Characteristics of Casein–Chitosan Edible Coating and Its Preservative Effect in Meat during Accelerated Storage

M W Apriliyani, P P Rahayu, R D Andriani, A Manab, Purwadi, M E Sawitri, and D T Utama

Faculty of Animal Science, Universitas Brawijaya, Malang, 65145, Indonesia

muliaapriliyani@ub.ac.id

Abstract. Meat is one of perishable foods that should be handled hygienically to preserve its quality. Edible coating containing antibacterial agent can be used for preserving meat by providing a barrier against microbial contamination. The objective of this study was to compare the effectiveness of edible coating made from casein-chitosan (CC) and casein-chitosan modified (CCM) on preserving the quality of meat during accelerated storage test. The coating solutions were characterized in terms of their composition (carbohydrate, protein, fat, moisture content, pH, Aw, and antioxidant capacity) in order to optimize coatings composition, then applied to the meat for accelerated storage test for 24, 120, 216, and 312 h at 7°C. The carbohydrate, protein, fat, ash, moisture content, pH, Aw, and antioxidant capacity of CCM edible coating were different with those of CC edible coating. CCM edible coating showed better antioxidant effect than CC but showed comparable antimicrobial capacity in meat during accelerated storage. Therefore, CCM edible coating could be used to preserve meat.

1. Introduction

Indonesian demand for meat tends to increase in line with the increasing population as well as public awareness of the importance of animal-based protein consumption. Chicken meat consumption in Indonesia dominates over the other sources of meat. In nutritional point of view, chicken meat is rich in protein with high biological value, especially when compared to vegetable-based protein, and micronutrients such as vitamin A, thiamine, iron, phosphorus, and nicotinic acid [1].

Meat supply business needs special attention because meat is one of the perishable foods. Meat quality degradation is indicated through changes in color, aroma and texture. Most of the damage have an impact on decreasing the shelf life and nutritional value of meat. Chicken meat sales in traditional markets are generally carried out in an open-air condition (without cover). Raw chicken meat is placed in locations that are not guaranteed for the cleanliness at room temperature until it is sold. Meanwhile according to SNI 3924:2009 raw chicken meat should be stored at a temperature of 0-4°C and for frozen chicken meat should be stored at a minimum temperature of -12°C. Storage at cold temperatures can prevent damage to meat due to the activity of spoilage microorganisms. Nowadays, environmentally friendly and edible (biodegradable) packaging, such as edible coating, has been intensively developed. Edible coating can be defined as a thin layer of edible material. It is usually applied as a liquid with varying viscosity on the surface of food products by spraying, dyeing, brushing, or other methods. Polysaccharides, proteins, and lipids are the main polymers used for the manufacture of edible coatings [2].
Casein and chitosan can be utilized as the main polymers of edible coatings with preservative ability. Chitosan could prevent the contamination of microorganism and reduce gas and aroma transfer [3]. Chitosan also inhibits the growth of Gram-negative and Gram-positive bacteria [4]. The interaction between casein and chitosan is expected to prevent the growth of bacteria through the inactivation of the metabolic activity [5]. Therefore, the objective of this study was to determine the characteristics of casein-chitosan edible coating and its preservative effect in meat during accelerated storage test.

2. Material and methods

2.1. Preparation of casein-chitosan edible coatings
The materials used in the manufacture of edible coatings were casein (Merck), chitosan (Makmur Sejati), glycerol (Merck), beeswax (Rimba Raya), distilled water, and 2% acetic acid. Casein mixture and chitosan mixture were prepared separately. First, 2.5 g of casein was dissolved in 100 mL distilled water for about 30 min at 50°C and then glycerol was added at 0.28% of solution’s weight during the heating process. For chitosan mixture, 2% acetic acid was added to chitosan, then the chitosan was dissolved in 98 mL distilled water for 30 min at 50°C and then the mixture was added with glycerol 0.28% (w/w) during the heating process. The next step was the mixing of casein-chitosan based on treatments. In this study, there were 2 groups with three replications. Edible coatings were prepared with casein-chitosan (1:3 w/w, CC) and casein-chitosan modified (1:3 w/w, with addition of catechin 0.5% w/w, CCM) to compare the efficiency. The proximate composition (carbohydrate, protein, fat, and moisture content), pH, water activity (a_w), and antioxidant capacity (DPPH radical scavenging activity) of the coatings were then analyzed.

2.2. Application of edible coatings in meat and accelerated storage test
Chicken breast fillet was cut into 10x3x1 cm and coated with the coating solution by spraying. The coating solution was put in a bottle spray. The meat was sprayed 5 times (0.75 mL) for each side and drained for 2 min. The spraying technique was used because it could increase the distribution of homogenous edible coating solution to the surface of meat. The samples were then stored for 24, 120, 216 and 312 h at 7°C for microbiology analysis. Sample (10 g) was homogenized with 0.1 % sterile peptone water (90 mL) in a Stomacher (Seward, BA6021, UK) for 1 min. One mL of the original homogenate was transferred into a sterile test tube containing 9 mL of 0.1 % sterile peptone water solution then appropriate serial dilutions were carried out. For the total aerobic plate count, 1 mL of each previously prepared serial dilution was carefully transferred into separate, duplicate, appropriately marked Petri dishes, and thoroughly mixed with 15 mL of previously melted and adjusted (45±1°C) plate count agar. After solidification, the plates were inverted and incubated promptly for 48±2 h at 37°C. The results were expressed as the logarithm of the colony forming units per gram (CFU/g).

2.3. Data analysis
Data were analyzed using analysis of variance (ANOVA) and the LSD test was performed to determine significant difference between the treatment [6].

3. Result and discussion

3.1. Characteristics casein-chitosan edible coating
Table 1 shows that the carbohydrate, protein, fat, and moisture content of each group were different significantly (P<0.05). The carbohydrate, protein, fat, and moisture content of CCM was higher than CC because of the addition of 0.5% catechin to casein-chitosan coating. Catechin is basically a phenol consisting of carbon, hydrogen and oxygen atoms. Therefore, the addition of catechin can increase the carbohydrate, protein and fat content of the coating.
The differences in chemical characteristics of casein-chitosan edible coatings are shown in Table 2. The antioxidant capacity of CCM was higher than that of CC (P<0.05). The pH values decreased after the addition of 0.5% catechin as it possesses acidic properties in chitosan solution. The antioxidant capacity of catechin and chitosan is responsible for their high oxidative stability of chicken fillet and red meat [7,8,9]. Chitosan itself possesses antioxidant capacity to enhance food quality and shelf life [10,11]. The application of chitosan coatings in chicken meat samples could stabilize the pH values during storage [12,13]. Thus, casein-chitosan edible coating modified with catechin could inhibit lipid oxidation on the surface of the meat when it is applied to coat the meat.

| Type of Edible Coatings | Carbohydrate (g/100g) | Protein (g/100g) | Fat (g/100g) | Moisture (%) |
|-------------------------|------------------------|------------------|--------------|--------------|
| CC                      | 6.64±0.03<sup>b</sup>  | 3.83±0.05<sup>a</sup> | 5.75±0.02<sup>b</sup> | 81.85±0.06<sup>b</sup> |
| CCM                     | 7.48±0.07<sup>a</sup>  | 4.59±0.04<sup>b</sup> | 6.83±0.03<sup>a</sup> | 83.10±0.03<sup>a</sup> |

Note: <sup>a,b</sup> Different superscripts in the same column showed significant differences (P<0.05)

Chitosan has excellent film-forming properties and broad antimicrobial activity against bacteria and fungi [10,11]. The decrease in <span class="subscript">a_w</span> values of the coating (<0.80) means that bacteria cannot grow easily. The observed values ranged from 0.66 to 0.71. These values are less than the range that permits the growth of bacteria, as for example bacteria can grow at <span class="subscript">a_w</span> of 0.90, while yeasts and molds can grow at <span class="subscript">a_w</span> of 0.80-0.90 and 0.60-0.70, respectively [10].

3.2. **Accelerated storage test**

There were no differences found on total plate count of the meat during accelerated storage test. After the 120 hours of storage, the chicken meat would be inadequate for consumption. Therefore, the addition of catechin did not add the preservative effect of casein-chitosan edible coatings.

| Type of Edible Coatings | 24 h  | 120 h | 216 h | 312 h |
|-------------------------|-------|-------|-------|-------|
| CC                      | 0.42±0.01 | 1.59±0.08 | 2.40±0.36 | 2.51±0.52 |
| CCM                     | 0.38±0.01 | 1.52±0.05 | 2.08±0.02 | 2.37±0.09 |

4. **Conclusion**

The addition of catechin to casein-chitosan edible coating only increased its antioxidant capacity without enhancing its antimicrobial activity when applied to raw chicken breast during accelerated storage test at 7°C.

**Acknowledgement**

This study was supported by an Institute of Research and Community Services Brawijaya University (LPPM) Brawijaya University.
References

[1] da Silva D C F, de Arruda A M V and Gonçalves A A 2017 *J. Food Sci. Technol.* **54** (7) 1818-1826
[2] Khare A K, Abraham R J J, Rao V A and Babu R N 2016 *Vet. World* **9** (2) 166-175
[3] Damayanti D, Rochima E and Hasan Z 2016 *Jurnal Hasil Pengolahan Perikanan Indonesia* **19** (3) 321-329
[4] Nurhayati and Agusman 2011 *Squalen* **6** (1) 38-45
[5] Kusumawati E, Supomo and Libiyah 2017 *Jurnal Sains dan Terapan Politeknik Hasnur* **5** (1)  1-7
[6] Yitnosumarto S 1991 Experiment analysis of design and interpretation. Gramedia Pustaka Utama, Jakarta
[7] Apriliyani M W, Rosyidi D, Purwadi, Purnomo H and Manab A 2014 *Advance Journal of Food Science and Technology* **6** (1) 48-55
[8] Min B and Ahn D U 2009 *J. Food Sci.* **74** 41–48
[9] Min B, Nam K C, Cordray J and Ahn D U 2008 *J. Food Sci.* **73** 439–446
[10] Aider M 2010 *LWT-Food Sci. Technol.* **43** (6) 837-842
[11] Hamed I, Özogul F and Regenstein JM 2016 *Trends Food Sci. Technol.* **48** 40-50
[12] Han J H 2000 *Food Technol.* **54** (3) 56-65
[13] Hassanzadeh P 2017 *Radiation Physics and Chemistry* **141** 103-109