Research Article

The Effectiveness of Marination with Fermented Coconut Water on Physical, Microbic, and Organoleptic Quality of Broiler Breast Meat

Dian Septinova*, Hananda Sofia, Nari Ratih, Armelia Rizqika, Riyanti, Veronica Wanniatie, Madi Hartono

Department of Animal Husbandry, Faculty of Agriculture, University of Lampung, Indonesia.

Abstract | This research was conducted to determine the effect of long marinating using fermented coconut water (FCW) and storage time at cold temperatures (5°C) on the physical, microbial, and organoleptic qualities of broiler breast meat. The study was conducted in a completely randomized design with a nested pattern with 0 minutes or control (M0), 40 minutes (M1) and 80 minutes (M2) as the main factor; and storage time of 7 days (S1) and 14 days (S2) as nesting factors. The results showed that marinating (40 and 80 minutes) of broiler breast meat with FWC had a significant effect on reducing pH, total meat bacteria, and raw meat color, but not on water holding capacity (WHC), cooking loss, organoleptic (raw meat odor, color, odor, and the taste of cooked meat). Storage time at cold temperatures (5°C) for 7 and 14 days affected the decrease in cooking loss, total bacteria, but not pH, and WHC of control and marinated meat. The 40 minutes of marinating using FWC can be applied to get the best quality of broiler breast meat up to 14 days of storage.

Keywords | Fermented coconut water, Marinade, Storage time, Broiler, Meat quality

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***Correspondence** | Dian Septinova, Department of Animal Husbandry, Faculty of Agriculture, University of Lampung, Indonesia; **Email:** dian.septinova@fp.unila.ac.id
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INTRODUCTION

Broiler meat has a very important role in meeting the needs of the Indonesian people for animal protein. Broiler meat has high nutrition and competitive prices compared to other sources of livestock meat (Sujiwo et al., 2018). Broilers have a nutrient content of 70.51% water, 0.82% ash, 21.18% protein, and 1.15% fat (Hidayah et al., 2019). These nutrients are not only needed and liked by humans but also by microbes. Meat contamination by microbes has an impact on quality degradation and spoilage. Without preservation, broiler meat will decay 6 hours after storet at room temperature (Arhiono et al., 2018).

Marinating with the immersion method can maintain the physicochemical quality of broiler meat during storage (Gamage et al., 2017). The marinades that have been extensively researched are acid-based ones. The addition of 1% lactic acid in the marinade solution significantly reduced the number of psychotropic bacteria (PTC) and Pseudomonas (Smaoui et al., 2011). Marinating with acid whey can suppress the growth of mesophilic aerobic bacteria and *Pseudomonas spp* in chicken breast (Presjnar et al., 2019).

Coconut water is a natural ingredient that has great potential to be used as a preservative. Coconut water contains quite a lot of organic acids, namely acetic acid, lactic

acid, citric acid, malic acid, and tartaric acid (Young et al., 2009). The coconut water fermentation process causes the number of lactic acid bacteria to increase and also causes a decrease in the pH value of coconut water to 3.8-4.0 (Pramana et al., 2018).

The effectiveness of marinade on meat quality is influenced by many factors, such as marinade ingredients (Ismail et al., 2018; Manohar et al., 2016), concentration (Patriani and Hafid 2021), length of marinade (Ismail et al., 2018), and storage of meat (Aziz et al., 2020). Therefore, this research was conducted to determine the effectiveness of marinating with fermented coconut water on the physical, microbial, and organoleptic qualities of broiler meat.

MATERIALS AND METHODS

Meat Sample Preparation

The samples used in this study were skinless breast fillets from 25-day-old broilers obtained from traditional abattoirs. Other ingredients used are aged coconut water, Saccharomyces cerevisiae from tape yeast, Lactobacillus casei from fermented milk (Yakult), and sugar.

Methods

The study was designed with a completely randomized design (nested pattern). Control treatment without marinade (M0); marinated for 40 minutes (M1), and marinated for 80 minutes (M2) were as the main factors, and storage time of 7 days (S1) and 14 days (S2) were as nested factors (S in M).

Coconut Water Fermentation

Old coconut water is mixed with yeast (tape yeast), probiotic drink (yakult), and sugar. Then the mixture was homogenized and stored in a closed container for 2 days at room temperature.

Marinating Broiler Meat

Broiler breast fillets were marinated by soaking in a 50% fermented coconut water solution and stored in the refrigerator (4°C) according to the treatment. The ratio of meat to the marinade solution is 1: 2.

Ph Test

The meat sample was mashed and weighed as much as 10 g, inserted and added 40 ml of distilled water. The sample was homogenized and then the pH was measured using a JenWay3520 digital pH meter.

Water Holding Capasity (Whc)

Weigh the sample as much as 0.28 – 0.32 g. Place the sample between two filter papers between two flat glass. Put the 10 kg weight on the glass and leave it for 5 minutes. Re-weigh the meat sample. Calculate the water holding capacity with the formula:

$$WHC(\%) = 100\% - \frac{(W0-W1)}{W0} x100\%$$

, where W0 = initial weight; W1 = final weight

Cooking Loss

Weigh the sample meat about 20 g as initial weight. Put the meat in a plastic bag and seal it tightly. Cook it in boiling water (100°C) for 20 minutes. Put the meat on a filter paper, and cool it at room temperature. Weigh the sample weight (final weight). Calculate cooking loss using the formula:

$$Cooking\ loss\ (\%) = \frac{(W0-W1)}{W0} x100\%$$

, where W0 = initial weight; W1 = final weight

Total Bacteria Count (Tpc)

The total number of bacteria was tested using the total plate count (TPC) method with PCA (Plate Count Agar) media (AOAC 966,23).

Organoleptic Test

Testing using semi-trained panelists as many as 25 people. Panelists were asked to rate the hedonic quality for the color, smell, and taste of the meat. The hedonic quality scale for meat color is 1 (dark), 3 (normal), 5 (pale), for meat odor is 1 (fishy), 3 (neutral), 5 (sour), for taste is 1 (fishy), 3 (neutral), 5 (acidic).

Data Analysis

The data obtained were analyzed using analysis of variance and further test with Duncan Multiple Range Test 5%.

RESULTS AND DISCUSSION

Ph Of Broiler Breast Meat

The pH of broiler meat marinated with FCW at different duration and storage time is presented in Table 1. Marinating with FCW had a significant effect ($P<0.05$) on the pH of broiler meat, but storage time had no significant effect ($P>0.05$). Meat that was marinated with FCW for 40 and 80 minutes significantly ($P<0.05$) had a lower pH than that which was not marinated. However, the pH of meat marinated for 40 and 80 minutes was not significantly different. The effect of acid marinade on pH was also stated by Hilmiati et al (2016) and Patriani and Hafid (2021). According to Patriani and Hafid (2021), the pH of meat marinated with gelugur acid (Garcinia atroviridis) is 5.74-5.77. The low pH of the meat was caused by the diffusion of acidic FCW (pH 3.8-4.0) into the meat. The buffer nature of FCW causes the results of this study to differ from

those of Ismail et al. (2018), that the longer the meat is marinated, the pH of the meat is significantly more acidic.

Table 1: pH value of broiler meat

	Storage time (day)		Marination
Lama Marination (minutes)	7	14	
Control (0)	6.09±0.03	6.24±0.11	6.16±0.11[b]
FCW (40)	5.91±0.13	5.54±0.17	5.72±0.23[a]
FCW (80)	5.71±0.20	5.72±0.19	5.71±0.19[a]

Description: Different superscripts in the same column indicated significantly different (P<0.05)

Meat storage time of 7 and 14 days at 5oC did not affect the pH of the meat, either unmarinated or marinated with FCW. This condition was caused by the inhibition of bacterial growth and protein denaturation during storage by organic acids present in FCW. Organic acids from coconut water and banana peels vinegar can be used as antimicrobials in food (Juniawati et al., 2018). The bacteria in the meat will denature the protein so that the pH of the meat also increases (Kim et al., 2019).

Water Holding Capasity Of Broiler Breast Meat

The water holding capacity (WHC) of broiler meat marinated with FCW can be seen in Table 2. WHC of broiler breast meat that was not marinated and marinated with FCW for 40 and 80 minutes was not significantly different (P>0.05). Meat WHC was also not significantly different (P>0.01) in broiler meat stored for 7 and 14 days.

Table 2: Water holding capacity (%) of broiler meat at different marination time and storage time

Marination duration (minutes)	Storage time (day)		Marination
	7	14	
Control (0)	64.55 ± 9.43	68.42 ± 4.46	66.49 ± 7.63
FCW (40)	55.55 ± 3.14	64.49 ± 2.31	60.02 ± 5.25
FCW (80)	60.50 ± 4.85	59.75 ± 3.42	60.12 ± 4.21

Although the WHC of unmarinated and FCW-marinated meat (40 minutes and 80 minutes) was not significantly different, it was seen that the WHC of broiler breast meat that was marinated with FCW was relatively lower than that of unmarinated. This is in accordance with the statement of Haq et al. (2015) that there is a relationship between the pH value and the WHC of meat. When the pH of the meat is higher than the isoelectric pH, the closer the pH is to the isoelectric value of the meat, the lower the water binding capacity. On the other hand, the further away from the isoelectric pH value, the higher the water holding capacity of the meat.

Although the WHC of unmarinated and FCW-marinated meat (40 minutes and 80 minutes) was not significantly different, it was seen that the WHC of broiler breast meat that was marinated with FCW was relatively lower than that of unmarinated. This is in accordance with the statement of Haq et al. (2015) that there is a relationship between the pH value and the WHC of meat. When the pH of the meat is higher than the isoelectric pH, the closer the pH is to the isoelectric value of the meat, the lower the water binding capacity. On the other hand, the further away from the isoelectric pH value, the higher the water holding capacity of the meat.

The lower pH value of meat that was marinated with FCW for 40 and 80 minutes caused the protein denaturation to be greater than that of unmarinated meat. Myofibrillar protein denaturation due to acid treatment has a significant impact on water retention because water is mostly bound by muscle myofibrils. Denaturation that occurs causes myofibril proteins to lose their ability to bind water (Ismail et al., 2018). According to Manohar et al. (2016), the lower WHC value of meat causes the meat to become mushy, watery, and pale. According to Kaewthong and Wattanachant (2018), meat WHC is also affected by proteolytic and protein oxidation.

There are special things that happen to meat that is marinated with FCW for 40 minutes after 14 days of storage. WHC meat tends to be higher than that stored for 7 days even though the pH is relatively lower. This is due to the presence of water that has come out first in the form of drip.

WHC meat usually decreases with increasing storage time. This is related to the increase in protein denaturation that occurs. The WHC value which was not significantly different in the treatment of marinating duration and storage time indicated that marinating with FCW could be used to maintain the quality of meat in terms of its ability to bind water.

Cooking Loss Of Broiler Breast Meat

The average cooking loss value of broiler meat marinated with FCW and stored for 7 and 14 days can be seen in Table 3. Based on the results of the analysis of variance, the cooking loss of unmarinated meat was not significantly different (P>0.05) with broiler breast meat that was marinated with FCW. At 14 days of storage, the cooking loss of broiler breast meat, both unmarinated and marinated, was significantly lower (P<0.05) than that stored for 7 days.

Table 3: Cooking loss (%) of broiler meat at different marination time and storage time

Marination duration (minutes)	Storage time (day)		Marination
	7	14	
Control (0)	34.33 ± 1.68[b]	24.93 ± 3.90[a]	29.63 ± 5.58
FCW (40)	31.00 ± 1.84[b]	28.90 ± 1.52[a]	29.95 ± 1.99
FCW (80)	34.40 ± 4.13[b]	31.57 ± 0.90[a]	32.99 ± 3.31

Description: Different superscripts in the same raw indicated significantly different (P<0.05)

Cooking loss of unmarinated and marinated broiler breast meat with FCW (40 and 80 minutes) was not significantly different (P>0.05). These results are in accordance with the research of Septinova et al. (2018), however, it is different from Patriani and Hafid (2021) that broiler breast meat marinated with acid has a significantly lower cooking loss. Cooking loss is affected by the WHC of the meat. In meat with a high WHC, the water that comes out of the meat is low so that the mass of the meat is reduced slightly.

Cooking loss is an indicator of the nutritional value of meat related to the value of meat juice. The lower the cooking loss, the better the quality of the meat because less nutrients are released from the meat (Kaewthong and Wattanachant, 2018). Based on this, it is still possible to marinate broiler breast meat with FCW for 80 minutes.

Cooking loss of meat stored for 14 days was significantly lower than that stored for 7 days in all control treatments and marinated meat with FCW. This is different from Aziz et al. (2020) that storage time affects cooking loss. Meat stored for 72 hours, the cooking loss is higher than that stored for 24 hours. In this study, the humidity of the meat stored for 14 days was reduced, so that when it was cooked the cooking loss was lower.

Total Bacteria Count (Tpc)

The total bacteria of meat that was marinated with FCW (40 minutes and 80 minutes) was significantly (P<0.05) lower than meat that was not marinated. The shelf life also significantly (P<0.05) on the total bacteria of both marinated and unmarinated meat. In unmarinated meat, the total bacteria in meat stored for 14 days was higher than that stored for 7 days. The effectiveness of fermented coconut water in inhibiting bacterial growth was seen from the total number of bacteria on the 14th day which was lower than that stored for 7 days (Table 4).

The lower total bacteria of broiler breast meat marinated with FCW was caused by the diffusion of organic acids such as acetic acid, lactic acid, citric acid, malic acid, and tartaric acid contained in FCW. According to Khotimah and Kusnadi (2014), lactic acid, acetic acid, acetaldehyde, hydrogen peroxide and bacteriocin act as antibacterial. These results are in accordance with the research of Smaoui et al. (2011) which stated that acid-based marinade can be done as an effort to inhibit microbial growth in meat and the addition of 1% lactic acid in the marinade solution significantly reduces the number of psychotropic bacteria and Pseudomonas.

Table 4: Total bacteria from broiler meat (10^3 CFU/g)

Marination duration (minutes)	Storage time (day)		Marination
	7	14	
Control (0)	5.73±0,45[a]	15.00±5,96[b]	10.37±6.27[B]
FCW (40)	3.10±0,59[b]	1.93±0,50[a]	2.52±0,80[A]
FCW (80)	3.30±0.57[b]	2.13±0.12[a]	2.72±0.72[A]

Description: Different superscript in the same row or different capital letters in the same column are significantly different (P<0.05)

The accumulation of acid from FCW causes a decrease in the pH of the meat. The low pH value of meat (acid) causes inhibition of the growth of bacteria, both gram-positive and gram-negative. Acid marinating can reduce the growth of *Campylobacter jejuni* bacteria during 25 days of meat storage at 4°C (Birk et al., 2010).

The total bacteria in broiler breast meat marinated with FCW for 40 minutes and 80 minutes were not significantly different (P > 0.05). However, the duration of broiler meat marinade with FCW for 40 minutes tends to be able to reduce the total number of meat bacteria better. At 80 minutes of marinade, it is suspected that the meat will be more and more contaminated by bacteria that are acid-resistant and low temperature, such as *L. monocytogenes* and psychrophilic bacteria. Marinating with FCW (40 and 80 minutes) can inhibit microbial growth. This condition is caused by the condition of the marinated meat which is more acidic so that it lyses the bacterial cell membrane of the meat.

The storage time of 7 days and 14 days on meat both for unmarinated and marinated with FCW for 40 and 80 minutes had a significant effect (P<0.05) on the total bacterial value of broiler breast meat. In unmarinated broiler breast meat, the total bacteria with storage time of 14 days were larger than those stored for 7 days. The opposite happened to meat that was marinated with FCW, where the total bacteria in meat stored for 14 days was less than that stored for 7 days. According to Mirdalisa et al. (2016), *Lactobacillus casei* is able to produce organic compounds and hydrogen peroxide which are antibacterial. Antimicrobial activity of *Lactobacillus casei* was able to inhibit *Staphylococcus aureus* bacteria in milk for 30 days of storage at 5°C. Kim et al. (2011) stated that the nutritional condition of

meat decreases, the medium is increasingly acidic, the accumulation of antimicrobial substances can inhibit growth even to a decrease in total bacteria so that the growth level will approach zero and the increase in the number of cells does not exist.

Organoleptic Of Broiler Breast Meat

Marinating with FCW had a significant effect (P<0.05) on the color of raw broiler meat. The color of raw broiler meat that was marinated with FCW was significantly lighter than that of unmarinated broiler. Marinating time of 40 and 80 minutes with FCW had no significant effect (P>0.05) on the color of the meat. In raw meat, broiler meat marinating treatment with FCW had no significant effect (P>0.05) on odor. The same thing happened to the color, smell, and cooked meat (Table 5).

Table 5: Organoleptic of broiler breast meat

Parameter	Marination time (minutes)		
	Control	40	80
Raw meat			
Color	2.56±1.30[a]	2.84±1.29[b]	3.36±1.32[bc]
Smell	2.20±1.60	2.20±1.39	2.36± 1.23
Preference	4.36±1.72	390±1.70	3.82±1.62
Cooked meat			
Color	2.28±1,11	3.00±1.38	3.00±1.13
Smell	3.08± 0,97	2.60±1.53	2.60 ± 1.25
Taste	2.84± 1,13	2.76±1.38	2.84±1.38
Preference	4.34±1,68	4.73±1.50	4,08±1.00

Note: Different superscript in the same raw indicated significantly different (P<0.05)

Meat that was marinated with FCW was significantly lighter in color (P<0.05) than that which was not marinated. This is in line with Unal et al. (2020) that marinating meat with an acid solution has an impact on pH, WHC, cooking loss and brightness of meat color. Unmarinated breast meat is dark in color, while that which is marinated with fermented coconut water becomes lighter in color and tends to turn pale. The pale color of the meat is caused by the absorption of an acidic coconut water solution (pH 4). According to Rini et al. (2019), meat color correlates with post mortem meat pH, the lower the pH the paler the color of the meat. According to Wideman et al. (2016), the decrease in the pH of meat occurs because the acid marinade can denature meat proteins. Langer et al. (2016) added that the denaturation of myofibril and sarcoplasmic proteins that occurs causes the color of the meat to become pale.

Marinating meat with FCW had no significant effect (P>0.05) on the color of broiler breast meat when cooked. The color of the raw meat that was significantly different (P<0.05) did not necessarily cause the color of the cooked meat to be different. According to Fletcher et al. (2000), the color of raw meat and pH affect the color of cooked broiler breast meat. However, the degree of color variation is reduced. In this study, the color variation in raw breast meat when marinated was not too far, so that when cooked the color was not significantly different (P > 0.05).

The marination treatment which had no significant difference on the smell, taste, color of the cooked meat indicated that the marination treatment did not have a negative impact on the quality of the meat. So that the marinade of meat with fermented coconut water can be applied.

CONCLUSION

Marinating (40 and 80 minutes) of broiler breast meat with fermented coconut water had an effect on decreasing pH, total meat bacteria, and raw meat color, but not on WHC, cooking loss, organoleptic (smell of raw meat, color, odor, and taste of ripe meat). The duration of storage at cold temperatures (5°C) for 7 and 14 days in control and marinated meat affected the decrease in cooking loss, total bacteria, but not on pH, and WHC. Marinating with FCW for 40 minutes is effective in getting the best quality of broiler breast meat up to 14 days of storage.

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CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

NOVELTY STATEMENT

Research on the use of fermented coconut water formulations for marinating broiler breast meat has never been done before.

AUTHOR'S CONTRIBUTION

All the authors contributed to the manuscript. Dian Septinova designed the experiment and drafted the manuscript. Hanada Sofia, Nari Ratih and Armelia Rizqika S collected and tabulated data. Riyanti and Veronica Wanniatie prepared and interpreted the results. Madi Hartono critically revised and approved the manuscript.

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