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**Ni Made Suci Sukmawati**
Faculty of Animal Husbandry, Udayana University, Bali, Indonesia

**I Ketut Sumadi**
Faculty of Animal Husbandry, Udayana University, Bukit Jimbaran, Bali, Indonesia

**Ni Luh Putu Sriyani**
Faculty of Animal Husbandry, Udayana University, Bukit Jimbaran, Bali, Indonesia

**Sri Anggreni Lindawati**
Faculty of Animal Husbandry, Udayana University, Bukit Jimbaran, Bali, Indonesia

**Ni Putu Yundari Melati**
Faculty of Animal Husbandry, Udayana University, Bukit Jimbaran, Bali, Indonesia

**Corresponding Author:**
**Ni Made Suci Sukmawati**
Faculty of Animal Husbandry, Udayana University, Bukit Jimbaran, Bali, Indonesia

# The effect of jamu makarens on physicochemical quality and antioxidant capacity of local bali pork

**Ni Made Suci Sukmawati, I Ketut Sumadi, Ni Luh Putu Sriyani, Sri Anggreni Lindawati and Ni Putu Yundari Melati**

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## Abstract
The study aimed to examine the effect of Jamu makarens in rations on the physicochemical quality and antioxidant capacity of local bali pork has been carried out for 12 weeks using 20 male local bali pigs. The experimental design used was a completely randomized design (CRD) consisting of 4 treatments and 5 replications. The treatment i.e: P0 (ration without jamu makarens), P1 (ration + 2% jamu makarens), P2 (ration + 4% jamu makarens), and P3 (ration + 6% jamu makarens"). The results showed that the administration of jamu makarens in rations could increase pH, water binding capacity, moisture and protein content, antioxidant capacity and reduce cooking loss, fat and cholesterol content, with the best results in 4%. Based on the results of the study, it can be concluded that jamu makarens can improve the physicochemical quality and antioxidant capacity of local bali pork with the best level of 4%.

**Keywords**: Local bali pork, jamu makarens, physicochemical quality

## Introduction
Local bali pigs are germplasm that needs to be preserved because the population is decreasing, while on the other hand it has quite promising business opportunities. Local bali pork is best used as *babi guling* because it has a distinctive taste. At first, *babi guling* was widely used as a means of ceremonies, but now it has developed into a very popular culinary in Bali and even became a tour package. Genetically, local bali pigs are a type of fat so that their meat contains a lot of fat. The presence of fat in meat is usually related to cholesterol levels which are feared by the public because they are considered to trigger narrowing of blood vessels and coronary heart disease.

One way to improve the quality of local bali pork is by giving jamu makarens. Jamu makarens is a natural fermented herb made from ripe maja fruits, old coconut water, palm sugar and rice washing water. Based on the results of laboratory tests, jamu makarens contains phytochemical compounds such as: alkaloids, phenolics, flavonoids, saponins, and tannins as well as vitamin C and lactic acid bacteria that function as probiotics. Phytochemical compounds are known to have benefits for livestock health because they have antibacterial, anti-inflammatory and antioxidant properties (Julianto, 2019) [12]. Antioxidants are able to inhibit oxidative processes and improve the quality of meat. Oxidation is considered the main cause of deterioration in meat quality which affects color, flavor and nutritional value (Soeparno, 2015) [21].

The effect of the use of probiotics on meat quality also showed positive results. Feed supplemented with probiotics is able to reduce drip loss and cooking loss of pork (Liu *et al*., 2013) [15]. The same results were also reported by Tian *et al*. (2021) [24], that the probiotic *Lactobacillus reuteri* improved the quality of pork compared to antibiotics by reducing drip loss, increasing inosinic acid and glutamic acid which can improve taste, and changing the characteristics of muscle fibers. Furthermore, Sukmawati *et al*. (2024) [24] reported that the provision of jamu makarens in rations by 2-6% can improve the quality of broiler meat aged 35 days. Based on this information, this study needs to be conducted to examine the effect of giving jamu makarens in rations on the physicochemical quality and antioxidant capacity of local bali pork.

## Materials and Methods

**Experimental design, cages, livestock and observed variables:** The experimental design used was a completely randomized design (CRD), consisting of 4 treatments (P0: Pig fed ration without jamu makarens, P1: Pig fed ration + 2% jamu makarens, P2: Pig fed ration + 4% jamu makarens, and P3: Pig fed ration + 6% jamu makarens) and 5 replicates.
The livestock used is 20 male local bali pigs which are kept in individual battery cages for 12 weeks. The variables observed included: the physical quality of the meat (pH, water binding capacity, cooking loss and meat color), the chemical quality of the meat (moisture, fat, protein and cholesterol content) and antioxidant capacity.

### Preparation of jamu makarens

Jamu makarens is made from ripe maja fruit (*Aegle marmelos* L.) mixed with palm sugar, old coconut water and rice washing water. Maja fruit is blended first until it is in the form of juice and palm sugar is melted, then all ingredients are put into a barrel to be fermented naturally for one month. After one month, the jamu makarens is filtered and ready to be given to pigs according to the treatment.

### Meat sampling and laboratory tests

Meat samples for physical and chemical quality tests were taken from the Longisimus dorsi as much as 300 g and then put into a labeled plastic bag. The meat sample is then taken to the Laboratorium to be analyzed physical qualities include: pH, cooking loss, water binding capacity, and meat color, while chemical qualities include: water content, protein content, fat content, cholesterol content and antioxidant capacity.

### Statistical analysis

All data were analyzed using one-way ANOVA to determine the differences among treatments. If differences were found ($p$<0.05), then further analysis was performed with Duncan's multiple range test using SPPS program version 26.0 (Steel and Torrie, 2017) [23].

## Results and Discussion

### Result

The administration of jamu makarens in rations of 2-6% had significantly effect ($p$<0.05) on the physicochemical quality of male local bali pork, including: meat pH, water binding capacity, cooking loss, meat color (brightness, reddish and yellowish levels), moisture content, protein content, fat content, cholesterol content, and antioxidant capacity. The physicochemical quality and antioxidant capacity data of local bali pork is shown in Table 1.

**Table 1:** Effect of jamu makarens in rations on physicochemical quality and antioxidant capacity of local bali pork

| Variable | Treatment | | | | SEM |
|---|---|---|---|---|---|
| | P0 | P1 | P2 | P3 | |
| **Physical quality** | | | | | |
| Meat pH | 5.88$^{a}$ | 5.99$^{ab}$ | 6.12$^{b}$ | 5.98$^{ab}$ | 0.06 |
| Water Binding Capacity (%) | 51.67$^{a}$ | 54.23$^{ab}$ | 56.80$^{b}$ | 53.62$^{ab}$ | 1.01 |
| Cooking loss (%) | 36.94$^{b}$ | 36.71$^{b}$ | 34.73$^{a}$ | 36.73$^{b}$ | 0.30 |
| **Meat color** | | | | | |
| Brightness level (L*) | 74.60$^{c}$ | 71.43$^{bc}$ | 68.15$^{b}$ | 61.93 $^{a}$ | 1.40 |
| Reddish level (a*) | 16.80$^{a}$ | 22.47$^{b}$ | 22.60$^{b}$ | 25.20$^{c}$ | 0.76 |
| Yellowness level (b*) | 6.70$^{b}$ | 6.65$^{b}$ | 8.44$^{c}$ | 2.83$^{a}$ | 0.51 |
| **Chemical quality** | | | | | |
| Moisture content (% bb) | 64.41$^{a}$ | 66.48$^{c}$ | 66.59$^{c}$ | 65.77$^{b}$ | 0.20 |
| Protein content (% bb) | 21.51$^{a}$ | 24.31$^{b}$ | 24.52$^{b}$ | 22.11$^{a}$ | 0.17 |
| Fat content (% bb) | 9.42$^{c}$ | 6.79$^{a}$ | 6.61$^{a}$ | 7.58$^{b}$ | 0.23 |
| Cholesterol content (mg/100 g) | 157.64$^{b}$ | 150.72$^{b}$ | 128.39$^{b}$ | 97.42$^{a}$ | 8.92 |
| Antioxidant capacity (mg/L GAEAC) | 5.61$^{a}$ | 8.89$^{c}$ | 9.22$^{c}$ | 7.95$^{b}$ | 0.23 |

**Note:**
1) Treatment: P0 = Pig fed rations without Jamu Makarens (control), P1 = Pig fed rations+ 2% Jamu Makarens, P2 = Pig fed rations + 4% Jamu Makarens, P3 = Pig fed rations + 6% Jamu Makarens
2) SEM = Standard Error of the Treatment Means
3) Values with different letters on the same line show significantly different ($p$<0.05)

### Physical Quality of Local Bali Pork

The results of the study show that the average pH of local bali pork in the P0 treatment (pig fed rations without jamu makarens, as a control) was 5.88 (Table 1), while in the P1 treatment (pig fed rations + 2% jamu makarens), P2 (pig fed rations + 4% jamu makarens) and P3 (pig fed rations + 6% jamu makarens) had higher pH values than the control of 1.84%, 3.92% and 1.67%, respectively but statistically P1 and P3 are not significantly different ($p$>0.05).
The water binding capacity of local bali pork in the P0 treatment (control) was 51.67% (Table 1), while in pork fed jamu makarens (P1, P2 and P3) had a higher water binding capacity than the control (P0) of 4.72%; 9.03% and 3.64%, respectively but statistically P1 and P3 are not significantly different ($p$>0.05).
The average cooking loss of local bali pork in the P0 treatment (control) was 36.94% (Table 1). The cooking loss value in the P1 and P3 treatments was lower than P0 by 0.62% and 0.57%, respectively but statistically not significantly different ($p$>0.05), while in the P2 treatment it was significantly ($p$<0.05) lower than P0 by 5.98%.
Meat color of local bali pork in P0 treatment had the highest brightness level, which was 74.60 (Table 1). The brightness level of pork in the P1 treatment was not significantly ($p$>0.05) lower than P0 by 4.25%, while in the P2 and P3 treatments, the brightness level was significantly ($p$<0.05) lower than that of P0 by 8.65% and 16.98%, respectively. The reddish level (a*) of pork in the P0 treatment was 16.80 (Table 1), while in the P1, P2, and P3 treatments was significantly ($p$<0.05) higher than the P0 (control) of 25.23%;

25.66% and 33.33%, respectively. The level of redness of meat among the treatments fed jamu makarens (P1, P2 and P3) showed that the P2 value was not significantly ($p$<0.05) higher than P1 by 0.58%, while the P3 was significantly higher than P1 by 10.83%. The yellowness level (b*) of pork in the P0 treatment was 6.70 (Table 1), while in the P1 treatment was not significantly ($p$>0.05) lower by 0.75%; the P2 was significantly ($p$<0.05) higher by 20.62% and the P3 was significantly ($p$<0.05) lower by 57.76% compare to the P0 (control).

**Chemical Quality and Antioxidant Capacity of Local Bali Pork**

The results of the ANOVA (analysis of variance) showed that the administration of jamu makarens in rations of 2-6% could significantly improve the chemical quality and antioxidant capacity of local bali pork, including: moisture, protein, fat and cholesterol content. Data on the effect of jamu makarens in rations on the chemical quality and antioxidant capacity of local bali pork are shown in Table 1.

The data in Table 1 show that the average moisture content of pork in P0 (control) treatment was 64.41%, while in the P1, P2 and P3 treatments was significantly ($p$<0.05) higher than that of control (P0) by 3.11%; 3.27% and 2.07% respectively. Among the treatments that fed jamu makarens, the moisture content of pork in the P1 and P2 treatments was not significantly different ($p$>0.05), but in the P3 treatment was significantly ($p$<0.05) lower than that of P1 and P2 by 1.07% and 1.23%, respectively.

The average protein content of local bali pork in the P0 treatment was 21.51% (Table 1), while in the P1 and P2 treatments were significantly ($p$<0.05) higher than the P0 by 11.52% and 12.28%, respectively, and the P3 treatment was not significantly ($p$>0.05) higher than the P0 by 2.71%. The average fat content of local bali pork in the P0 treatment was 9.42% (Table 1), while in the P1, P2 and P3 treatments were significantly ($p$<0.05) lower than the P0 respectively by 27.91%; 29.83 and 19.53%.

The average cholesterol content of local bali pork in the P0 treatment (control) was 157.64 mg/100 g), while in the P1, P2 and P3 treatments were lower than the control by 4.39%, 18.55% and 38.20% respectively, but statistically P1 and P2 not significantly different ($p$>0.05).

The average value of antioxidant capacity of local bali pork in the P0 treatment was 5.61mg/L GAEAC (Table 1), while in pork consuming the jamu makarens (P1, P2 and P3) were significantly ($p$<0.05) higher than the control (P0) by 36.89%; 39.15% and 29.43%, respectively.

## Discussion

**Physical Quality of Local Bali Pork**

The physical quality of meat affects the quality meat processing. Meat that has good physical quality will certainly provide good processed products and will make it easier during the process

processing. Physical properties of meat include pH, water binding capacity, cooking loss and meat color.

**Meat pH**

The pH is a value used to express the level of acidity or alkalinity based on the concentration of Hydrogen ions ($H^+$) possessed by a substance, solution or object measured on a scale of 0 to 14. Normal pH has a value of 7. A pH value smaller than 7 indicates acidity, while a pH value greater than 7 indicates an alkaline. The average pH value of pork in this study ranged from 5.88-6.12 (Table 1), so it was slightly acidic.

According to the Indonesia National Standard (SNI) [11] No. 01-6366-2000, regarding the quality of fresh meat, it is stated that low pH (5.1-6.1) causes meat to have an open structure so that it is very good for salting, bright pink so that it is preferred by consumers, has a preferred flavor and has better stability against damage by microorganisms. A high pH (6.2-9.0) causes the meat to have a closed or dense structure with a dark red-purple color, unpleasant taste and more favorable conditions for the development of microorganisms. So, the pH value of pork as a result of this study (5.88-6.12) is still in the range of fresh meat quality standards with good quality criteria.

When compared to the ultimate pH, the pH value of pork in the results of this study (5.88-6.12) shows a higher value because according to Soeparno (2015) [21], the ultimate pH of normal meat is 5.4-5.5. The higher pH value obtained is because the measured value is the initial pH (4-6 hours after slaughter), so it has not reached the ultimate pH which is usually reached 24 hours after slaughter. After the animal die, aerobic metabolism does not occur because the supply of $O_2$ is stopped due to blood circulation to muscle tissue is stopped, so the metabolism changes to an anaerobic system that causes the formation of lactic acid as a result of the glycolysis process. The accumulation of lactic acid in meat causes a decrease in the pH of muscle tissue. The higher the lactic acid produced, the greater the decrease in pH. Therefore, it can be concluded that the decrease in pH after the death of animal is basically determined by the condition of lactic acid deposited in the muscles. This is in line with the opinion of Lawrie (2003) [14], that lactic acid production is the only cause of pH decline during postmortem glycolysis. Lactic acid deposits will stop once muscle glycogen reserves become depleted or after the pH is low enough to stop the activity of glycolytic enzymes that play a role in the anaerobic glycolysis process.

The high pH value of the meat produced in this study is also related to the type of muscle used for the sample, namely the loin part which is a passive muscle. Soeparno (2015)[21] stated that the pH of meat is affected by the function and type of muscles. Active muscles have a lot of glycogen deposits so that lactic acid is higher and the pH is low, and vice versa in passive muscles the glycogen deposits are low so that the lactic acid formed is low and the pH of the meat is high.

Based on the results of the Duncan test, it was found that pork fed with jamu makarens in rations of 2-6% had a higher pH value than the control of 1.84% (P1), 3.92% (P2) and 1.67% (P3), respectively, but statistically P1 and P3 were not significantly different ($p$>0.05). This reflects that the administration of jamu makarens at the level of 4% can reduce the rate of decrease in the pH of post mortem meat. The rapid rate of decrease in the pH of meat will result in the color of the meat becoming pale, the water binding capacity of meat protein becomes low and the meat cutting surface becomes wet due to the release of liquid to the surface of the pieces of meat called moist and juicy meat (Soeparno, 2015) [21].

This increase in pH value is due to the increase in antioxidant capacity in meat that has the same pattern (Table 1). Antioxidants are able to inhibit the rate of glycolysis and oxidation of fatty acids and meat proteins by microbes so that meat spoilage can be inhibited (Lawrie, 2003) [14]. The pH value of local bali pork in the results of this study is almost the same as reported by Agastia *et al*. (2015) [2] which states that the pH value of bali pork given turmeric extract were ranges from 5.70-5.80. This shows that the administration of jamu makarens in rations can reduce the rate of pH decline of meat after slaughter at the best level by 4% so that the quality of meat will be better. Soeparno (2015) [21] stated that an increase in the pH of meat will usually increase juice and water binding capacity, as well as decrease cooking loss.

**Water binding capacity (WBC)**

Water binding capacity is one of the determining factors for meat quality because it is directly related to the ability of meat proteins to bind free water in the meat. The water binding capacity of meat is closely related to tenderness, juice effect and meat color. There are several factors that affect water binding, including: livestock nutrition, meat pH, actomiocin binding, storage and preservation, muscle type, fat content, and meat protein. The average water binding capacity (WBC) of local bali pork in this study ranged from 51.67-56.80% (Table 1) with the highest value in the P2 treatment, followed by P1, P3, and P0.

Based on the results of the statistical analysis, it was found that pork that consumed jamu makarens (P1, P2 and P3) had a higher water binding capacity than the control (P0) by 4.72%, 9.03% and 3.64%, respectively, but statistically P1 and P3 are not significantly different ($p>0.05$). Among the treatments that fed jamu makarens, the P2 treatment had water binding capacity not signicantly ($p>0.05$) higher than P1 and P3, by 4.52% and 5.59%, respectively. The results of this study are in accordance with Sukmawati *et al.* (2024) [24] that the administration of jamu makarens in rations can increase water binding capacity in broiler meat aged of 35 days. The water binding capacity in the results of this study is slightly lower than reported by Sriyani *et al*. (2015) [22] that the water binding capacity of bali pork is around 60.57±1.47.

The increase in the water binding capacity of meat in pigs consuming jamu makarens is due to the higher protein content of meat and lower fat (Table 1) so that the ability to bind water is higher. This statement is supported by Kartikasari *et al*. (2018) [13] that the WBC percentage value in meat is positively correlated with the protein content in the meat and negatively correlated with the fat in the meat. The lower the fat content in the meat, the protein content will increase and can increase the water binding capacity of the meat.

The water binding capacity of meat is also affected by pH. Data in Table 1 showed that the pH of pork treated with jamu makarens was higher than that of pork that did not given jamu makarens treatment. This opinion is in accordance with Delfia *et al*. (2022) [10], which states that the water binding value is greatly influenced by the magnitude of the pH value, where the lower the pH, the lower the water binding capacity value as well. In low pH, the protein reactive group decreases and causes more water content of the meat to be released, so that the binding capacity of meat water is low. According to Lawrie (2003) [14], it is stated that the speed of pH decline after slaughter is the main determinant of the water binding capacity of meat. In addition, it is said that the breakdown of sarcoplama proteins increases with a very high rate of pH drop. The rate of pH decline will increase the tendency of actomiocin to contract, which causes the discharge of fluid as water separates itself from muscle proteins.

**Cooking Loss**

Cooking loss is the weight lost during the cooking or heating process. Cooking loss is an indicator of the nutritional value of meat in relation to meat juice, namely the amount of water that binds in and between muscle fibers. Meat with lower cooking loss has relatively better quality compared to higher cooking loss (Soeparno, 2015) [21]. This statement is corroborated by Yanti *et al*. (2008) [28], that meat that has a low cooking loss value below 35% has good quality because the possibility of meat nutrition during cooking is also low. The average cooking loss of local bali pork in the results of this study ranged from 34.73-36.94% (Table 1), so the pork in the results of this study is still classified as good quality. The cooking loss value in the results of this study is higher than reported by Sriyani *et al*. (2015) [22], that the cooking loss value of bali pork is around 23.70± 6.36, but it is still in the normal range as stated by Soeparno (2015) [21], that the cooking loss value of meat varies between 1.5-54.5% with a range of 15-40%.

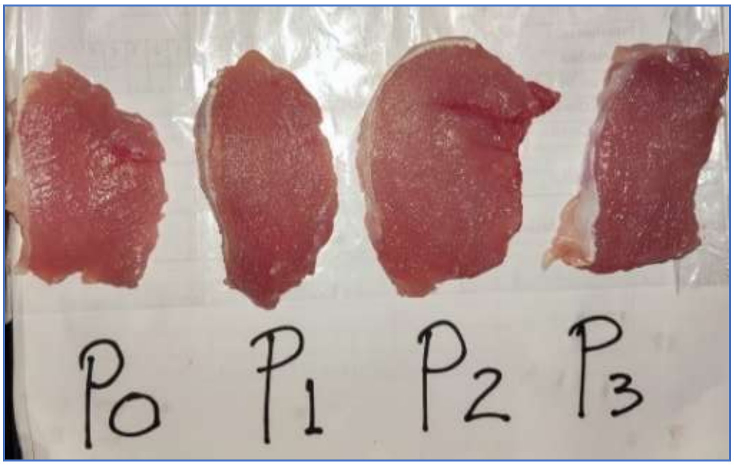
Based on the results of the Duncan test, it was found that the cooking loss value of pork in the P1 and P3 treatments was not significantly ($p>0.05$) lower than P0 by 0.62% and 0.57%, respectively, while in the P2 treatment it was lower than P0 by 5.98%. The reduction in the cooking loss value of meat in pigs given jamu makarens is due to the increase in the water binding capacity of the meat (Table 1). This statement is supported by Soeparno (2015) [21] who states that cooking loss is affected by water binding capacity, high water binding capacity causes low cooking loss, while low water binding capacity causes high cooking loss. High water binding capacity during cooking has a role in retaining a certain amount of free water by muscle proteins so that not much meat juice comes out. In addition to water binding capacity, the cooking loss of meat is also affected by pH. The lower the pH of the meat, the higher the cooking loss of the meat, and vice versa. This can be seen in Table 1, that the pH value of meat increased with the highest value in the P2 treatment so that the lowest cooking loss of meat was also found in the P2 treatment.

**Meat color**

Color is one of the physical properties that affect consumers in choosing products, including meat. The color of meat is mainly affected by the concentration of myoglobin pigments, while chromoprotein and hemoglobin pigments have a relatively small effect. Myoglobin is a pigment in muscles that contains iron, just like hemoglobin in the blood. The concentration of myoglobin will cause red muscle and white muscle. The difference in the surface color of the meat is mainly due to the chemical status of the myoglobin molecule. The purple color of fresh red meat is a reflection of the dominance of original myoglobins. When oxygen binds to myoglobin, oxymyoglobin will be formed and the color of the meat becomes bright red, which consumers associate with freshness, as the color of fresh meat that most consumers want. However, when meat is stored longer, the iron in myoglobin loses electrons and forms metmyoglobin and the meat turns brown (Soeparno, 2015) [21].

The results of the statistical analysis showed that the administration of jamu makarens in the ration had a significant effect ($p<0.05$) on the brightness level (L*) of local bali pork with the highest value in the P0 treatment followed by P1, P2 and P3. The decrease in the brightness level of meat is caused by the pH of pork that fed jamu makarens is higher so that the color of the meat becomes darker. This statement is supported by Afrianti *et al*. (2013) [1], who stated that if the final pH of the meat is high, then the color of the meat will look dark. This is due to the high intracellular water content, causing the ability to reflect light will decrease so that the color of the meat will look dark.

The reddish level (a*) of local bali pork in the results of this study ranged from 15.10-23.87 (Table 1) with the highest value in the P3 treatment (25.20), followed by P2 (22.60), P1 (22.47) and the lowest in the control (16.80). Statistically, the results were significantly different ($p<0.05$). The comparison of the color of pork as a result of this study is shown in Figure 1. The increase in red color in pork that fed jamu makarens was caused by a high pH value of 6.12 for meat. This statement is supported by Soeparno (2015) [21], that the pH of meat above 6.0 has a high level of tenderness but has a darker meat color. The difference in red color in meat is also influenced by phytochemical compounds, including tannins. This opinion is in accordance with Luciano (2009) [16], who stated that tannin supplementation in concentrated feed can increase the value of a* (reddish level) and reduce the b* value (yellowish level) of semimembranous muscle (SM) in sheep. Tannins can act on myoglobin which is the main red pigment in meat and causes changes in the color of the meat. In addition, tannins can also affect other factors related to red pigment such as the pH of meat and the availability of necessary iron for the formation of the red pigment (Choi J. *et al.,* 2022) [9].




**Source:** Personal documents

**Fig 1:** Comparison of the color of pork fed jamu makarens (P0:0%, P1:2%, P2:4%, P3:6%)

The administration of jamu makarens in rations of 2% has not significantly effect on the level of yellowness of meat color and is only noticeable in the administration of 4-6%. The yellowish color of the meat is due to the low content of the pigments myoglobin and hemoglobin in the meat. In addition, the content of marbling fat in meat also affects the yellowness of the stored meat, due to the presence of beta-carotene content (Soeparno, 2015) [21].

### Chemical Quality and Antioxidant Capacity of Local Bali Pork

The chemical quality of meat is closely related to the nutritional content of meat itself. The chemical quality of meat is influenced by water content, fat content, and protein content (Prasetyo *et al*., 2013) [19]. According to the USDA (2009) [26], the chemical composition of pork includes water, fat, and protein content ranging from 60-70%, 6-10%, and 20-28% respectively.

### Moisture content

Moisture content is the percentage of water content of a material that can be expressed based on wet weight or dry weight (Retno *et al*., 2013) [20]. Moisture content is very important in determining the shelf life of foodstuffs because it affects physical properties, chemicals, microbiological changes and enzymatic changes. Good meat has a moisture content that is not too high and not too low so that the meat can be stored for a long time (Amertaningtyas, 2012) [3]. According to Lawrie (2003) [14], the moisture content in fresh meat is around 75% with a normal limit of 65-80%. The moisture content of local bali pork in the results of this study ranged from 64.41-66.59% (Table 1), so it was classified as a normal range. The moisture content of meat is influenced by the type of livestock, age, gender, feed as well as the location and function of muscle parts in the body (Soeparno, 2015) [21].

The results of the Duncan test showed that the average moisture content of pork in P1, P2 and P3 treatment was significantly higher than P0 ($p<0.05$) respectively by 3.11%; 3.27% and 2.07%. The increase in moisture content in pork fed with jamu makarens is due to increased water binding capacity (Table 1). This opinion is supported by Soeparno (2015) [21], who stated that the moisture content of meat is closely related to water binding capacity. Low water binding capacity results in a decrease in moisture content resulting in weight loss followed by a decrease in meat nutrition during storage. The increase in water content in meat fed with jamu makarens is also influenced by increasing protein levels and decreasing fat levels (Table 1). This is in accordance with the opinion of Lawrie (2003) [14] that the water content in the carcass has a negative relationship with fat content and has a positive relationship with protein content.

The protein content of food is one way to measure the quality of food. Protein is a key element of nutrients necessary for growth and as a structural component of the body (Bidura *et al*. 2012) [6]. The protein content of local bali pork in this study ranged from 21.51-24.52% (Table1). The protein content of pork in this study is still relatively normal because according to the USDA (2009) [26] the protein content of pork is around 20-28%. The results of the variety analysis showed that the provision of jamu makarens in the ration by 2-6% significantly ($p<0.05$) increased the protein content of local bali pork with the highest value at 4% (P2). This is due to the fact that the protein content of the ration in the P2 treatment is the highest so that the protein content in meat is also high.

The presence of fat in meat greatly affects the flavor of meat. The fat that is in the meat is known as marbling. The higher the marbling value, the more tenderness, crispiness and aroma of the meat will be increased. On the other hand, low marbling values cause the meat to appear dry and have a bad taste. Local bali pork, whose fat is mostly composed of unsaturated fatty acids, especially oleic acid and linoleate, causes local bali pork to have a distinctive taste (Budaarsa, 2017) [7]. According to Soeparno (2015) [21] the content of muscle fat varies greatly and can range from 1.5%-13% and according to the USDA (2009) [26] around 6-10%. The fat content of local bali pork in the results of this study ranges from 6.61-9.42% so that is still in the normal range.

The results of the statistical analysis showed that the administration of jamu makarens in the ration of 2-6% significantly ($p<0.05$) could reduce the fat content of local male bali pork. The highest meat fat content was found in the control treatment (P0) of 9.42%, followed by the treatment of P3 (7.58%), P1 (6.79%) and P2 (6.61%) (Table 1). Based on Duncan's further test, it was found that the meat fat content in the P1, P2 and P3 treatments was significantly ($p<0.05$) lower than P0 respectively by 27.91%; 29.83 and 19.53%. The decrease in meat fat levels is caused by lactic acid bacteria that produce short-chain fatty acids such as acetate, propionate and butyrate. Propionate is an inhibitor of the lipogenesis process in the liver so that the level of meat fat decreases (Beylot, 2005) [5]. Probiotics can also decrease the activity of acetyl-CoA carboxylase, an enzyme responsible for the rate of fatty acid synthesis, by producing statins as inhibitors of fat formation in the liver. Statins are substances as inhibitors of 3-hydroxy-3-methyl-glutarin CoA reductase that function as enzymes regulating the biosynthesis of fats, cholesterol, and triglycerides (Cavallini *et al*., 2009) [8].

**Cholesterol levels**

Cholesterol is a type of lipid derivative that is classified as a steroid compound that functions as a precursor to other steroid compounds in the body, such as corticosteroids, sex hormones (estrogen, progesterone, testosterone, costosterone and aldosterone), bile acids and vitamin D. Cholesterol is a typical product of animal metabolism so it is only found in foods of animal origin. Cholesterol is formed from acetyl CoA derived from glucose, fatty acids and amino acids catalyzed by the enzyme 3-Hydroxy 3-Methyl Gluteryil-Co.A reductase (HMG Ko-A reductase) (Murray *et al*. 2003) [18]. Cholesterol in meat is often cited as the cause of cardiovascular disease, so it is a consideration for consumers in choosing meat products.

The cholesterol levels of local bali pork in the results of this study ranged from 97.42-157.64 mg/100 g (Table 1), with the highest value in the P0 treatment (157.64 mg/100 g), followed by P1 (150.72 mg/100 g), P2 (128.39 mg/100 g) and P3 (97.42 mg/100 g). Statistically, the results were significantly different ($p<0.05$). The results of the variety analysis showed that the administration of jamu makarens in rations of 2-4% did not have a significant effect ($p>0.05$) on the reduction of cholesterol of local bali pork, while in the administration of 6% there was significantly decrease ($p<0.05$) of 38.20% compared to the control. This is due to the high number of lactic acid bacteria in the P3 treatment. This opinion is in accordance with Cavallini *et al*., 2009) [8] which states that lactic acid bacteria produce statins which are inhibitors of the enzyme 3-hydroxy-3-methyl-glutarin CoA reductase which plays a role in the biosynthesis of fats, cholesterol and triglycerides.

In addition, lactic acid bacteria also produce bile salt hydrolase (BSH) enzyme which causes the deconjugation of bile acids into deconjugated bile salts that are difficult to dissolve so that they are wasted with feces. This causes an increase in the absorption of cholesterol from the blood for the formation of bile so that blood cholesterol decreases and will ultimately lower cholesterol levels in meat. A decrease in the pH of the small intestine due to the presence of lactic acid can also lower meat cholesterol because a lot of bile acids are released to neutralize the pH so that blood cholesterol is much drawn for the formation of bile. This can reduce cholesterol in the blood so that meat cholesterol is also reduced. Another mechanism is the absorption of cholesterol in the intestines for the formation of lactic acid bacterial cell membranes so that its absorption into the blood will be reduced and has an impact on decreasing meat cholesterol levels (Astuti *et al*., 2009) [4].

**Antioxidant capacity of local bali pork**

Antioxidants are compounds that can inhibit the oxidation reaction of free radicals by neutralizing these free radicals, while antioxidant capacity is the ability of antioxidant compounds to reduce the amount of prooxidants. The antioxidant capacity in this study was determined by the DPPH (1,1-diphenyl-2-picrylhydrazil) method using the gallic acid standard. Galic acid is a group of polyphenol compounds that have been known to have high antioxidant activity with the GAEAC unit. DPPH inhibition activity is a method of measuring antioxidant activity with the principle of stabilization of radical compounds by antioxidants. Hydrogen from antioxidants pairs with DPPH free electrons to form DPPH-H so that the color changes from purple to pale yellow (Molyneux, 2004) [17].

The average antioxidant capacity of meat in this study ranged from 5.61-9.22 mg/L GAEAC (Table 1), with the highest value in the P2 treatment, namely 9.22 mg/L GAEAC, followed by P1 (8.89 mg/L GAEAC), P3 (7.95 mg/L GAEAC) and P0 (5.61 mg/L GAEAC). The results of the Duncan test showed that the antioxidant capacity of pork fed with jamu makarens (P1, P2 and P3) was higher than that of the control (P0<) by 36.89%; 39.15% and 29.43%, respectively. The increase in antioxidant capacity is caused by the high content of phytochemical compounds, especially phenolic and vitamin C, in the jamu makarens which has an impact on antioxidants in meat. In the food sector, antioxidants play an important role in maintaining product quality, preventing rancidity, changes in nutritional value, color and aroma changes, and other physical damage caused by oxidation reactions (Widjaya, 2003) [27].

**Conclusions**

Based on the results of this study, it can be concluded that the administration of jamu makarens in rations can increase the physicochemical quality and antioxidant capacity of local bali pork, include: pH of meat, water binding capacity, redness level, moisture content, protein content and as well as reduce cooking loss, fat content and cholesterol content of meat with the best level of 4%.

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**Conflict of interest declaration**
We confirm that there is no conflict of interest with any financial institution regarding the content discussed in the manuscript.

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