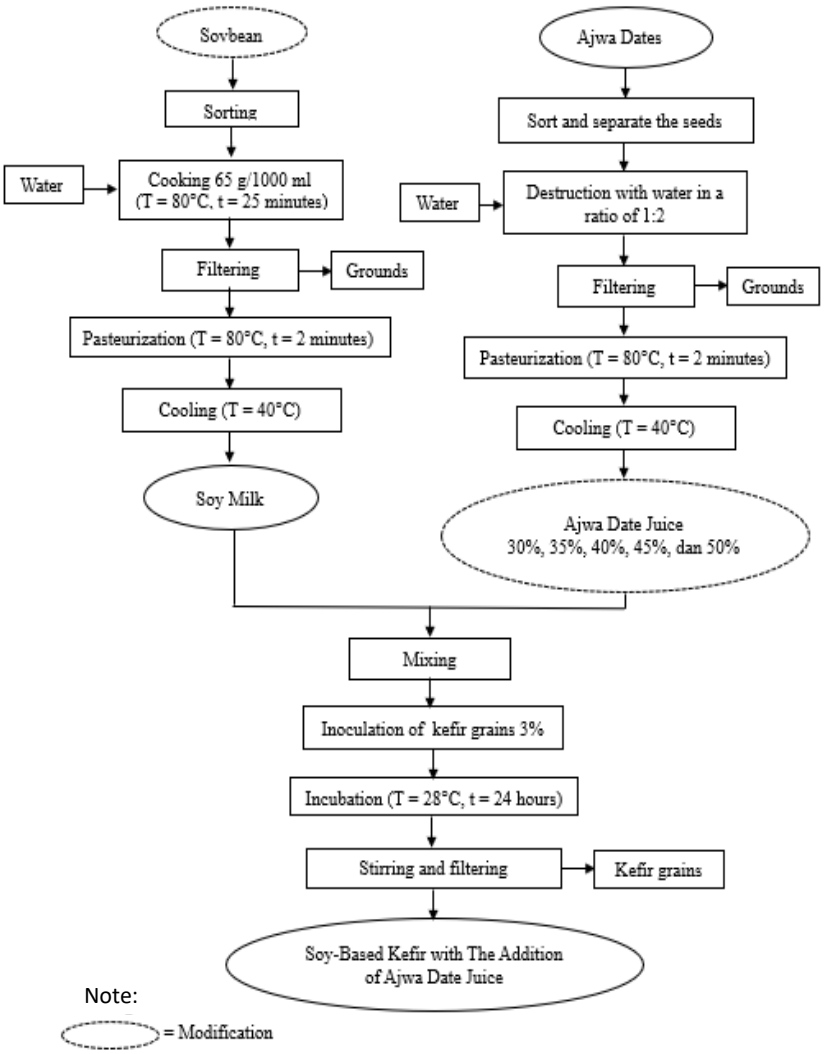

Figure 1. Diagram of the process of soy-based kefir with the addition of ajwa date juice

2.3. Procedure and Testing

Figure 1 summarized process of soy-based kefir with the addition of ajwa date juice modified from (Hapsari, 2022). The kefir product was tested for physical, chemical, microbiological and organoleptic. Physical testing included total dissolved solids (TDS) (SNI 3719:2014) and viscosity (Brookfield Engineering Laboratories, 2021). Chemical testing included pH (AOAC, 2005), total titratable acid (SNI 7552:2009), protein (AOAC, 2005), and fat (AOAC, 2005). Microbiological test included total lactic acid bacteria and total yeast (FDA, 2001). Organoleptic test was carried out by 30 non-standard panelists performing hedonic and quality score evaluation for texture, color, aroma, and taste based on SNI ISO 11056:2021 (BSN, 2022). Antioxidant activity (IC_{50}) test (AOAC, 2012) and total flavonoids (Ipandi *et al*., 2016) were conducted to support entire evaluation. Data were processed using SPSS software to analyze one way ANOVA (analysis of variance) followed by the Duncan Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

3.1. Physical properties: Total Dissolved Solids

The total dissolved solids (TDS) is tested to determine the sugar content of the material. This aligns with (Ismawati *et al.,* 2016), who found that the combined content of total sugars, lactic acid, and organic acids is measured as TDS. The

dissolved solids fraction comprises total sugars, pigments, organic acids, and proteins. Testing total dissolved solids uses a refractometer whose units are expressed in the form of °Brix. A graph of the average total dissolved solids test value can be seen in Figure 2a. The average total dissolved solids value ranged from 8.00 – 9.13°Brix with the lowest value in the treatment of adding ajwa date juice at a concentration of 30%, namely 8.00°Brix and the highest value in the treatment of adding ajwa date juice at a concentration of 50%, namely 9.13°Brix. Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the total dissolved solids of soy kefir (α = 0.05), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT test showed that A5 (50%) showed the highest total dissolved solids value which was not significantly different from A4 (45%), but significantly different from A1 (30%), A2 (35%), and A3 (40%). Treatments A1 (30%), A2 (35%), and A3 (40%) showed no significant difference from each other in terms of the total dissolved solids.

The results of the study showed that the total dissolved solids concentration of 50% was the highest among the other concentrations. This is in line with research (Wiyono *et al.,* 2022), which states that the high sugar content of fruits added as ingredients contributes to a higher level of total soluble solids. This difference in total soluble solids indicates that the addition of dates influences the resulting total soluble solids content. Total soluble solids are influenced by Lactic Acid Bacteria (LAB); a higher number of LAB colonies leads to an increase in total soluble solids. This is attributed to sucrose metabolism and the dependence of microbial growth on sugar catabolism (Destro *et al.,* 2019). LAB fermentation produces metabolites such as lactic acid and other organic acids. Total acids and residual total sugars contribute to the total soluble solids content. Since LAB are composed of cell walls (polysaccharides) and cell membranes (proteins and lipids), a higher number of LAB colonies in the fermentation medium results in a greater amount of total solids (Ismawati *et al.,* 2016).

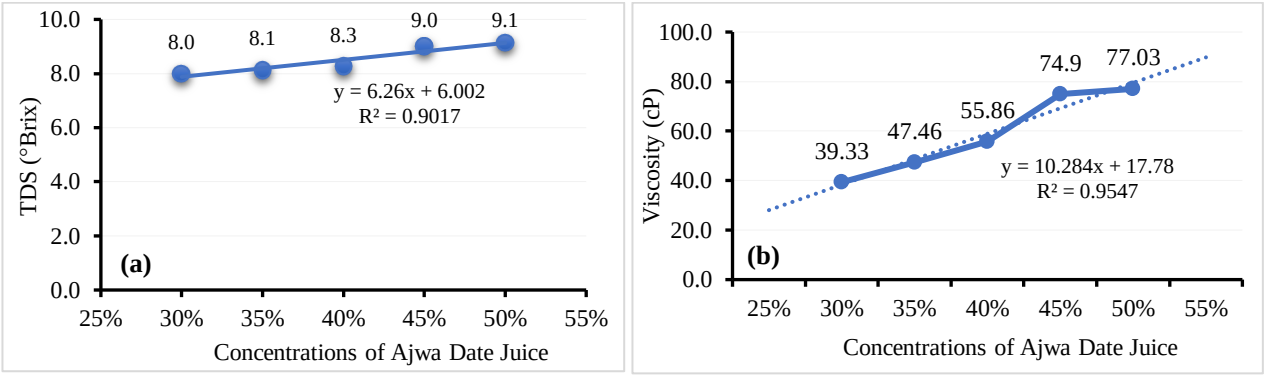

Figure 2. Effect of ajwa date juice concentrations on: (a) Total dissolved solids (TDS), and (b) viscosity of soy kefir

3.2. Physical properties: Viscosity

Viscosity refers to the thickness or consistency of a food product and is typically used to determine its physical quality. Viscosity testing is conducted using a Brookfield viscometer, with measurements expressed in centipoise (cP). High viscosity can be attributed to a high total milk solids content (Prajapati *et al.,* 2016). A graph of the average viscosity test values can be seen in Figure 2b. The average total viscosity value ranged from 39.33 – 77.03 cP with the lowest value in the treatment of adding ajwa date juice at a concentration of 30%, namely 39.33 cP and the highest value in the treatment of adding ajwa date juice at a concentration of 50%, namely 77.03 cP. Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the viscosity of soy kefir (α = 0.05), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT test showed that A5 (50%) showed the highest viscosity value which was not significantly different from A4 (45%), but significantly different from A1 (30%), A2 (35%), and A3 (40%). Treatments A1 (30%), A2 (35%), and A3 (40%) showed significant differences from each other in terms of viscosity.

The results of the study showed that the viscosity concentration of 50% was the highest among the other concentrations. This aligns with research by (Kumalasari & Indri, 2024), which states that the increase in viscosity is

attributable to the addition of sugar. Sugar reduces the amount of free water by binding to it, thereby increasing the mixture's thickness. During fermentation, lactic acid bacteria (LAB) transform the kefir's texture from a liquid state to a thicker consistency through coagulation. Milk coagulation occurs due to the denaturation of proteins and milk fats driven by the activity of kefir grains, resulting in a thicker texture (Rahayu *et al.,* 2020). Higher kefir viscosity generally indicates superior quality, as it reflects a higher total solids content. Increased viscosity can also result from a high population of lactic acid bacteria acting optimally within the product; this activity promotes the formation of coagulants, thereby raising the viscosity (Silalahi *et al.,* 2028).

3.3. Chemical Properties: pH

The degree of acidity (pH) is a number that indicates the acidity or alkalinity of a solution, with a value between 1 to 14. Direct pH measurements are made using a pH meter. The formation of lactic acid causes a decrease in pH and results in a sour kefir taste. In addition to the breakdown of lactose, the breakdown of milk protein into amino acids also contributes to a lower pH (Anggraini & Suryani, 2019).

Based on Figure 3a, the average total pH value ranged from 4.31 – 4.68 with the lowest value being in the treatment of adding ajwa date juice at a concentration of 50%, namely 4.31 and the highest value in the treatment of adding ajwa date juice at a concentration of 30%, namely 4.68. Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the pH of soy kefir ($\alpha = 0.05$), so further DMRT was needed. The results of the DMRT test showed that each treatment was significantly different in terms of pH.

The results showed that the pH concentration of 50% was the lowest among the other concentrations. A decrease in pH value is a common occurrence in fermented food products due to bacterial growth and acid production during the kefir fermentation process (Destro *et al.,* 2019). This is attributed to the robust growth of lactic acid bacteria, facilitated by the addition of Ajwa date juice, which serves as a prebiotic source for the growth medium. Higher concentrations of added Ajwa date juice result in increased lactic acid formation, thereby lowering the pH value. This aligns with the findings of (Nabila *et al.,* 2023), who stated that low pH values can result from the conversion of lactose into glucose and galactose by lactic acid bacteria. These products subsequently undergo glycolysis to form pyruvic acid. Pyruvic acid is then converted into the specific end product lactic acid, a transformation process that causes a reduction in the product's pH. A low pH value indicates a synergistic effect wherein an adequate microbial population effectively utilizes the soybean substrate, a process likely enhanced by the available sugar components (Ifall *et al.,* 2025).

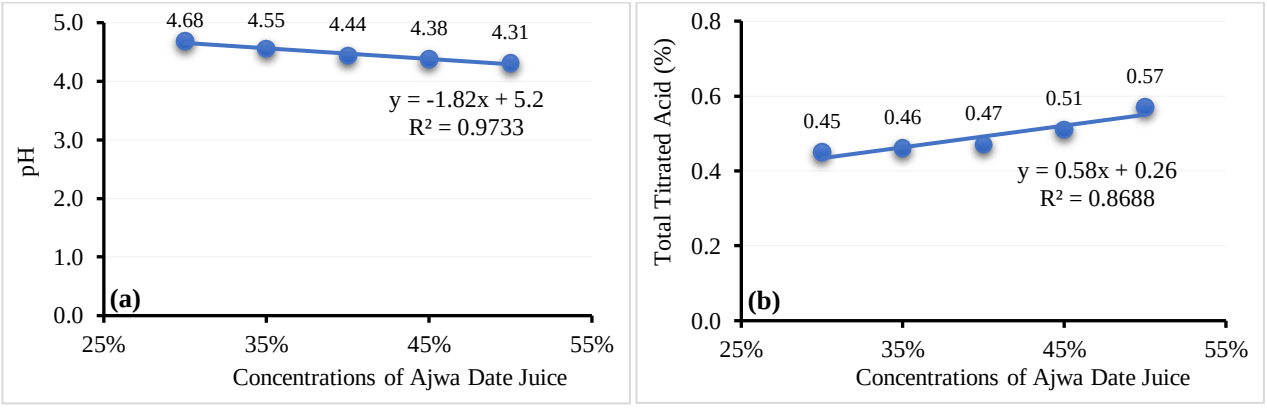

Figure 3. Effect of ajwa date juice concentrations on the chemical properties of soy kefir: (a) pH, and (b) TTA

3.4. Chemical Properties: Total Titrated Acid

Total titratable acidity refers to the amount of lactic acid produced during the fermentation process (CODEX, 2003). The value of total titratable acidity is closely related to pH, with the two exhibiting an inverse relationship; the higher the total titratable acidity, the lower the resulting pH value (Rahayu *et al.,* 2020).

Based on Figure 3b, the average total titratable acid value ranged from 0.45 – 0.57% with the lowest value in the treatment of adding ajwa date juice at a concentration of 30%, namely 0.45% and the highest value in the treatment of adding ajwa date juice at a concentration of 50%, namely 0.57%. Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the total titratable acid of soy kefir ($\alpha = 0.05$), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT test showed that A5 (50%) showed the highest total titratable acid value which was significantly different from A1 (30%), A2 (35%), A3 (40%), and A4 (45%). However, the four treatments showed no significant difference from each other in terms of total titratable acid.

The results of the study showed that the total titrated acid concentration of 50% was the highest among the other concentrations. This indicates that higher sugar concentrations lead to an increase in the total Lactic Acid Bacteria (LAB) count, as more energy is utilized and lactic acid production rises. A higher nutrient content in the product promotes LAB growth; LAB convert sugars into lactic acid, resulting in lactic acid accumulation and a consequent rise in total acidity (Yuliana *et al.*, 2023). Total acidity is inversely related to pH; as total acidity increases, the pH value decreases. This aligns with findings by (Limbad *et al.*, 2023), which demonstrated that an increase in total acidity is accompanied by a drop in pH. This occurs because the conversion of sugars into lactic acid and other organic acids by LAB is a crucial step during fermentation that influences pH levels.

3.5. Chemical Properties: Protein

Protein is one of the most important ingredients in probiotic kefir drinks. The protein content of the fermented product is the sum of the protein from the raw materials and the protein from the bacteria contained in the starter. A graph of the average protein test values can be seen in Figure 4a. The average total protein value ranged from 1.29 – 1.76% with the lowest value in the treatment of adding ajwa date juice at a concentration of 50%, namely 1.29% and the highest value in the treatment of adding ajwa date juice at a concentration of 35%, namely 1.76%. Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the total titratable acid of soy kefir ($\alpha = 0.05$), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT test showed that A2 (35%) showed the highest protein content which was not significantly different from A1 (30%), but significantly different from A3 (40%), A4 (45%), and A5 (50%). Treatments A3 (40%), A4 (45%), and A5 (50%) showed no significant difference from each other in terms of protein content.

The results of the study showed that the protein concentration of 35% was the highest among the other concentrations, and there was a decrease during the addition of the concentration of ajwa date juice. This decrease in protein levels was caused by the protein content of soybeans, which is 40g/100g, which is higher than that of ajwa dates, which is 2.91g/100g. Based on this, it can also be seen from the DMRT test at a concentration of 35% which was significantly different from the concentrations of 40%, 45%, and 50% which were lower, due to the formulation used in this study. In addition, this can be influenced by the Dilution effect. Date juice tends to have a relatively lower amount of protein than soybean juice, when date juice is added, there will be dilution in the soybean protein so that the overall protein concentration will decrease (Kumalasari & Indri, 2024).

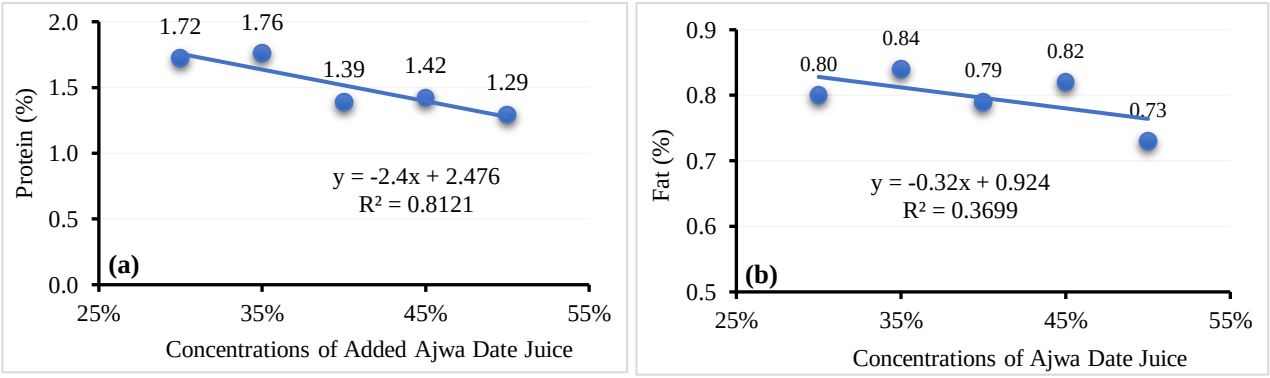

Figure 4. Effect of ajwa date juice concentrations on the chemical properties of soy kefir: (a) Protein content, and (b) Fat content

3.6. Chemical Properties: Fat

Fat content is one of the parameters used to determine the quality of food, including kefir. This test was conducted to determine the percentage of fat in a soy kefir drink with the addition of ajwa date juice. A graph of the average fat test values can be seen in Figure 4b. The average total fat value ranged from 0.73 – 0.84% with the lowest value in the treatment of adding ajwa date juice at a concentration of 50%, namely 0.73% and the highest value in the treatment of adding ajwa date juice at a concentration of 35%, namely 0.84%. Based on the ANOVA results, it was found that the addition of ajwa date juice did not significantly affect the fat content of soy kefir ($\alpha = 0.05$), so no further testing was needed.

The results of the study showed that the fat concentration of 35% was the highest among the other concentrations. This occurs because the proportion of the solute —in this case, date extract, which has a relatively lowfat content results in a negligible increase, or even a decrease, in the product's fat level. This aligns with the findings of (Kumalasari & Indri, 2024), who stated that a higher initial fat content leads to a higher fat content in the fermented product. The reduction in fat content may also be attributed to the activity of lipolytic enzymes in kefir grains, which tends to decline in acidic environments, resulting in relatively minor changes to the kefir's fat composition.

3.7. Microbiology Properties: Total LAB

The number of lactic acid bacteria in a fermented product is an indicator of the microbiological quality of the product Lactic acid bacteria play a role as probiotics, improving the digestive process and inhibiting the growth of pathogenic bacteria in the intestine. A graph of the average total lactic acid bacteria test values can be seen in Figure 5. The average total lactic acid bacteria value ranged from 0.82×10^{10} – 2.79×10^{10} CFU/mL with the lowest value in the treatment of adding ajwa date juice at a concentration of 30%, namely 0.82×10^{10} CFU/mL and the highest value in the treatment of adding ajwa date juice at a concentration of 50%, namely 2.79×10^{10} CFU/mL. Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the total lactic acid bacteria in soy kefir ($\alpha = 0.05$), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT test showed that A5 (50%) showed the highest total lactic acid bacteria which was significantly different from A1 (30%), A2 (35%), A3 (40%), and A4 (45%). Treatment A3 (40%) was not significantly different from A2 (35%) in terms of the total lactic acid bacteria.

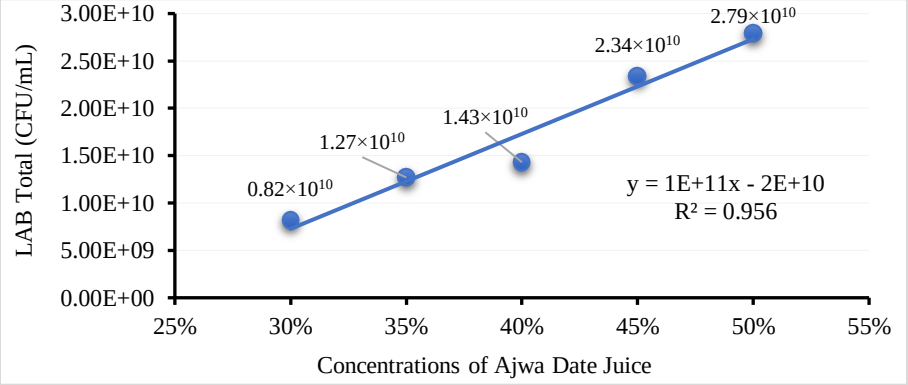

Figure 5. Graph of average lactic acid bacteria total

The results of the study showed that the total lactic acid bacteria concentration of 50% was the highest among the other concentrations. Figure 5 also shows that total LAB of the soy kefir linearly related with the ajwa date juice concentration with high R^2 (0.956). The higher the total sugar content in the medium, the greater the total lactic acid bacteria produced. This growth occurs because the juice added during the fermentation process serve as a source of energy and nutrients for the metabolism and growth of lactic acid bacteria. This aligns with research by (Nabila *et al.*, 2023), which indicates that higher concentrations of date juice in kefir lead to a higher total count of lactic acid bacteria, as the bacteria are able to utilize the date juice as a growth medium. Sugar content, whether sucrose, glucose,

or fructose acts not only as a source of sweetness but also as an effective energy source for the growth of lactic acid bacteria. During fermentation, sucrose is utilized not only by lactic acid bacteria but also by yeasts and acetic acid bacteria for metabolic processes (Anjliany *et al.,* 2022). An increase in the total lactic acid bacteria population can also lead to higher lactic acid production; consequently, higher lactic acid levels in the product result in a lower pH. This is consistent with research findings showing that the pH at a 50% concentration was 4.31, representing the lowest pH value among the various treatments.

3.8. Microbiology Properties: Total Yeast

The presence of yeast in kefir is a very important characteristic. The yeast contained in kefir will break down the simple sugars contained in date juice into alcohol and carbon dioxide. The glucose used by yeast has two functions, namely for growth and reproduction, and to be converted into metabolite products in the form of alcohol, CO_2 and organic acids. Thus, the results of the kefir fermentation process will have a sour taste and a foamy sensation due to the CO_2 content (Nabila *et al.,* 2023). A graph of the average yeast total test values can be seen in Figure 9.

Based on the measurement, the average total yeast value ranged from zero (0.00 CFU/mL) in the treatment of adding ajwa date juice at a concentration of 35%, 40%, 45%, and 50%, to 0.67×10^2 CFU/mL in the treatment of adding ajwa date juice at a concentration of 30%. Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the total yeast of soybean kefir ($\alpha = 0.05$), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT test showed that A1 (30%) showed the highest total yeast value which was significantly different from A2 (35%), A3 (40%), A4 (45%), and A5 (50%). However, the four treatments showed no significant difference from each other in terms of the total yeast.

The research results indicate that the total yeast count is lower than the total lactic acid bacteria count. This occurs because the microbial population in kefir is dominated by lactic acid bacteria. This finding aligns with (Cho *et al.,* 2018), who stated that kefir fermented using kefir grains contains over 50 species of lactic acid bacteria, followed by yeasts and acetic acid bacteria. The low total yeast count may be influenced by the pH and temperature conditions of the kefir. A low pH value indicates high total acidity, which renders the yeast unable to break down the substrate as effectively as they could at the beginning of fermentation (Nabila *et al.,* 2023).

3.9. Hedonic and Score: Texture

Texture is one of the factors influencing the level of panelist acceptance of a product (Hanifa *et al.,* 2024). Overall, the score categories in the hedonic test are 1 = dislike very much; 2 = dislike; 3 = dislike somewhat; 4 = like somewhat; 5 = like; and 6 = like very much. Meanwhile, the categories in the texture score test are 1 = very not thick; 2 = not thick; 3 = not thick somewhat; 4 = slightly thick; 5 = thick; and 6 = very thick. The graphs of the average hedonic test values and texture scores can be seen in Figure 6a and 6b. The average texture hedonic value ranged from 4.2 – 4.9 (slightly like to like) with the lowest value in the treatment of adding ajwa date juice at a concentration of 30% (4.2, slightly like) and the highest value in the treatment of adding ajwa date juice at a concentration of 45% (4.9, like). Based on

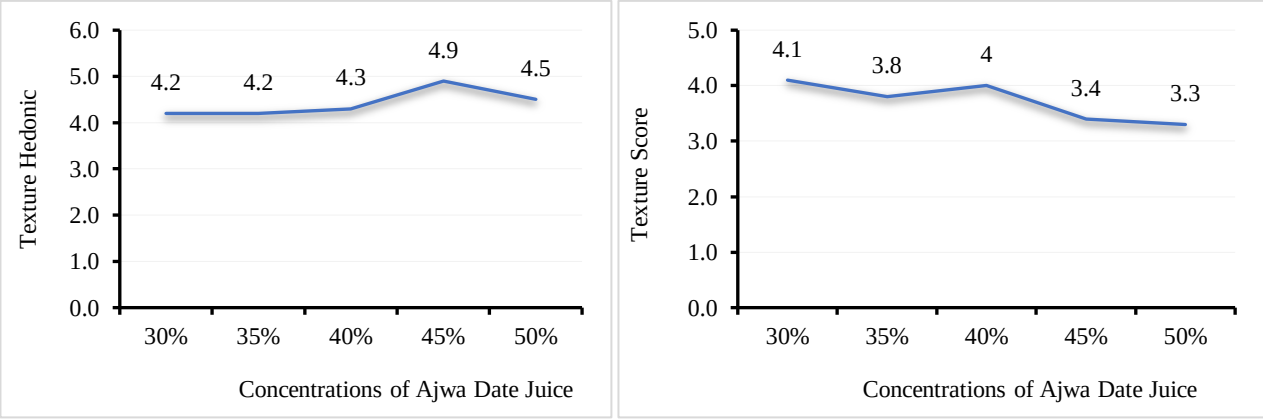

Figure 9. Effect of ajwa date juice on the average texture of soy kefir product: (a) Texture hedonic, (b) Texture score

the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the texture hedonic test value of soy kefir (α = 0.05), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT further test showed that A4 (45%) showed the highest texture hedonic value which was significantly different from A1 (30%), A2 (35%), A3 (40%), and A5 (50%). However, the four treatments showed no significant difference from each other in terms of the texture hedonic value. The results of the study showed that the texture hedonic test concentration of 45% was the highest among the other concentrations. This occurs because, during the fermentation process, LAB transform the milk's consistency from liquid to a thicker state, a phenomenon known as milk coagulation. Coagulation results from the activity of the starter culture, which denatures milk proteins and fats, thereby causing the mixture to thicken. The texture of this date-infused kefir product is also influenced by the quantity of dates added; a higher concentration of date extract results in a thicker kefir consistency due to an increase in the total LAB population. LAB transform the milk from its initial liquid state into a thicker consistency during fermentation (Rahayu *et al.*, 2020).

Based on Figure 6b, the average texture score value ranged from 3.3 – 4.1 (slightly not thick – slightly thick) with the lowest value in the treatment of adding ajwa date juice at a concentration of 50% (3.3, slightly not thick) and the highest value in the treatment of adding ajwa date juice at a concentration of 30% (4.1, slightly thick). Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the texture score test value of soy kefir (α = 0.05), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT further test showed that A1 (30%) showed the highest texture score test value which was not significantly different from A2 (35%) and A3 (40%), but significantly different from A4 (45%) and A5 (50%). Treatments A4 (45%) and A5 (50%) showed no significant difference from each other in terms of the texture score test value. The results of the study showed that the texture score test concentration of 30% was the highest among the other concentrations. When compared to the viscosity value at a 30% concentration obtained in this study, a viscosity of 39.33 cP was obtained, indicating a liquid texture. This contrasts with research (Ainiyyah & Rismaya, 2022) which stated that increasing the amount or percentage of date palm juice mixed into milk increases the viscosity of the date palm juice milk product. This may occur due to the presence of a dissolved substance, namely date palm juice, which increases the total solids content.

3.10. Hedonic and Score Test: Aroma

Aroma plays a significant role in the deliciousness of food or beverages; consequently, it is a key factor in determining quality. The aroma of a food product influences the level of consumer preference for that product (Hanifa *et al.*, 2024). The categories in the aroma score test are 1 = very no date aroma; 2 = no date aroma; 3 = slightly no date aroma; 4 = slightly date aroma; 5 = date aroma; and 6 = very date aroma. The graphs of the average hedonic test values and aroma scores can be seen in Figures 7a and 7b. the average aroma hedonic value ranged from 3.5 – 4.8 (rather dislike – like) with the lowest value in the treatment of adding ajwa date juice at a concentration of 30% (3.5, rather dislike) and the highest value in the treatment of adding ajwa date juice at a concentration of 45% (4.8, like). Based on the ANOVA the

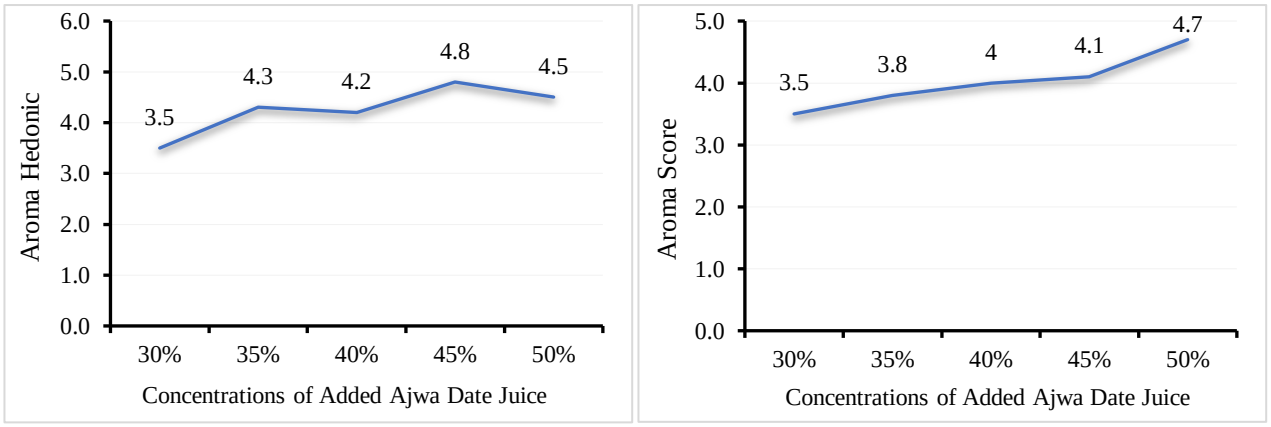

Figure 7. Effect of ajwa date juice on the average aroma of soy kefir product: (a) Aroma hedonic, (b) Aroma score

results, it was found that the addition of ajwa date juice had a significant effect on the aroma hedonic value of the soy kefir (α = 0.05), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT further test showed that A4 (45%) showed the highest aroma hedonic value which was not significantly different from A5 (50%), but significantly different from A1 (30%), A2 (35%), and A3 (40%) on the aroma hedonic value. The results of the study showed that the aroma hedonic test concentration of 45% was the highest among the other concentrations. This indicates that as the concentration of Ajwa date juice increases, the characteristic aroma of the kefir diminishes. This finding aligns with research by (Ainiyyah & Rismaya, 2022), which suggests that increasing the addition of date juice leads to a reduction in the dairy product's aroma; this is due to the combination of added date juice affecting the product's structure—a factor that influences panelist preference.

Based on Figure 7b, the average aroma score value ranged from 3.5 – 4.7 (slightly no date aroma – date aroma) with the lowest value in the treatment of adding ajwa date juice at a concentration of 30% (3.5, slightly no date aroma) and the highest value in the treatment of adding ajwa date juice at a concentration of 50% (4.7, date aroma). Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the aroma score test value of soy kefir (α = 0.05), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT further test showed that A5 (50%) showed the highest aroma score test value which was significantly different from each other with A1 (30%), A2 (35%), A3 (40%), and A4 (45%) on the aroma score value. The results of the study showed that the aroma score test concentration of 50% was the highest among the other concentrations. This indicates that a higher percentage of added date extract enhances the aroma, thereby attracting consumer interest. This occurs because milk has the ability to absorb the aroma of the date extract; specifically, the milk fat plays an active role in absorbing surrounding aromas that are much more intense (Okarini & Suartiningsih, 2017).

3.11. Hedonic and Score Test: Color

The color of a food product indicates its brightness, which influences consumer preference for the product. A food product will not be consumed if its color does not align with the product's characteristics (Hanifa *et al.*, 2024). The categories in the color score test are 1 = very not brown; 2 = not brown; 3 = somewhat not brown; 4 = somewhat brown; 5 = brown; and 6 = very brown. The graphs of the average hedonic test values and color scores can be seen in Figures 8a and 8b. the average color hedonic value ranged from 4.1 – 4.5 (somewhat liked) with the lowest value in the treatment of adding ajwa date juice at a concentration of 40% and 50% (4.1, somewhat liked) and the highest value in the treatment of adding ajwa date juice at a concentration of 30% (4.5, somewhat liked). Based on the ANOVA results, it was found that the addition of ajwa date juice did not significantly affect the color hedonic test value of soy kefir (α = 0.05), so no further testing was needed. The results of the study showed that the color hedonic test concentration of 30% was the highest among the other concentrations and did not provide a significant effect. This aligns with research (Gumilang *et al.*, 2022) stating that fermenting bacteria in kefir grains break down lactose into lactic acid, a process that does not affect the color of the resulting kefir. Soy milk kefir is generally milky white in color; however, the addition of dates to soy milk kefir results in a brownish color.

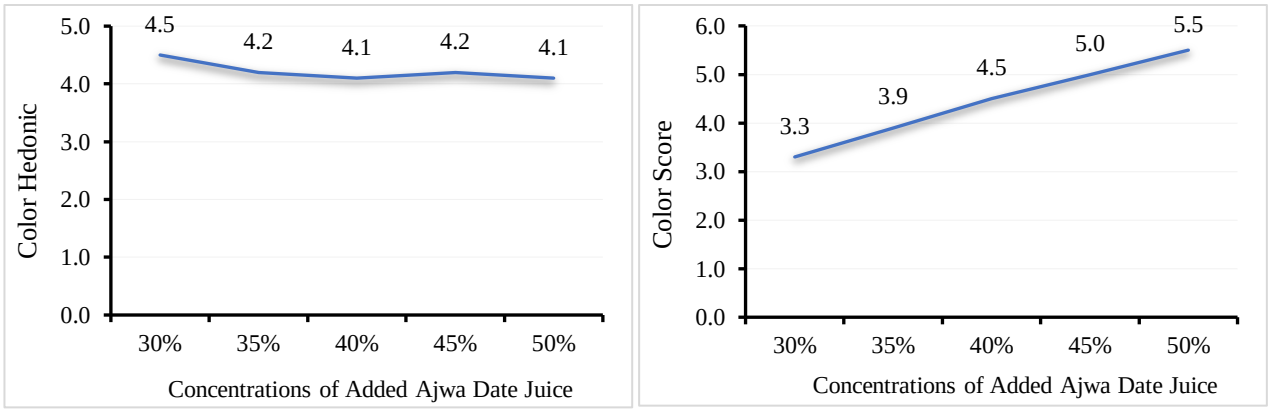

Figure 8. Effect of ajwa date juice on the average color of kefir product: (a) Color hedonic, (b) Color score

Based on Figure 8b, the average color score value ranged from 3.3 – 5.5 (slightly not brown – brown) with the lowest value in the treatment of adding ajwa date juice at a concentration of 30% (3.3, slightly not brown) and the highest value in the treatment of adding ajwa date juice at a concentration of 50% (5.5, brown). Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the color score test value of soy kefir ($\alpha = 0.05$), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT further test showed that each treatment was significantly different in terms of the color score test value. The results of the study showed that the color score test concentration of 50% was the highest among the other concentrations. This indicates that the higher the concentration of Ajwa date extract added to the kefir, the browner the resulting product becomes. This aligns with the study by (Ainiyyah & Rismaya, 2022), which states that the dominant color produced is influenced by the addition of date extract, resulting in a final product with a brownish hue.

3.12. Hedonic and Score Test: Taste

Taste is a response to a chemical stimulus that reaches the taste buds, specifically the tongue, specifically some common tastes such as salty, sour, sweet, and bitter (Ayustaningwarno *et al*., 2020). Flavor is the most important quality attribute in determining the level of acceptance of a food or beverage product (Hanifa *et al*., 2024). The categories in the taste score test are 1 = very unsweet; 2 = not sweet; 3 = somewhat unsweet; 4 = somewhat sweet; 5 = sweet; and 6 = very sweet. The average hedonic test values and taste scores can be seen in Figures 9a and 9b.

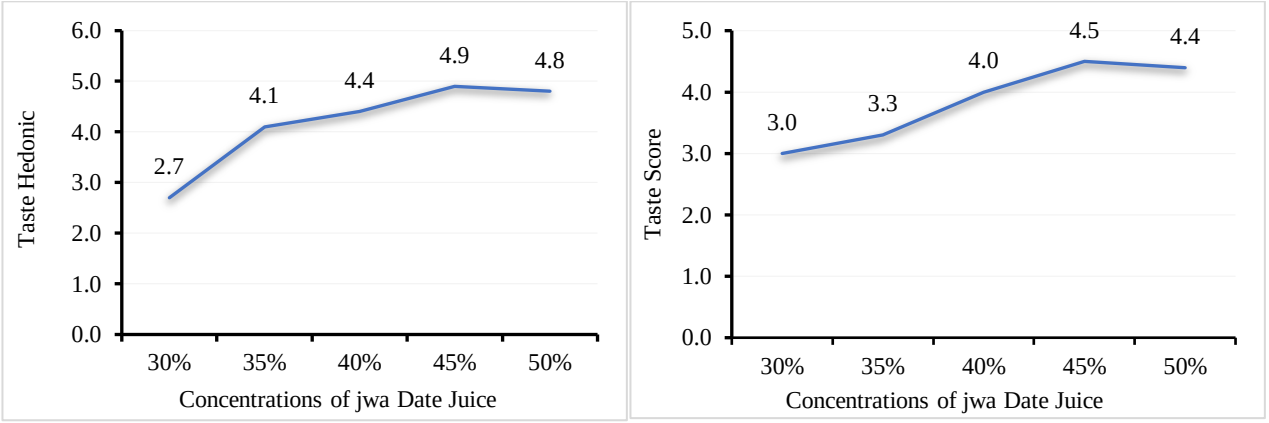

Figure 9. Effect of ajwa date juice on the average color of kefir product: (a) Taste hedonic, (b) Taste score

Based on Figure 9a, the average taste hedonic value ranged from 2.7 – 4.9 (somewhat dislike – like) with the lowest value in the treatment of adding ajwa date juice at a concentration of 30% (2.7, somewhat dislike) and the highest value in the treatment of adding ajwa date juice at a concentration of 45% (4.9, like). Based on the ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the hedonic taste test value of the soy kefir ($\alpha = 0.05$), so further testing was required with the Duncan Multiple Range Test (DMRT). The results of the DMRT further test showed that A4 (45%) showed the highest taste hedonic value which was not significantly different from A5 (50%), but significantly different from A1 (30%), A2 (35%), and A3 (40%) in terms of the taste hedonic value. The results of the study showed that the taste hedonic test concentration of 45% was the highest among the other concentrations. When compared to the pH value at the 45% concentration obtained in this study, a pH of 4.38 was obtained, indicating a sweet or slightly sour taste. This indicates that increasing the addition of Ajwa date fruit extract to the kefir enhances panelist preference. This finding aligns with research by (Shahein *et al.*, 2022), which reported that the addition of 8% date syrup to a fermented camel milk beverage was preferred by panelists over the control and the 6% concentration, with 8% being the highest concentration tested.

Based on Figure 9b, the average taste score value ranged from 3.0 – 4.5 (slightly not sweet – slightly sweet) with the lowest value in the treatment of adding ajwa date juice at a concentration of 30% (3.0, slightly not sweet) and the highest value in the treatment of adding ajwa date juice at a concentration of 45% (4.5, slightly sweet). Based on the

ANOVA results, it was found that the addition of ajwa date juice had a significant effect on the taste score test value of soy kefir ($\alpha = 0.05$), so further testing was needed with the Duncan Multiple Range Test (DMRT). The results of the DMRT further test showed that A4 (45%) showed the highest taste score test value which was not significantly different from A5 (50%), but significantly different from A1 (30%), A2 (35%), and A3 (40%). Treatment A1 (30%) was not significantly different from A2 (35%) in terms of the taste score value. The results of the study showed that the taste score test concentration of 45% was the highest among the other concentrations. This is attributed to the sweetness derived from Ajwa date extract. Every 100 g of dried Ajwa dates contain 51.3±0.3% glucose, 48.5±0.2% fructose, 3.2±0.3% sucrose, and 74.3±0.2% total sugar (Gumilang *et al.,* 2023). The relatively high sugar content in the date extract imparts a sweet flavor, provided the extract is combined with soy extract in the correct ratio. Although the sugar content in dates is quite high, their glycemic index is relatively low compared to granulated sugar, as the sugars present are simple sugars that are easily absorbed by the body (Chaudhary *et al.,* 2018).

3.13. Supporting Tests: Antioxidant Activity

Supporting tests were determined based on physical, chemical, microbiological, and organoleptic tests which were selected based on the most dominant concentration showing the best results for each parameter and providing the most significant influence on the research objectives, so that the best treatment was obtained, namely the addition of 45% ajwa date juice.

Antioxidants are compounds that have a preventive or detectable effect on the oxidative chain propagation by stabilizing the resulting radicals, thereby helping to reduce oxidative damage in the human body (Santos-Sánchez *et al*., 2019). The method used in testing antioxidant activity in this study was the DPPH radical sorption method. This method is simple, easy, and uses a small amount of sample in a short time (Maesaroh *et al*., 2018). The analysis of antioxidant activity resulted that average IC_{50} value of the kefir is 7917.29±0.05 ppm. The antioxidant activity of soy kefir with the addition of ajwa date juice is expressed in IC_{50} against DPPH radicals. There are two main types of antioxidants, namely primary antioxidants (chain reaction breakers, free radical scavengers) and secondary or preventive antioxidants. Secondary antioxidant mechanisms may include metal deactivation, inhibition of lipid hydroperoxides by disrupting the production of unwanted volatiles, regeneration of primary antioxidants, and removal of free oxygen. Therefore, antioxidants can be defined as compounds that in low amounts are able to prevent or slow the oxidation of easily oxidized materials such as fats (Maesaroh *et al*., 2018).

The results showed that the average antioxidant activity of soy kefir with 45% ajwa date juice was 7917.29 ppm. Previous research by (Alayouni, 2026) reported an antioxidant activity value of 785.29 ppm for a camel milk prebiotic beverage supplemented with Khalas dates. It was observed that antioxidant activity decreased as the dilution level increased. This is attributed to the low content of phenolic compounds and flavonoids in the date fruit probiotic beverage. The activity is also linked to sugar content; extensive sugar metabolism by lactic acid bacteria releases a greater quantity of phenolic compounds, thereby enhancing antioxidant activity. The conversion of sugars into lactic acid by these bacteria acts synergistically by donating H^+ ions to free radicals, thus boosting primary antioxidant activity. This phenomenon aligns with studies indicating a correlation between total phenolic or flavonoid content and the resulting antioxidant efficacy (Hadiansyah *et al.,* 2024).

3.14. Supporting Tests: Total Flavonoids

Flavonoids are naturally occurring compounds with potential antioxidant activity capable of neutralizing free radicals, which contribute to the development of degenerative diseases through mechanisms involving the impairment of the immune system and the oxidation of lipids and proteins (Hadiansyah *et al.,* 2024). Total flavonoid content analysis is a measurement of the total flavonoids contained in the sample. The method used is UV-Vis spectrophotometry. The standard used is quercetin, because quercetin is a flavonol flavonoid that has a keto group at the C-4 atom and also a hydroxyl group at the neighboring C-3 and C-5 atoms. The maximum wavelength measurement was carried out in the 410 nm wavelength range. In determining the quercetin standard curve, quercetin was prepared with a concentration series of 20, 40, 60, 80, and 100 µg/mL. The calibration curve was obtained by making a standard quercetin solution with the aim of measuring the level of accuracy of the data obtained. The results obtained from the creation of the calibration curve are a linear regression equation $y = 0.0059x + 0.0247$ with a coefficient of determination (r^2) of

0.9850. The magnitude of this linearity is close to one, so it can be said that absorbance is a function whose magnitude is directly proportional to concentration and follows a linear regression equation.

The analysis resulted that average flavonoids value of the kefir is 0.3138±0.0016 mgQE/g. Based on the research results, the flavonoid content of soy kefir with the addition of ajwa date juice is 0.3138 mgQE/g, meaning that the flavonoid content per gram of the sample is equivalent to 0.3138 mg of quercetin. These results align with the study by (Darwish *et al.,* 2018), which reported a total flavonoid content of 0.33 mgQE/g in fermented milk beverages containing date seeds. The increase in total flavonoids during fermentation is attributed to the activity of lactic acid bacteria; during the process, these bacteria produce enzymes that synthesize sugars and release phenolic compounds present in the dates, thereby adding phenolic groups to the flavonoid compounds (Hadiansyah *et al.,* 2024).

4. CONCLUSION

Based on the results of research on the manufacture of kefir made from soybean juice with the addition of ajwa date juice (30%, 35%, 40%, 45%, and 50%) showed a significant effect at $\alpha = 0.05$ on the parameters of total dissolved solids, viscosity, pH, total titratable acid, protein, total LAB, total yeast, and organoleptic in the form of hedonic tests (texture, aroma, and taste) and score tests. The best quality soybean kefir based on physical, chemical, microbiological, and organoleptic tests is soybean kefir with the addition of ajwa date juice concentration of 45% because it can improve the sour taste of soybean kefir, and it is known that the results of the treatment at a concentration of 45% are not significantly different from 50%. The results of supporting tests are in the form of antioxidant activity IC_{50} 7917.29 ppm and total flavonoids 0.3138 mgQE/g. Based on the research that has been conducted, the author suggests conducting alcohol content testing as well as further studying and researching the stability of soy kefir with added ajwa date juice against the addition of starter concentration and fermentation time.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE MANUSCRIPT PREPARATION

Not applicable. The authors did not use any generative AI tools or services in the preparation of this manuscript. All content is entirely the intellectual work of the authors.

AUTHOR CONTRIBUTION

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
QAK	✓	✓		✓				✓		✓		✓	✓	✓
JAR		✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓

C: Conceptualization
M: Methodology
So: Software
Va: Validation
Fo: Formal Analysis
I: Investigation
R: Resources
D: Data Curation
O: Writing - Original Draft
E: Writing - Review & Editing
Vi: Visualization
Su: Supervision
Fu: Funding Acquisition
P: Project Administration

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