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Research Article

Evaluation Dangke Cheese Processing by Edible Film Coating Made from Whey Combined with Konjac Flour

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Dangke cheese (DC) is a traditional cheese from Enrekang Regency, South Sulawesi, Indonesia. The functional dangke cheese (FDC) was developed from DC with product diversification to obtain new cheese variants. FDC is hard cheese (HC) through fermentation, ripening, and coating processes. Therefore, the EF becomes an alternative for coating HC because it can maintain product mass, shelf life, and flavor. This study is aimed at determining edible film (EF) characteristics and analyzing EF's prospects in coating HC. The research method was conducted in two stages. The first stage was to make a whey base EF solution with 1%, 1.5%, and 2% KF. The EF was analyzed using a randomized complete block design. The analysis result of whey-based EF combined with KF was then conducted in the second stage of the research by applying HC produced in the laboratory and then stored for 0, 10, 20, and 30 days, respectively. Physical tests such as pH and organoleptic were carried out using factorial pattern group randomized design analysis. The results of the first stage of the study showed that EF from whey combined with KF had a very significant effect ($P < 0.01$) on EF parameters (gelation time, thickness, extensibility, tensile strength, and water vapor transmission rate (WVTR)). The results of the second stage of the study showed that EF applied to HC using different storage lengths had a significant effect ($P < 0.01$) on color and liking but no significant effect ($P > 0.05$) on pH and texture parameters. Meanwhile, HC without EF coating has a significant impact ($P < 0.01$) on texture and color parameters but no significant effect ($P > 0.05$) on pH, aroma, and liking. 1.5% KF in an EF formulation is the best. HC coated with EF was more durable (20 days) than HC without EF (10 days).

1. Introduction

Dangke cheese is a typical cheese from Enrekang Regency, which is made by curdling fresh milk using papaya sap; then, the curd formed is molded using coconut shells. The process for making this cheese is the same as cottage cheese, but the shape is different because dangke cheese is coagulated with papaya sap. Hence, it requires the right concentration when coagulating so as not to taste bitter. Also, the shape of this cheese is unique because it is molded in the form of a coconut shell, so the shape is like a semicircle, which is slightly oval.

The coating on cheese is mainly used to prevent the skin layer on the cheese from evaporation [1]. Various coatings have been used, for example, wax or paraffin synthetic with multiple colors, the most are wax red and yellow [2]. Natural coating materials in our previous studies use candle honey (bee wax). The coating for cheese is mainly to prevent the formation of the outer layer of cheese so that it does not harden, especially for cheese that will be stored for a long time. This research will develop dangke cheese into hard cheese for a longer shelf life. The following process remains in vacuum packaging to avoid evaporation and prevent microbial contamination.

EFs are type coatings like *films*, sheets, or thin layers as an integral of product food and can be consumed together with packaged products [3, 4]. Besides, to reduce the characteristic brittle of the resulting *film*, added material *plasticizer* (sorbitol) [5, 6], increasing the height of the plasticizer used, produces more characteristics of plastic that are not healthy for human consumption [7]. The EF made from this organic material can be one solution for reducing the pollution of the environment [8]. The use of plastics coating on food can cause plastic to accumulate in the environment and also can cause plastic substance residues in food, which can be dangerous for consumers' health [9]. The material plasticizer field also affects the formation of edible whey protein films [3]. *Plasticizers* are materials with added low-weight molecules, meaning increased elasticity from EFs [10].

Flour konjac is a simple polysaccharide found on the market [11–13]. The additional percentage mixture of different hydrocolloids will produce characteristics of other EF. The previous study resulted in the addition of konjac in EF making that can repair parts of strong tensile, elongation, thickness, water vapor transmission rate (WVTR), and time gelation [14].

Whey proteins are one material common to EF formation obtained as by-products in dangke and cheese making [3, 15, 16]. *EFs* from *whey* protein have a good nature as a coating that forms a transparent film that is soft, not smelly, and not colored and can hold the scent of the food that coated the product.

A mixture of flour konjac can produce good gels because there is a synergistic connection in gel formation, stimulating gel with better gel strength, texture, and elasticity [17]. Widjanarko [18] states that konjac, as an agent gel, can form *reversible* and *irreversible* gels under different conditions. Flour konjac can form a gel with heat up to 85°C in a deep condition alkaline (pH 9-10). Konjac flour for edible films also has the potential to act as an antioxidant, so it is an edible film that can be eaten, so it does not need to be removed when the cheese is eaten.

Elongation is a measure to find out how long an EF can thicken or form a gel after being poured into a mold [19–21]. Glaciation or gel formation is an exciting and very complex phenomenon, but until now, the mechanism has yet to be explained. In principle, the formation of a hydrocolloid gel occurs due to the forming of a three-dimensional network by primary molecules that cover the entire volume of the gel formed with the amount of water trapped in it [22]. The strength of the gel EF is related to the chemical structure of the polymer, additives, and environmental conditions during the process of forming the EF [23].

Gel strength is the maximum force determining the EF [24]. EFs with high TS can protect packaged products from mechanical disturbances [25]. Elongation shows the maximum long moment change to obtain tensile force until the film breaks. The elongation value is always related to the tensile strength, indicating the gel's ability to be stretched as a coating [26]. Strong attraction is the maximum force to determine EF. EF with high TS can adequately protect packaged products from mechanical disturbances [25]. Elongation shows the maximum long change of moment to obtain tensile force until the film breaks [27]. The elongation value is always related to the tensile strength, which indicates the gel's ability to be stretched when used as a coating [28]. Prosperity is good if the value is more than 50% and wrong if the value is less than 10% [25]. Purwadi's research (2010) using chicken skin gelatin combined with soy protein isolate had an average value of 6.88 N, while EF elongated at 30.74%.

Cheese is a dairy product that contains high food nutritional value [29, 30]. Based on the texture, cheese can be divided into three parts: hard cheese, semihard cheese, and soft cheese [31]. Various types of cheese can be found in the commercial market [32]. Fresh cheese, commonly called fresh cheese, does not require ripening or fermentation in the manufacturing process [33].

Several factors influence the type and variety of cheese, the degree of milk acidity in the curd formation process, the type of microorganism used for fermentation [34], and the nutritional composition of milk in cheese making, including fat content, also including incubation temperature, humidity, production process, and ripening time in processing cheese [35, 36].

To extend the product's shelf life and prevent skin formation on the cheese, it is overcome by using a coating. The commonly used coatings are wax and paraffin, but wax and paraffin are nonedible. Therefore, an innovation was created using layers from EF using organic materials that can be functional, namely, konjac.

2. Materials and Methods

2.1. Materials. Fresh bovine milk (3.1% fat, 3.2% protein, and 4.1% lactose) was obtained from a smallholder farm, Enrekang Regency, South Sulawesi, Indonesia. KF was obtained from a commercial supermarket in South Sulawesi, Indonesia.

2.2. Research Design. This research was conducted in 2 stages. Stage 1 was to analyze the characteristics of whey-based EF with a combination of KF. Stage 2 was to investigate the prospects for the EF produced as a coating material for HC. This method used a completely randomized design (CRD) in one direction with three treatments and four replications. The treatment in stage 1 was K1, 1% konjac flour (KF); K2, 1.5% KF; and K3, 2% KF. The parameters evaluated were the physical characteristics of the EF, such as thickness, substantial drag, elongation, water vapor transmission rate (WVTR), and gelation time. An EF with the best physical characteristics will be selected to be applied as a layer of HC. Figure 1 shows the process production of edible film coating made from whey combined with konjac flour.

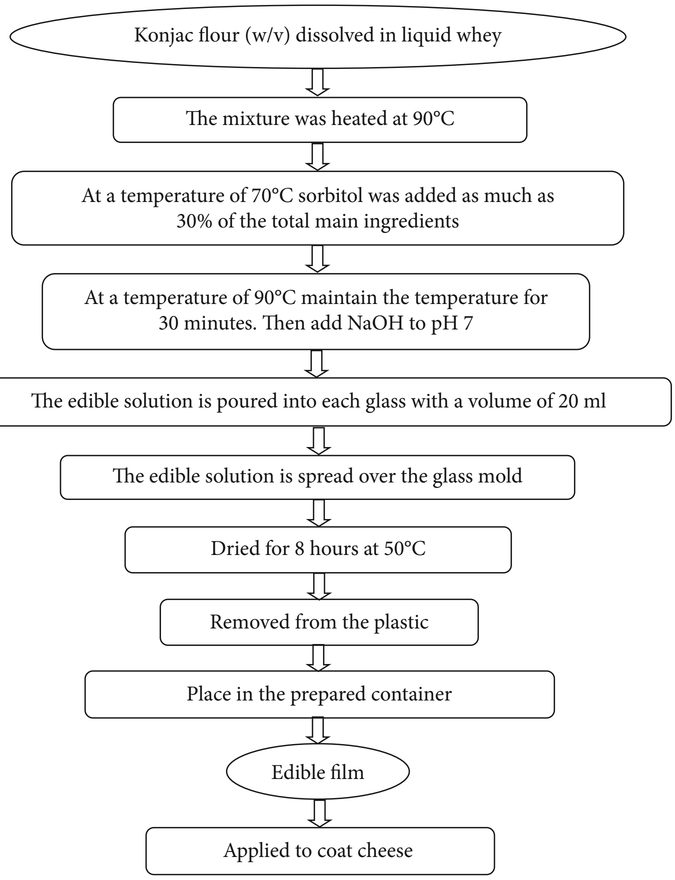

Figure 1: Edible film coating made from whey combined with konjac flour production.

Phase 2 of this study used a completely randomized design (CRD) with a factorial pattern using two groups, group A applying EF to HC by different storage time (P1: storage 0 days, P2: 10-day storage, P3: 20-day storage, and P4: storage 30 days) and group B which are HCs without EF coating which also have different storage times (Q1: 0-storage days, Q2: storage ten days, Q3: storage 20 days, and Q4: storage 30 days). Furthermore, the ripening process was carried out at 4°C. The parameter measured pH and organoleptic (aroma, color, texture, and preference) to analyze the prospects using EF as a coating of hard cheese.

2.3. EF and HC Production. KF was weighed with an analytical balance (Sojikyo, 500 g/001 g) with the percentage (*w*/*v*) 1, 1.5, and 2 (%) dissolved in the liquid whey. Liquid whey is obtained from the cheese making [37]. The flour and whey solutions were thoroughly stirred using a hot plate and a magnetic stirrer while being heated until they reached a temperature of 90°C. When the solution reached 70°C, 30% plasticizer was added from the main ingredient. When the EF solution has reached a temperature of 90°C, the temperature of the solution is maintained for 30 minutes. Therefore, the solution was adjusted by adding 1-2 ml of 1 N NaOH until it reached a pH of 7. Then, the solution was poured over a 12×12 cm printing glass, with a volume of 20 ml, and covered by the same glass and then dried in an oven at 50°C for 8 hours. The dried EF was removed from the printing glass and stored in a container for 24 hours. Furthermore, the EF is ready to be tested and used as a coating for HC. EF and HC production can be seen in Figure 1.

2.4. Cheese Making. Cheese is made from pasteurized fresh milk at 85°C for 15 seconds [38], then 0.3% papain is added [39]. After coagulating the milk, it is printed on hemispherical molds, perforated, and pressed with a press to release the whey. The cheese is then stored on a cheese rack, and the whey is drained [36]. The cheese is ripened for seven days at 5°C until the color turns yellow [40]. The cheese is then coated with konjac EF. The cheese was stored in the refrigerator to be investigated for quality.

2.5. Gel Strength and Elongation. The TS of the EF was measured using a digital meter HF 500. The size of the EF tested was $8 \times 3\,\text{cm}^2$. The EF was attached horizontally to a clamp/hook with an area of 1.5 cm on both sides of its length. The TS value was read after sampling was removed from the tools. Meanwhile, the elongation was calculated using the following equation [23, 41]:

$$E = \frac{100 \times (d_{\text{after}} - d_{\text{before}})}{d_{\text{before}}}, \quad (1)$$

where E is the elongation of EF, after is the length EF after pulled, and before is the length EFs before pulled.

2.6. Thickness. EF thickness was measured using a micrometer (Syntec Digital Micrometer) with an accuracy of 0.001 mm. Thickness measurements were performed at five different locations on each EF sample to obtain a representative average thickness value [42].

2.7. Water Vapor Transmission Rate (WVTR). WVTR is the rate constant at which water vapor can penetrate the EF at a specific temperature and relative humidity. The WVTR glass to be used is heated at 60°C for 10 hours [43]. The cold glass was weighed first in an empty state before use. Then, the glass has been filled with 3 grams of silica gel, and the glass is considered again. Then, the EF was cut into a circular shape with a diameter of 2.8 cm. The surface pieces of EF are then placed in WVTR glass and weighed again. The glass containing the sample is then stored in a controlled desiccator with ±55% humidity. Every hour for 8 hours, the glass is removed from the desiccator and reweighed. The WVTR unit is expressed in g/mm^2/hour. The WVTR formula was calculated using the following formulation (modification from Sukkunta et al. [44]):

$$\text{Cap WVTR} = \frac{[G/n]}{A}, \quad (2)$$

where G/n is the difference in water weight increase, which is absorbed by glass (g), and A is the wide area EF (g/mm^2/h).

2.8. Gelation Time. The EF GT was tested by calculating the time required using a stopwatch after the EF solution heated with a hot plate stirrer was poured into a printing glass until the solution solidified (formed a gel).

2.9. pH. EF solution was evaluated to pH by using Hanna pH meter [45]. The sample was weighed as much as 5 g, then mixed into 25 ml of distilled water, and homogenized. Furthermore, it was blended well after adding 50 ml of distilled water again. The pH of the solution was measured with a pH meter (Scott Instrument 850-pH meter).

2.10. Sensory Evaluation. The organoleptic evaluation in this study used the hedonic scale [46] to assess the quality of HC-coated whey-konjac EF and without whey-konjac EF using different storage times. Panelists were asked to score according to the impressions obtained and the criteria provided. Panelists can evaluate existing samples based on milk aroma, texture (hardness), color, and preference. Panelists assess each piece by marking it as a number with the scale provided on the questionnaire sheet. Sensory evaluation was carried out in the laboratory in a specific room by a panelist of 30 members (male and female), aged between 17 and 23 years, based on EFs with the addition of different KF had a significant effect ($P < 0.01$) on the GT of EFs. Duncan's further test showed that the more KF was used, the more the GT value would decrease. This is because KF can make a good gel. This is the opinion [25], which states that adding KF to manufacture EFs greatly determines the time for EF gelation. A mixture of KF can produce a good gel, and this is due to a synergistic relationship in gel formation to make a gel with higher gel strength, better texture, and more ranging between 20 and 25 years old.

The texture was rated as very hard (number 1) and very soft (number 6). The colors are very white (number 1) and very yellow (number 6). Likewise, the product appearance is dislikes (number 1) and like (number 6). Likes: rate your preferred EF based on your favorite cheese texture, milky aroma, and color.

2.11. Data Analysis. Data analysis in stage 1 used a one-way variance analysis [47] with four repetitions. If the results of the variance analysis have a significant difference, then continue with Duncan's significant difference test. The data obtained in the study's second phase were analyzed using a two-way analysis of variance with 20 repetitions. Data on pH values and sensory tests were analyzed using variance analysis, and if there were significant differences, then further testing was carried out with Duncan's test.

3. Results

3.1. Physical Properties of EF

3.1.1. Gelation Time. Gelation time (GT) was measured using a long glass, which was calculated using time, starting from when the solution was poured until it was printed until the solution formed a gel [48]. The film formation process is a result of the temperature treatment of the gel formation process, resulting in the formation of a matrix or network through intermolecular and intramolecular hydrogen bonding interaction. Gels are approximately 99.9% water but have more solid characteristics, particularly elasticity and stiffness [25]. Table 1 shows the effect of KF concentration on the manufacture of whey-based EF. GT was measured using a long glass and calculated using time, starting from when the solution was poured until it was printed until the solution formed a gel [49]. The film formation process is a result of the temperature treatment of the gel formation process, resulting in the formation of a matrix or network [50]. Gels are approximately 99.9% water but have more solid characteristics, particularly elasticity and stiffness [25].

The GT in processing EFs made from whey DC with different combinations of KF is 8.50–14.29 seconds. The results of this study were lower than those of studies of EFs with other materials. Husnaeni's study (2022) on EF made from casein with the addition of red ginger juice found that the GT was 17.13–24.73 seconds and, meanwhile, elasticity. Setiani et al. [42] stated that starch gels are thicker and more stable than protein gels in EF formation. Arsal's research (2021), based on casein with the addition of KF in making EF, has an average GT of 19.5–13.9 seconds. Arsal [25] also said that KF, or konnyaku, a source of hydrocolloid polysaccharides, comes from the amorphophallus plant. Adding KF to the EF solution can shorten the compressed time of the EF after being poured into the mold. KF contains high glucomannan, which can absorb water, bind water, form a gel (gelling agent), and increase elasticity [51]. Adding KF to the EF solution can shorten the solidification time of EF after being poured into the mold. The low GT value indicates that

Table 1: Physical properties by using KF with different concentrations for making whey-based EFs.

KF concentration (%)	GT (sec)	Thickness (mm)	TS (*N*)	Elongation	WVTR (g/mm^2/hour)
1.0	14.50 ± 1.73^c	0.08 ± 0.00^a	3.20 ± 0.00^a	22.00 ± 2.16^c	1.60 ± 0.24^a
1.5	11.25 ± 0.50^b	0.10 ± 0.02^a	3.80 ± 0.60^a	18.50 ± 0.57^b	3.13 ± 0.00^b
2.0	8.50 ± 1.29^a	0.15 ± 0.01^b	8.17 ± 1.00^b	18.25 ± 0.50^a	7.34 ± 1.20^c

Note: different superscripts indicated very significant difference ($P < 0.01$). WTPR: water vapor transmission rate.

the EF produced is more elastic than others whose EF is more rigid and stiffer.

Table 1 also illustrates the average thickness of whey-based EF produced by treating different KF concentrations, which are 0.15–0.01 mm. Several factors that influence EF thickness are the type and composition of the material used. Several studies have shown almost the same thickness, including the results of this study. The results of research [52] using casein as a base material were the resulting thickness of 0.04–0.06 mm. The EF uses the essential ingredients of whey [53] and agar with a 0.02–0.04 mm thickness. Fox et al. [54] used corn starch as the primary material for making EF, obtaining a 0.08 – 0.13 mm thickness.

Analysis of variance indicated that the manufacture of EF through the addition of KF with various concentrations had a very significant effect ($P < 0.01$) on the thickness of the EF. Duncan's further test showed that the viscosity value would increase if the increased concentration levels of KF were added to the EF. The reason why EF is getting denser is because there are more and more solids in EF as a result of the composition of the ingredients used. One factor that influences the viscosity of this product is the ingredients contained in the solution [52]. Figure 2 shows a cheese-coated EF-based whey-konjac EF.

The amount of solids in solution is positively correlated with viscosity. Viscosity will increase with the higher number of solids in the product. Nugroho et al. [55] suggested that an increase in the number of solids in solution resulted in more and more polymers making up the EF matrix. So, the more KF concentration, the more viscosity will increase, affecting the EF material's thickness.

The EF thickness increases with the increased concentration of starch. This is because the more starch added, the matrix of the polymer composite film will increase, and the amount of EF solids will increase so that the resulting film will be thicker. An increase in starch concentration caused the solids in the film to increase [56]. Consequently, the thickness of the EF also increased. Bourtoom [23] also reported similar results that the ratio of potato starch will increase monoglycerides and can produce EF with increased thickness.

The volume of edible solution can also cause a difference in the thickness of the EF poured on the printed plate; the more edible solution is produced in EF sheets, the greater the thickness is with the same surface area. The thickness of the EF can be adjusted depending on the volume of the solution poured into the mold. The greater the volume of the EF solution used, the thicker the resulting EF will be increased because the total solids in the EF solution will be more significant.

3.2. Tensile Strength (ST). The volume of edible solution can also cause a difference in the thickness of the EF poured on the printed plate—the more edible solution produced in EF sheets, the greater the thickness with the same surface area. The thickness of the EF can be adjusted depending on the volume of the solution poured into the mold. The EF thicker will become, the more significant used EF solution volume. This is because the total solids in the EF solution will be more significant. The same thing was stated [57]: the material's composition and properties greatly determine the EF thickness.

TS is the maximum pull reached until EF is intact before breaking. Strong TS is a mechanical characteristic of EF. The strong interest determines the strength of the EF. The greater the ST, the better the EF resists mechanical damage.

The average TS EF based on whey at various KF concentrations is 3.20–8.17 N, as seen in Table 1. TS from EF gives more significant results when compared with that made from whey and porang protein flour that is 0.4-6.5 N. The results of Judge's research (2015) used whey and agar to have a TS value of 13.3–22.9 N. The TS of EFs from research [25] made from 3% casein with a konjac combination of 1.2–1.5% showed no difference; there was 7.4–7.4 N. Several factors, including the type and amount of material for manufacture and plasticizers, influence the TS of EFs. The type of material determines TS on EF [58]. Each type of material has a different power to form molecular bonds. Arsal [25] noted that the material formulation used in making EF has the TS edible film.

The analysis of variance indicated that the addition of KF concentration in the manufacture of EFs significantly affected the TS of the EFs. Duncan's further tests show that TS will increase as more KF is added to produce EF. The results also show that the thicker the EF, the higher the tensile strength. This is due to the presence of hydrogen bonds in the flour, which results in stronger chemical bonds of konjac edibles, so to achieve maximum tensile strength, it is necessary to have good tensile strength. This is the explanation [42], which states that the hydrogen bonds formed will cause an increase in the matrix of the EF. Konjac will experience a glassy and mutual bond when drying the film, resulting in a compact film matrix and high tensile strength. Handayani and Nurzanah [59] suggested that changes in TS are caused by interactions between protein molecule chains so that less and less of the film matrix is formed. The reduction in intermolecular interactions is due to the high concentration of plasticizers or liquid concentrations, which disrupt the cohesiveness of the starch, reduce intermolecular interactions, and increase the mobility of the polymer [6]. The results of Kasmawati's research (2018) conducted a study

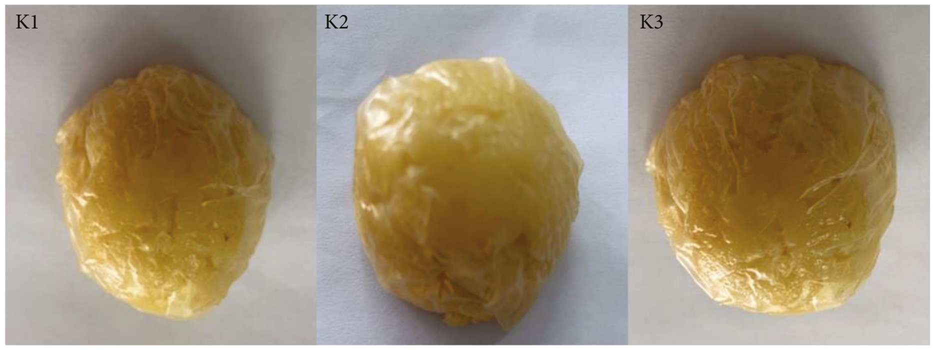

Figure 2: Cheese-coated EF-based whey-konjac (konjac 1.0 (K1), 1.5 (K2), and 2% (K3)).

of shallow whey-based EFs using the plasticizer sorbitol, which affected strong traction. This is because the sorbitol concentration can cooperate in reducing the bond between polymer materials to increase the TS and soften the EF. Sorbitol can reduce the intermolecular forces on the polymer chains, increasing the flexibility of EFs, widening the distance between molecules, and reducing hydrogen bonds in the polymer chains.

The solid tensile properties are physical characteristics related to the strength of EFs to withstand physical damage when used as food packaging materials. The EF with the highest TS is expected to withstand maximum physical impairment so that product damage received is minimal. EFs with high TS can protect packaged products from mechanical disturbances [60].

Elongation shows the elasticity of the EF. Prosperity is the maximum change in length during stretching until the film sample breaks. The average elongation value of whey-based EFs produced by treating with different concentrations of KF is 18.25–22.00%. This is very different from the research results by Arsal [25], using the essential ingredients of casein with a combination of KF 20.4–22.4%. Sara and Karakteristik [61] with whey-based ingredients has an elongation of 20.00–73.33%. Further test results showed that each concentration of KF experienced a different expansion than others.

Variance analysis indicated that the percentage of KF in the manufacture of EF had a very significant effect ($P < 0.01$) on the elongation of EF. Duncan's further test results show that the higher the concentration of KF used in making EF, the higher the elongation value. This is due to adding flour to accompany konjac by increasing the plasticizer used. The addition of dissolved solids and plasticizers affects the performance of the polymer chain, thereby affecting the elongation of the EF [41]. A high elongation value indicates that the EF is more flexible. The addition of plasticizers that are inappropriate or exceed a certain amount will result in low elongation of the EF so that the EF becomes inflexible and brittle [58]. Increasing KF, mainly starch and glucomannan, to a certain level of use does not change its effectiveness; however, if the amount is higher, it will affect the elongation of the EF [25]. Adding 3% concentration would decrease the elongation of the EF. Molecule chain bonds of the solid constituent materials will reduce molecular motion and increase the gelation temperature transition [62]. The bond formed will be stiffer if the gelation transition temperature increases.

3.3. WVTR. WVTR is the rate transmission possible water vapor passes or penetrates an EF on temperature and humidity specific. Research results influence the concentration of flour konjac in manufacturing *EFs* made from base whey, as shown in Table 1.

The average value of the water vapor transmission rate (WVTR) of whey-based EF produced with different concentrations of KF was 1.60–7.34% g/mm^2/hour. This result is higher than research on EF with other materials. Al Awwaly [63] used a whey-based ingredient with various glycerol concentrations having an average WVTR of 0. 01–0.014 g/mm^2/hour. Wahyuni [58] used casein-marked WVTR with an average of 3.26–5.00 g/mm^2/hour.

Analysis of variance indicates that the KF concentration in making whey-based EF has a significant effect ($P < 0.01$) on the WVTR value. Duncan's further test showed that the more KF added, the higher the WVTR value. This is because the WVTR value is influenced by the type and amount of material used to process EFs. The magnitude of the water vapor transmission rate is caused by the type and amount of material used [58]. The hydrophilic water vapor related to the material transmission rate is used in EF making [64]. This condition causes the EF to absorb more and more water from the environment. The addition of plasticizer also affects the value of WVTR. The transmission rate of water vapor increased with the addition of plasticizers in manufacturing EFs. The EFs made of protein and polysaccharides have the characteristic of high-water vapor transmission [61]. The increase in the intermolecular distance and the hydrophilic nature of sorbitol leads to a rise in the water vapor transmittance signature. The increase in intermolecular distance causes the formation of a free whey protein EF matrix space that facilitates water vapor diffusion.

3.4. pH. Potential hydrogen (pH) is a parameter to determine a solution's acidity and wettability level. In this dangke ripening study, the pH was measured to compare cheese covered with EF without using a coating of EF. The pH value can be seen in Table 2.

The pH value of HC continued to increase up to 30 days of storage. HC without an EF coating obtained a pH value

Table 2: Potential hydrogen (pH) dangke uses whey-konjac-EF and without the use of EF by storage time.

Storage time (h)	pH	
	HC without EF	HC coated EF
0	5.24 ± 0.06	5.16 ± 0.01
10	5.23 ± 0.21	5.16 ± 0.01
20	5.32 ± 0.13	5.08 ± 0.00
30	5.19 ± 0.02	5.08 ± 0.00

ranging from 5.19 to 5.32. Meanwhile, HC using an EF layer received a result of 5.08–5.16. The longer the HC is stored, the more alkaline or pH value increases. The longer it is stored, the more alkaline it becomes or loses its acidity, and the pH value can affect the taste of a food product [65]. However, in this study, the change in pH was stable for both types of cheese, so it did not significantly affect HC either without an EF or with an EF coating. The variance analysis showed that HC without EF and using EF with different storage times had no significant effect ($P > 0.05$) on the pH value of HC. This is presumably not influenced by the activity of bacteria present in cheese products. The activity of lactic acid-forming bacteria is caused by the bacteria capable of producing lactic acid at certain temperatures, especially at optimal growth temperatures. The fermentation process involving LAB is characterized by the accumulation of organic acids, causing a decrease in pH and an increase in lactic acid levels.

The pH decreases during the ripening process in cheese, generally due to lactic acid produced by lactic acid bacteria (LAB); the higher the lactic acid (LA) content in the cheese, the lower the pH. LAB in cheese can produce LA from the lactose present in cheese, which is needed to form flavors, preventing pathogenic bacteria's growth and the safety of the final product [66]. LA is the result of glucose metabolism from the breakdown of lactose. The increase in LA occurs due to the presence of H^+ ions. Because the decomposition produces volatile lactose acid and breaks down the organic phosphates in the casein, producing acid, LAB will continue to form LA until the amount of cell activity decreases [67]. The activity of LAB cells can be reduced or even die if the medium they grow is too acidic.

The lower the pH of fresh cheese, the softer the curd formed, while the higher pH will produce elastic fresh cheese. A low pH will make curd with a brittle texture and easily crushed [55]. Meanwhile, a high pH will produce an elastic texture. Acidity affects activity in the coagulation process. This also occurs in the manufacture of fresh cheese with papaya fruit extract. The acidity of milk produced with papaya latex coagulants can affect clotting activity and the curd's strength. It can affect cheese yield [54].

A drop in pH occurs because BAL activity produces energy through the fermentation process with the broken substrate, which becomes simpler components. Formation energy is addressed for metabolism cells. One substrate contained in the liquid starter is lactose in the milk medium.

3.5. Organoleptic Test of FHC Coating by EF. Organoleptic assessment is a test based on sensing processes. The body parts that play a role in sensing are the eyes, ears, sense of taste, smell, and touch. The ability of these five sensory organs to give impressions or responses that can be analyzed or differentiated based on the level of images presented by the panelists. The field of appearance describes the distribution or range of tools that receive sensory stimulation. The ability to provide an impression can be distinguished based on the ability of the sense organs to react to the stimulus received. These abilities include the ability to detect, recognize (recognition), differentiate (discriminate), compare (scaling), and express likes or dislikes (hedonic) [68].

Color is the first sensory that can be seen directly by the panelists. The presence of spots on the surface of the cheese can identify damage to the color of the cheese. Cheese coated with and without EF has the color characteristics presented in Table 3.

Observations on the color change of HC without EF and HC coated with EF can be seen in Table 3 and Figure 3. The color of HC without EF increased during storage from 3.16 to 4.40 (slightly yellowish white), and HC coated with EF experienced an increase in color during storage of 3.86–5.33% (yellow-white). The results of this study were higher than the results of research [33], which obtained a product of coconut cheese with a color of 3.44. From the variance analysis, we can see that the length of storage of DC had a very significant effect ($P < 0.05$) on the suitability of the cheese color coated with EF and without EF. Further test results showed that the longer DC was stored without an EF layer, the more yellow the color. This is because the yellow color of DC is caused by ripening. The ripening cheese within a month will produce complex and yellow cheese [69]. The color of the EF that the naked eye can detect is yellowish. Color gets a slight influence from whey color. The whey color of some literature is yellowish-white. The carotenoid content in the milk determines the intensity of the color. These carotenoids are pigments that produce a yellowish color. The carotenoid pigments found in cow's milk will give a yellow color to the coagulum-formed [55].

Texture is one of the characteristics of physical organoleptic assessment using the sense of touch or hands. Texture is also important to assess consumer acceptance of food products. Texture is one parameter affecting consumer acceptance because it affects food delicacy. The texture formed is influenced by the raw materials of a food product [70]. The research results on the texture of HC using and without EF coating can be seen in Table 3.

The texture of HC coating with EF decreased with the length of storage, namely, 4.05-5.04. Likewise, HC with an EF layer, namely 3.55–4.26. Analysis of variance showed that the storage time of DC had no significant effect ($P > 0.01$) on the texture value. It can be seen in Table 3 that the longer the storage time, the texture of DC, both coated and not using EF, will produce a hard texture. This is due to the ripening process, which results in more extended storage and a more complex cheese texture. Cheese ripening too long will produce a challenging cheese [71].

Aroma is the smell emitted by a processed food product caused by chemical odor stimulation by the sense of smell

Table 3: Average score color, texture, and aroma HC coated whey-konjac EF and without coated EF.

DC	Storage time (h)	Code	Color	Texture	Aroma
HC without EFs	0	WT 1	3.86 ± 0.33^{a}	4.93 ± 0.24	4.93 ± 0.24
	10	WT 2	4.19 ± 0.62^{a}	5.04 ± 0.88	5.04 ± 0.88
	20	WT 3	3.90 ± 0.21^{a}	4.16 ± 0.19	4.16 ± 0.19
	30	WT 4	5.33 ± 0.58^{b}	4.05 ± 0.20	4.05 ± 0.20
Coated DC EFs	0	CT 1	4.40 ± 0.57^{a}	4.26 ± 0.55	2.08 ± 0.63
	10	CT 2	3.19 ± 0.62^{a}	3.80 ± 0.67	3.70 ± 0.54
	20	CT 3	3.16 ± 0.33^{a}	3.93 ± 0.77	3.48 ± 0.15
	30	CT 4	4.07 ± 0.27^{b}	3.55 ± 0.21	3.05 ± 0.34

Note: different superscripts show a significant difference ($P < 0.05$).

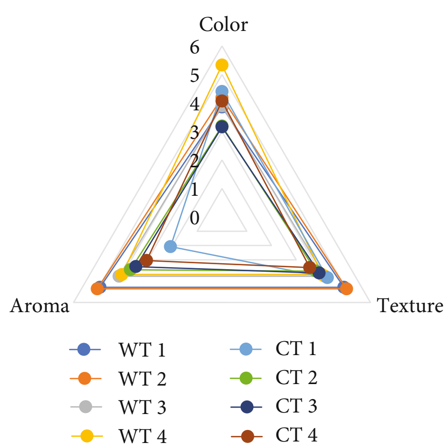

Figure 3: Radar map of average score color, texture, and aroma HC-coated whey-konjac EF and without coated EF (WT: HC without EFs; CT: coated DC EFs).

Table 4: Average preference coated DC whey-konjac EF and without coated EF.

Storage time (h)	Preference	
	Cheese without EF	Coated DC EF
0	3.50 ± 0.10	3.50 ± 0.10
10	3.56 ± 0.46	3.56 ± 0.46
20	4.00 ± 0.37	3.24 ± 1.19
30	4.03 ± 0.30	3.71 ± 0.30

due to the presence of volatile contents that can affect a food's acceptance by consumers and increase the attractiveness of the food product. The smell is caused by chemical odor stimulation by the olfactory nerves in the nasal cavity [72]—the results of the aroma study of DC products coated with and without EF.

Table 3 and Figure 3 display that the longer the incubation time, the more HC coated with EF, and the smell of milk decreases without coated EF. Analysis of variant data indicated that the length of DC storage had no significant effect ($P > 0.01$) on the aroma value of HC milk without EF or HC EF coating. This is because the longer the storage, the less smell of milk. The aroma value in this study shows that the aroma of milk is in the control treatment or 0 days (without cooking) because the control treatment is still in the form of fresh cheese, so the milk aroma is still detected. Consumers prefer the control cheese in this controlled study. Unripened cheese is a type of fresh cheese without ripening; the aroma of the cheese has not been formed and is still dominated by the aroma of the milk used [73].

The hedonic test is a preference test (Table 4). Panelists expressed likes or dislikes. This level of preference is called hedonic. The panelists' level of choice for food products includes preference for texture, color, and aroma [74].

With longer storage, the HC coated with EF decreased by 3.50 and 4.03. Meanwhile, HC without EF ranged from 3.24 to 3.71. The preference value is similar to Daulay's [73] results, where EF research produces a preference value ranging from 2.59 to 4.00. Analysis of variance showed that the curing time of HC coated with EF at 5°C had no significant effect ($P < 0.01$) on preference. The longer the storage, the more complex the cheese texture. Besides that, the EF does not stick to the cheese and makes the appearance of the cheese less attractive to the panelists. The cheese ripened too long will produce hard cheese, resulting in panelists not liking the product [75].

4. Conclusion

The whey-based EF combined with KF with a percentage of 1.5% is perfect in decreasing its viscosity and elongation. HC coated with and without EF can increase the pH value and color but decrease the texture, aroma, and preference value. EF, made from whey and konjac, can be used to coat hard cheese, and for 20 days of storage at 5°C, the quality of the cheese is good.

Data Availability

The data supporting the study's finding are available and will be provided upon reasonable request by the corresponding author.

Conflicts of Interest

The authors have declared no conflicts of interest for this article.

Authors' Contributions

R.M. was responsible for the conceptualization. R.M., F.A.A., and R.W.K. were responsible for the data curation. R.M. and F.A.A. were responsible for the formal analysis. R.M. and F.A.A. were responsible for the methodology. R.W.K. was responsible for the software. R.M. was responsible for the validation. R.M., F.M., F.A.A., W.H., I.I, K.K., W.S.P., and M.A were responsible for the investigation. R.M., F.A.A., and R.W.K. wrote the original draft. R.M., F.M., F.A.A., W.H., I.I., K.K., W.S.P., M.A., and R.W.K. wrote, reviewed, and edited the manuscript.

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