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# Effects of the Antimicrobial Component *Rhodotorula glutinis* in Whey on the Physicochemical, Microbiological and Organoleptic Properties of Beef

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## ABSTRACT

Beef is meat from cattle that is highly perishable if not stored or treated properly. *Rhodotorula glutinis* has antimicrobial properties, and if used with whey protein could potentially produce a coating material to preserve the beef. This research aims to determine the effect of coating materials using the antimicrobial component *Rhodotorula glutinis* in whey on the physicochemical, microbiological and organoleptic properties of beef. Four treatments (T0 = 100% whey, T1 = 25% whey: 75% *Rhodotorula glutinis*, T2 = 50% whey 50% *Rhodotorula glutinis*, T3 = 75% whey 25% *Rhodotorula glutinis*) were prepared. The cooking loss, water holding capacity, tenderness, fat, protein, moisture, initial spoilage, total plate count, resistance, and organoleptic properties analyses were carried out. The use of whey and the antimicrobial component *Rhodotorula glutinis* as an edible coating did not affect physical quality, chemical quality, microbiological quality and organoleptic except for T1 which had a significant effect on the tenderness value after 5 hours (63.28%), protein content (22.02%), fat content (7.99%), and initial spoilage (681min). In conclusion, using 25% whey and 75% *Rhodotorula glutinis* is the best concentration as a coating for beef preservation.

**Key words:** Beef, Coating, *Rhodotorula glutinis*, quality, Whey

## INTRODUCTION

Beef is a highly nutritious protein source derived from ruminant livestock, containing essential nutrients such as high-quality protein, fats, minerals, and a small amount of carbohydrates (Nurwanto and Surhatayi 2012). Despite its nutritional benefits, beef is highly perishable due to microbial contamination, especially during post-slaughter handling, storage, and processing (Ilahi et al. 2021). To extend shelf life and maintain product quality, synthetic preservatives such as nitrite, nitrate, sorbic acid and benzoic acid are commonly used in the meat industry. However, growing consumer awareness of health risks associated with synthetic additives has driven demand for clean-label meat products containing natural preservatives (Yu et al. 2021). Natural bio-preservatives, including plant extracts from *Moringa oleifera*, garlic, ginger, *Syzygium polyanthum*, and antimicrobial peptides, have been explored as safer alternatives for meat preservation (Pursudarsono et al. 2015; Beti et al. 2020; Ramadani et al. 2021; Setianingsih and Jayanti 2022).

In recent years, microbial-based preservation techniques have gained attention as a sustainable approach to meat processing. *Rhodotorula glutinis*, a non-pathogenic yeast, has demonstrated antimicrobial properties, making it a promising candidate for natural meat preservation (Roy et al. 2023). This yeast belongs to the order *Sporidiobolales*, class *Microbotryomycetes*, and phylum *Basidiomycota* (Kot et al. 2016). It is characterized by its coral pink pigmentation, rapid growth at 30°C and ability to produce bioactive compounds such as microbial oils, β-carotene, torularhodin, and torulene (Hernández-Almanza et al. 2014; Zoz et al. 2015). Notably, torularhodin exhibits strong antimicrobial and antioxidant properties, making it a valuable component in edible coatings for food preservation (Ungureanu et al. 2016). The antimicrobial activity of *R. glutinis* is primarily attributed to its ability to synthesize bioactive fatty acids, including oleic, linoleic, palmitic and stearic acids, which inhibit the growth of spoilage microorganisms (Putranto et al. 2010).

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An advantage of *R. glutinis* is its ability to utilize industrial by-products, such as whey, as a growth medium for metabolite production. Whey, a major by-product of cheese manufacturing, is rich in bioavailable proteins and nutrients, making it an ideal substrate for microbial fermentation (Fatma and Taufik 2015). However, despite its nutritional value, whey remains underutilized in the food industry, often being discarded as waste (Tunick et al. 2025). Recent studies have explored the use of whey in microbial fermentation to enhance metabolite production while simultaneously reducing environmental waste (Wróblewska et al. 2023). The bioconversion of whey into value-added compounds by *R. glutinis* offer a dual benefit of sustainable waste management and enhanced food preservation.

With increasing consumer preference for minimally processed foods with extended shelf life, the application of edible coatings enriched with antimicrobial agents has emerged as an effective preservation strategy. Recent research has demonstrated that edible coatings containing bioactive compounds can significantly improve the physicochemical and microbiological stability of meat products (Forato et al. 2021; Hashemi et al. 2023; Smeti et al. 2025). Given the potential of *R. glutinis* as a bio-preservative, this study aims to evaluate its effectiveness in an edible coating for beef. Specifically, this research investigates the impact of *R. glutinis* cultivated in whey on the physicochemical, microbiological, and organoleptic properties of beef, providing insights into its potential application in the meat industry as a natural preservative.

## MATERIALS AND METHODS

### Raw materials

Five kilograms of beef thighs were obtained from a traditional market Rancaekek Trade Center (RTC), Dangdeur Rancaekek, West Java, Indonesia. The beef was cut into 20 parts weighing 250g each for the treatments.

Whey was obtained from 3L of cow's milk that had been pasteurized at 60°C for 3min. The milk was then cooled to 35°C, and 1% papain enzyme along with 0.4% CaCl of the total milk was added. The mixture was left for 1 hour, allowing the milk to separate into two parts: curd and whey. The curd was cut into cubes and left to sit for 30min. The whey liquid was then ready for use. The method has been illustrated in Fig. 1. Subsequently, the results of the treatment are presented in Fig. 2.

### Experimental design

Four edible coating solutions with different concentrations were prepared: T0 (100% whey), T1 (25% whey: 75% *Rhodotorula glutinis* antimicrobial component), T2 (50% whey: 50% *Rhodotorula glutinis* antimicrobial component) and T3 (75% whey: 25% antimicrobial component *Rhodotorula glutinis*) (four treatments × five replications). The treatments were carried out by completely dipping the fresh beef for 3s in the solution, placing it in the covered plastic container and leaving it for 10min at room temperature (24-29°C) before proceeding with the analyses. For tenderness analysis, the coated beef samples were further kept for another 5 hours in the same condition.

### Physical properties

#### Cooking loss

The cooking loss was measured based on the method by Prawesthirini et al. (2009). The treated beef sample was cooked in hot water at 80°C for 30min. The weight with the Fujitsu FS-Q, of the beef sample was measured before and after cooking and the cooking loss was calculated using the following equation:

$$\text{Cooking Loss (\%)} = \frac{initial\ weight - final\ weight}{initial\ weight} \times 100$$

#### Water holding capacity

The water holding capacity (WHC) was measured using the method by Soeparno (2005). A sample of 0.3g was placed on 2 glass plates covered with filter paper, pressed with a load of 35kg for 5min and the wet area was calculated. Calculation of Water Holding Capacity (WHC) was carried out using the following formulas:

Wet area = Area of wet area – Area of covered area

$$\text{MgH2O} = 100 - \frac{Wet\ Area\ (cm2)}{0.0948} - 8.0$$

$$\text{Water Content} = \frac{\text{Initial sample weight - Final sample weight}}{\text{Initial sample weight}} \times 100\%$$

$$\text{Water Holding Capacity} = \text{Water content} - \frac{\text{mgH}^2\text{O}}{300} \times 100$$

#### Tenderness

Tenderness testing was measured using a penetrometer with the HUMBLT H-1200 (Muchtadi and Sugiyono 2011), a sample cut to the size of 5×3cm was placed under the penetrometer needle with the scale needle showing zero, the measurement was carried out for 10 seconds, and calculated using the following formula:

$$\text{Tenderness (mm/g/sec)} = \frac{\text{average measurement}}{\text{10 seconds}}$$

### Chemical properties

#### Water content

Water content was measured using the AOAC method (AOAC 2012). The porcelain cup was dried in an oven Lab Tech LDO-100E, Indonesia at 150°C for 15min. The porcelain cup was placed in a desiccator Duran for 5–10min. A sample of 5g was weighed by using Fujitsu FS-Q and placed in a porcelain cup then placed in an oven Lab Tech LDO-100E at a temperature of 100–105°C for 3-6h, then cooled in a desiccator Duran, and weighed until it reached a constant weight. Water content was calculated using the following formula:

$$\text{Water Content (\%)} = \frac{\text{Porcelain cup weight - Porcelain cup and sample weight}}{\text{Porcelain cup weight}} \text{ x } 100\%$$

#### Protein

Protein content was measured using the Kjeldahl method using a Pyrex Kjeldahl flask, Pyrex distillation apparatus, Pyrex burette, Iwaki beaker glass, Iwaki Erlenmeyer flask, Iwaki measuring flask, Iwaki measuring cup, Pyrex volume pipette, Iwaki test tube and Fujitsu FS-Q analytical balance (AOAC 2012). A sample of 2g was put into 100mL and 2g of K2SO4 and CuSO4 were added and 2.5mL of clear green H2SO4. The mixture was cooled and transferred into a distillation apparatus, and 10mL of concentrated NaOH distilled water was added. The distillate was collected in an Erlenmeyer containing 5mL of H3BO3 and methyl red and blue indicators and then distilled using 0.02N HCl. Protein content was calculated using the following formula:

$$\% \text{ Nitrogen} = \frac{\text{mL HCl sample - mL blank}}{\text{mg sample}} \text{ x N x } 14.007 \text{ x } 100\%$$

$$\%\text{Protein} = \%\text{ nitrogen x } 5.55$$

**Fat**

The fat content was determined using the Soxhlet method with tools Auto Fat Extraction System FOSS Soxtec 2050 (AOAC 2012). The fat flask was placed in the oven at 105°C for 15min, then cooled in a desiccator for 15min to remove water vapor. Next, 5g of sample was wrapped in lead paper, covered with fat-free cotton and then placed into Soxhlet extraction which had been connected to a fat flask. Hexane solvent was poured until the sample was submerged and reflux or fat extraction was carried out for 5-6h or until the fat dropped into the fat flask. The fat solvent that had been used was distilled, and stored, and the fat extract contained in the fat flask was dried in the oven at a temperature of 100-105°C for 10min. The fat flask was cooled in a desiccator for 15min and weighed. The drying stage was repeated until a constant weight was obtained. Fat content was calculated using the following formula:

$$\text{Fat Content } \% = \frac{\text{[weight of flask and extracted fat(g)] - [weight of empty flask(g)]}}{\text{Sample weight}} \text{x} 100\%$$

**Microbiological properties**

**Total Plate Count (TPC)**

The microbiological analyses, including the Total Plate Count (TPC), were conducted using the spread plate technique (Suharman et al. 2023). Sample preparation was prepared in 6 sterile test tubes and filled with 9mL of 0.9% NaCl. 1mL of homogenized sample was pipetted and inserted into a test tube containing 9mL of 0.9% NaCl (dilution $10^{-1}$), 1mL of sample $10^{-1}$ was transferred into the next tube as a dilution of $10^{-2}$, and so on until dilution $10^{-6}$. Then 0.1mL was taken from dilutions $10^{-5}$ and $10^{-6}$ and planted in Merck Natrium Agar (NA) media, which had frozen and was sterile, the sample was leveled using a hockey spatula and incubated for 24 – 48h at 37°C. The number of colonies was calculated using the following formula:

$$N = \frac{\sum C}{[(1 \times n_1) + (0.1 \times n_2)] \times (d)]}$$

N = number of colonies per ml or gram of product
$\sum C$ = total number of colonies on all plates
n1 = the number of plates counted in the first dilution
n2 = the number of plates counted in the second dilution
d = the first dilution that is calculated/meets the requirements.

**Initial rot**

Initial decay was determined by the $H_2S$ method (Lukman and Trioso 2009). A total of 10g of beef sample was placed in a petri dish and covered with Whatman No. 41 filter paper, then 1-2 drops of 10% Pb acetate solution were dripped into the center of the filter paper. The petri dish was covered with a lid and sealed with parafilm and stored at room temperature 25°C. The initial time of sample decay was recorded by observing the appearance of black-brown color or spots on the filter paper.

**Inhibition test**

The inhibition test was carried out using the Kirby Bauer method (Kaseng et al. 2016). Sterile osse was placed into a test tube containing bacterial suspension and smeared on NA media. Then, a well was made and filled with the diluted sample and covered using a paper disc. The sample was incubated at a temperature of 37°C for 24–48h and was declared positive if it was marked by the formation of a clear inhibition zone around the paper disc and then calculated using the formula:

$$\text{Inhibition test} = \frac{(\text{dv}-\text{dw})+(\text{dh}-\text{dw})}{2}$$

dv = Vertical clear zone diameter
dh = Horizontal clear zone diameter
dw = Well hole diameter

**Organoleptic properties**

Organoleptic tests were conducted on 20 semi-trained panelists. Semi-trained panelists are panelists who have acquired knowledge about organoleptic tests and before the test was conducted were given an explanation to recognize and assess certain properties, selected from a limited group which in this study came from students of the Faculty of Animal Husbandry, Padjadjaran University. Taste, aroma, color, texture and total acceptance were measured using a 9-point hedonic scale consisting of 1 = extremely dislike, 2 = very dislike, 3 = dislike, 4 = somewhat dislike, 5 = neutral, 6 = somewhat like, 7 = like, 8 = very like, and 9 = extremely like (SNI No.01-2346-2006).

**Statistical analysis**

This research was carried out using a Completely Randomized Design (CRD), which consisted of 4 treatments and 5 replications. Data were analyzed using the Statistical Package for the Social Science (SPSS) software with the ANOVA test and continued with the Duncan Multiple Range Test if there were significant differences ($P<0.05$). The organoleptic tests were carried out using the Kruskal-Wallis test and the Man-Whitney advanced test.

## RESULTS AND DISCUSSION

**Cooking loss, Water Holding Capacity (WHC) and tenderness**

Table 1 shows the cooking loss, WHC and tenderness of the cooked meat related to the amount of water released from the cells, including muscle fibers and can be influenced by the temperature, pH, cooking time, and muscle type (Murti et al. 2013; Kartikasari et al. 2019). No differences ($P>0.05$) were observed for the cooking loss between treatments indicating that different concentrations of whey and *Rhodotorula glutinis* did not affect the cooking loss. Beef coated with edible coating can maintain the quality against cooking loss, this is in line with Apirantini and Budiman (2020), which reported that the addition of propolis extract as an edible coating ingredient can maintain the quality of beef against cooking loss. Good quality meat is indicated by a low cooking loss value, this is because little nutritional content is lost during the cooking process (Silaban et al. 2021).

Water holding capacity is the ability of meat to bind water due to external pressure or processing such as during cutting, heating, and grinding processes, as well as from environments containing liquids. The use of whey and the antimicrobial component *Rhodotorula glutinis* as an edible coating did not show significant changes ($P>0.05$) between treatments. This can be supported by the consistent moisture content results (Table 2). In addition, protein content in meat will go hand in hand with water holding capacity. This is further proven by the high protein content results in this study (Table 2). The results showed that the water holding capacity values are in the normal range between 44.31-77.67% (Hartono et al. 2013).

**Table 1:** Physical Quality of beef with whey coating and antimicrobial component *R. glutinis* as edible coating

| Treatment | Cooking Loss, % | Water holding capacity, % | Tenderness, mm/g/10 sec | |
|---|---|---|---|---|
| | | | 10min | 5 hours |
| T0 | 41.9 0±1.75a | 76.85±6.58a | 40.32±3.13a | 71.88±15.47ab |
| T1 | 38.84±3.29a | 73.87±2.08a | 42.48±2.23ab | 63.28±6.47a |
| T2 | 39.25±3.27a | 73.26±2.65a | 42.00±2.03ab | 76.76±8.57ab |
| T3 | 43.75±3.21a | 76.88±6.60a | 44.92±2.55b | 81.64±11.56b |

Values (mean+SD) followed by different letters in a column differ significantly (P<0.05). T0 = 100% whey, T1 = 25% whey: 75% *Rhodotorula glutinis*, T2 = 50% whey 50% *Rhodotorula glutinis*, T3 = 75% whey 25% *Rhodotorula glutinis*

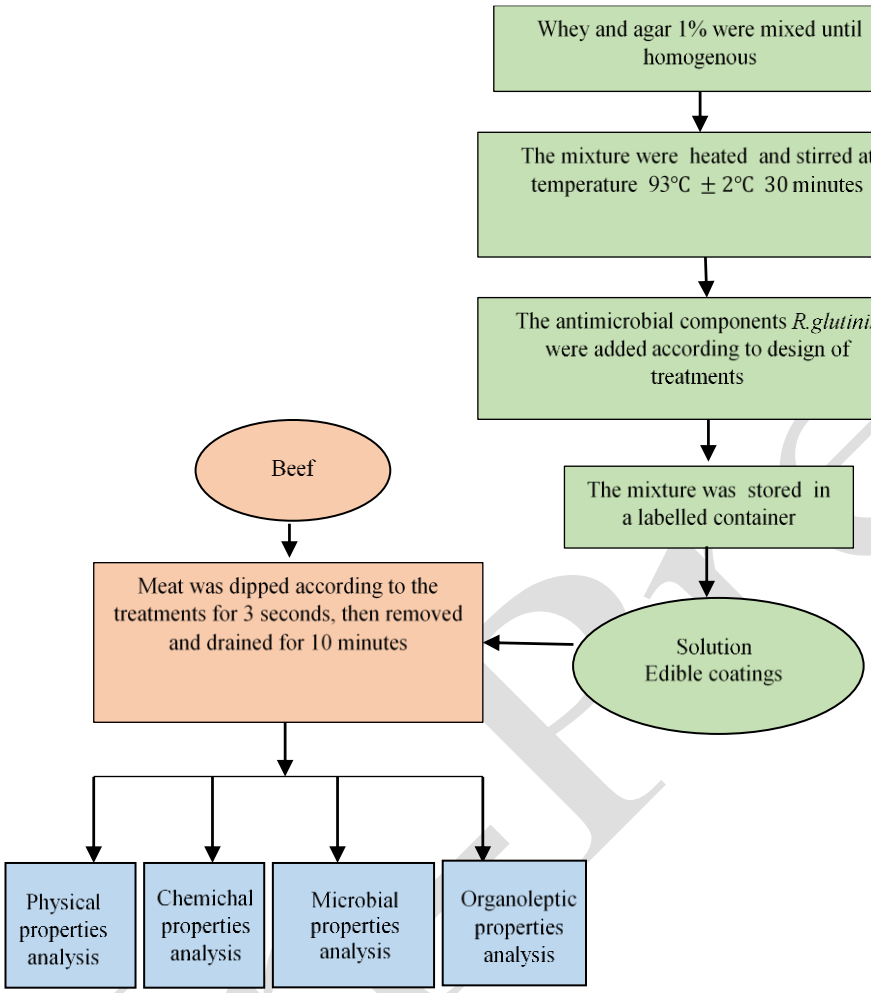


**Fig. 1:** Research flowchart (Source: Research Documentation 2023).

**Table 2:** Chemical quality of beef with whey coating and antimicrobial component *R. glutinis* as edible coating

| Treatments | Fat (%) | Protein (%) | Water Content (%) |
|---|---|---|---|
| T0 | 8.03±0.25a | 21.16 0.23a | 79.67±6.57a |
| T1 | 7.99±0.03a | 22.02±0.17b | 76.54±2.20a |
| T2 | 6.86±0.12c | 24.49±0.19d | 75.92±2.69a |
| T3 | 7.58±0.22b | 23.62±0.55c | 79.64±5.92a |

Values (mean+SD) followed by different letters in a column differ significantly (P<0.05)

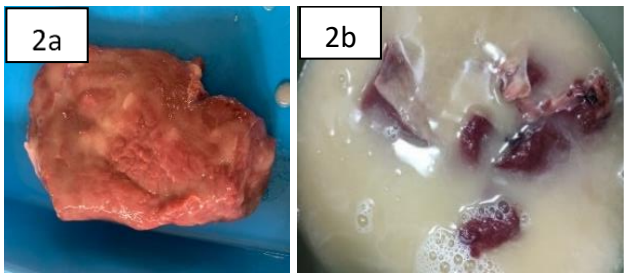


**Fig. 2:** Before treatment (2a) and after treatment (2b) (Source: Research Documentation 2023).

Tenderness is the main factor in assessment and influences the level of consumer taste preference. The easier the meat to be chewed and the less meat remaining during the chewing process indicates that the meat is getting softer (Sinaga et al. 2021). The beef treated with edible coating and left for 10min showed increased tenderness values as the *Rhodotorula glutinis* concentration increased with increments between T3 and T1. Samples that were coated and left for 5h had T1 significantly more tender (P<0.05) compared to T3. Use of antimicrobial components *Rhodotorula glutinis* can produce protease enzymes which can increase the tenderness of beef caused by protein degradation. The edible coating effectively preserves meat tenderness (Hashemi et al. 2023). The decomposition and breakdown of meat protein and connective tissue will give the meat a softer and tender texture (Suantika et al. 2017). Yeasts that can produce extracellular protease enzymes are *Rhodotorula, Pichia, Candida, Cryptococcus, Hansenula* and *Metschnikowia* (Fleet 1990). Tenderness can be influenced by factors

before slaughter (antemortem) such as the age, type of livestock, conditions, etc. as well as after slaughter such as the processing methods and the presence of additional tenderizer substances (Lapase et al. 2016). This study proves that the coating treatment can improve the tenderness of the beef, especially with a higher concentration of *Rhodotorula glutinis*.

**Fat, protein and moisture contents**

Fat is an energy source substance that provides the largest number of calories and source for the body's metabolic processes, in addition to protecting cell wall components (Mamuaja 2017). Table 2 shows the fat content values for all the samples between 6.86–8.03%, which can be considered normal. Soeparno (2015) stated that generally, the fat content in beef ranges from 1.5–13%. The edible coating should function as a barrier to inhibit fat migration similar to the work by Laga et al. (2021), in which the edible coating functions to slow down the migration of water vapor, fat and oil and gas transfer. A reduction in fat content ($P<0.05$) was observed for meat treated with a lower concentration of *Rhodotorula glutinis*, T0 and T1 against T2 and T3. This can happen due to *Rhodotorula glutinis* having lipolytic properties which can hydrolyze lipids. Roostita et al. (2019) reported that yeast which has lipolytic properties is mainly found in *Candida*, *Rhodotorula*, and *Cryptococcus*, this genus plays a role in the breakdown of fat from meat and dairy products. At 75% *Rhodotorula glutinis*, higher fat content was observed, this could be caused by *Rhodotorula glutinis* contained in edible coatings capable of producing oil and can affect the fat content in meat.

Protein is the largest chemical component in meat which plays an important role in growth, and cell maintenance and is a source of calories (Fausiah and Al Buqhori 2019). The function of protein in the body is to form new tissue and maintain existing tissue, a source of energy other than carbohydrates and fat, and a building and regulating substance (Umar 2023). The results show that the protein content in beef that has been coated with edible coating with the addition of whey and the antimicrobial component *Rhodotorula glutinis* ranges from 21.17-24.48%. Adding whey as a coating material could increase the overall protein content of the meat samples (Table 2) as milk whey contains 0.8% protein (Oktafiyanti et al. 2024).

The coated meat showed that the water content was still within normal limits (75.92–79.67%) (Table 2), similar as reported by Soeparno (2015), water ranges between 68–80% in meat. In addition, Liur et al. (2019) stated that the water content in meat does not exceed 80%. The function of the edible coating is to protect the coated food ingredients so that physical changes do not occur and inhibit changes in the contents of the coated food ingredients.

**Microbiological quality**

**Beginning of decay (minutes)**

The addition of various concentrations of the antimicrobial component *Rhodotorula glutinis* in whey as an edible coating showed a significantly different result ($P<0.05$) at T1 (25% whey and 75% *Rhodotorula glutinis*) (Table 3). The result could occur because of the carotenoid content in *Rhodotorula glutinis* which is antibacterial and plays an important role in reducing the number of pathogenic bacteria in food such as *Salmonella enteritidis*, *S. aureus*, and *B. subtilis*, and thus can be used as a natural preservative in food storage and packaging (Keceli et al. 2013). The edible coating effectively prevents microbial growth (Hashemi et al. 2023).

**Table 3:** Microbiological quality of beef with whey coating and antimicrobial component *R. glutinis* as edible coating

| Treatments | Beginning of Decay (minutes) | TPC ($\times 10^6$ CFU/g) | Inhibition Test (mm) |
|---|---|---|---|
| $T_0$ | 531±65.03a | 3.70±2.38a | 0.00a |
| T1 | 681±131.45b | 3.34±1.95a | 0.00a |
| T2 | 543±69.06a | 3.57±3.89a | 0.00a |
| T3 | 531±49.29a | 3.47±2.75a | 0.00a |

Values (mean+SD) followed by different letters in a column differ significantly ($P<0.05$)

The initial process of rot in meat is marked by the formation of lead sulfide (PbS), which then causes a colour effect in the form of brownish spots on filter paper that has been treated with Pb acetate. The short shelf life of fresh meat and causing it to rot can occur due to the activity of spoilage microbes which causes the degradation of proteins in meat into amino acids (Rahayu and Darmawi 2022). Types of spoilage bacteria that are often found in fresh meat include *Aeromonas*, *Enterococcus*, *Acinetobacter*, *Moraxella*, *Chromobacterium*, and *Pseudomonas* (Nychas et al. 2008).

**Total Plate Count (TPC)**

The addition of whey and the antimicrobial component *Rhodotorula glutinis* averaged in the range of 3.34 to $3.70\times10^6$cfu/g. The results showed that the edible coating used could suppress the number of bacteria from both whey and the antimicrobial *Rhodotorula glutinis*, although not significantly. This is in line with research by Chawla et al. (2021), which states that coating food ingredients using edible film with added antimicrobials can limit, inhibit and suppress the growth of microbes that can cause food contamination.

The results show that the presence of an edible coating on beef exceeds the maximum quality requirements for microbial contamination in meat that has been determined by SNI, which is $1\times10^6$cfu/gram (SNI 7388-2009). Microbial contamination that exceeds the predetermined threshold can be influenced by contamination from previous conditions, and after slaughter, slaughterhouse conditions (Sundari et al. 2020). Contamination can also occur due to the use of unclean water, unhygienic equipment, or a polluted environment (Ilahi et al. 2021). Factors that can influence the growth of microorganisms are generally divided into two, namely intrinsic factors (meat nutrition, water conditions, pH, oxidation-reduction potential and absence of barrier substances) and extrinsic factors (temperature, relative humidity, presence or absence of oxygen and condition of the meat) (Ilahi et al. 2021).

**Inhibition test**

Animal food products are safe to consume if they do not contain pathogenic bacteria, namely microbes that can cause health problems in humans who consume them. Foodborne disease is a common problem in public health

**Table 4:** Organoleptic test results of beef with whey coating and the antimicrobial component *R. glutinis* as edible coating

| Treatments | Aroma | Flavor | Colour | Texture | Overall acceptability |
|---|---|---|---|---|---|
| T0 | 5.15±1.13a | 5.00±1.45a | 4.45±1.54a | 5.30±0.92a | 5.00±0.91a |
| T1 | 4.90±1.11a | 5.25±1.21a | 4.95±1.19a | 5.75±1.07a | 5.45±0.99a |
| T2 | 4.85±1.18a | 6.05±1.19a | 4.60±1.46a | 4.90±1.65a | 5.15±1.31a |
| T3 | 5.05±0.99a | 5.00±1.29a | 4.15±0.98a | 5.40±1.09a | 5.15±1.04a |

Values (mean+SD) followed by different letters in a column differ significantly (P<0.05)

(Rahayu and Darmawi 2022). The results of a study on the effect of the concentration of the antimicrobial component *Rhodotorula glutinis* in whey as an edible coating on the inhibition test showed that no inhibition zone (negative) (0.00mm) was formed in all treatments on beef. Testing of edible coating on beef was carried out on *E. coli* bacteria. *E. coli* bacteria are Gram-negative bacteria, rod-shaped, do not form spores, can move using flagella, can produce gas from glucose and can ferment (Ilahi et al. 2021). The clear zone that was not formed could be because the antimicrobial component *Rhodotorula glutinis* has a greater antibacterial ability on Gram-positive bacteria compared to Gram-negative bacteria (Yolmeh et al. 2016)

The inhibition zone that was not formed can also be caused by the edible coating only being able to protect beef from external contamination, but does not change the nutritional content of the beef. The inhibition zone that was not formed in the tested bacteria was because the concentration of flavonoids in the extract was not enough to damage the bacterial cell membrane, so that the bacteria could still multiply their cells. Factors that can affect the formation of the inhibition zone are the sensitivity of bacterial growth, the reaction between the active ingredient and the medium and the incubation temperature (Shufyani and Dominica 2022).

**Organoleptic evaluation**

Organoleptic testing is a test that uses human senses as a tool to assess product quality based on smell, taste, texture and several other factors needed to assess a food product (Ismanto 2022). Table 4 shows the results of the organoleptic test on all the treated beef samples. Overall, no significant differences were observed for all the parameters tested between all the treatments. Beef that has been coated with edible coating has a distinctive milky and sour aroma. The characteristic aroma of milk results from the use of whey. Khusna et al. (2021) stated that whey is a by-product of processing cheese which still has quite a high nutritional content and, therefore, can have a strong aroma. The sour aroma is produced from the use of *Rhodotorula glutinis* in edible coatings, and according to Putranto et al. (2010), *Rhodotorula glutinis* has organic acid properties in the form of hexanoic, octanoic and decanoic acids.

Taste is an important factor in determining and influencing the level of acceptance of a product (Khalisa et al. 2021). Based on observations, the taste character is at a neutral level, which was still within normal limits, like the taste of meat in general. Taste can be influenced by chemical factors, temperature, concentration, and interactions with other flavour components (Putri et al. 2021). The use of whey and *Rhodotorula glutinis* as edible coatings did not have a significant effect on the taste of meat, because this coating only protects and coats the meat from the outside and does not penetrate the meat.

Meat color with edible coating produces a normal red color of beef, without any significant changes to the color of the meat. Factors that can influence color include age, gender, breed, environment, conditions before cutting and storage, intramuscular fat and water content and feed given (Mudirman et al. 2019). Meat color can also be influenced by the myoglobin levels in the meat.

The texture of beef in each treatment was at a neutral level. A good meat texture means that if you press it with your finger, the meat will not be damaged and if it crumbles, it indicates damaged meat (Gunawan 2013). The texture of the meat after boiling produces meat that is rough and somewhat dry but is still acceptable to the panelists. Texture changes can occur during the boiling process, in which the protein denaturation process occurs (Lapase et al. 2016).

Total acceptance from the panelists' assessments was in the neutral to favorable range. These results show that the use of whey and antimicrobial components as a natural coating is still acceptable to the panelists. The use of whey and *Rhodotorula glutinis* can give the impression of a milky aroma to the meat produced by whey, but does not change the character of color, taste, aroma and texture and is still acceptable to the panelists.

**Conclusion**

The use of whey from 25 to 100% and the antimicrobial component *Rhodotorula glutinis* from 25 to 75% as an edible coating can be applied for coating beef. Adding the antimicrobial component *Rhodotorula glutinis* in whey did not affect physical quality, chemical quality, microbiological quality and organoleptics. Except, the results have a significant effect on the tenderness value after 5 hours (63.28%), protein content (22.02%), fat content (7.99%) and initial spoilage (681min) in beef using 25% whey and 75% *Rhodotorula glutinis*, in which the most potential concentration to be used for coating the beef.

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