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Quality of Bali Beef Cut on Different Management of Slaughterhouses (RPH) in Bali Province

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Abstract---*The purpose of this study was to determine the physical, chemical and microbiological quality of Balinese beef from Slaughterhouses (RPH) with different management in Denpasar City and Badung Regency as abattoirs that supply most of Bali beef on the island of Bali. The material used was male Bali beef in the Longisimus Dorsi (LD) muscle which was cut at three different abattoirs. The RPH are UPT RPH Mambal, UPT RPH Pesanggaran and RPH belonging to the community of RPH Darmasaba in Banjar Bersih Darmasaba Village. This study used a completely randomized design (CRD) with 3 treatments where three abattoirs were treated and each treatment consisted of 10 repetitions of Bali beef cuts. The variables sought in this study were physical quality variables, namely pH, color, water holding capacity, and meat cooking loss. Chemical quality variables are meat moisture content, protein content, fat content and ash content. Meat microbiological variables were TPC, colliform, e-coli and salmonella. The results showed that the physical quality of Bali beef slaughtered at the Darmasaba RPH had the lowest physical quality compared to the Mambal and Pesanggaran abattoirs, especially on the pH and meat color variables. The chemical quality of Bali beef slaughtered at the three abattoirs had no significant difference in water content, protein content, and ash content. The total plate count, coliform was below the SNI threshold while e-coli was not identified and salmonella was negative.*
Keywords---*Bali cattle, chemical, meat quality, microbiological, physical, Slaughterhouse*

Introduction

Meat is a food that has high nutritional value because it contains quite complete nutrients, both micro and macronutrients such as protein, fat, minerals and vitamins that are needed by the body (Ernawati et al., 2018). Beef is the choice of many consumers in meeting the needs of animal protein consumption in Indonesia. Consumption of beef and buffalo in 2019 reached around 782.40 thousand tons or around 2.93 kg per capita per year, and within 2 years the consumption of beef has increased by 11 percent when compared to the study of staples in 2017 (Agency Center for Statistics, 2021). Beef consumption continues to increase until in 2021 the total number of cattle slaughtered at slaughterhouses (RPH) in Indonesia is recorded at 913,885 heads (Central Bureau of Statistics, 2022).

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The need for beef continues to increase due to increasing demand and public awareness of the importance of nutritious food (Soeharsono et al., 1990; Suardana et al., 2017).

With the increasing public demand for meat, the quality of meat is very important to be considered by consumers in choosing meat. Meat quality is a consumer reference in choosing meat. According to Soeparno (2011), indicators that can describe the physical quality of meat are pH, water binding capacity by meat protein and cooking loss. The chemical quality or nutritional value of meat is related to the content of protein, fat, carbohydrates, minerals and vitamins contained in the meat. The microbiological quality of meat is also very important to look at the safety aspects of meat, especially the contamination of pathogenic bacteria in meat which will affect the health of consumers (Pinero et al., 2008; Zinoviadou et al., 2009).

Meat quality is determined by factors before slaughter and factors after slaughter. According to Hidayat et al. (2016), meat quality is strongly influenced by factors before slaughter including genetics, species, nation, type of livestock, sex, age, feed including additives (hormones, antibiotics, and minerals) and stress factors. The condition of livestock before slaughter greatly affects the quality of the meat produced (Rahayu, 2009). The conditions before the slaughter were very closely related to the management of the abattoir where the cattle were slaughtered. The management includes whether or not there is a rest before slaughtering, inspection of livestock before slaughter and after slaughter, handling of livestock before slaughter whether or not it follows animal welfare rules and slaughtering techniques whether carried out by professional officers or not (Grunert et al., 2004; Meng & Doyle, 2002).

Bali cattle on the island of Bali are slaughtered at RPH managed by the government and the community. Slaughterhouses (RPH) in the city of Denpasar and in Badung Regency as the RPH which supply the largest beef to the city of Denpasar have variations in management. Some of the operational RPH are managed by the government, some are managed by the community, which of course has different management. This difference in management allows for differences in the quality of the meat produced. For example, government-run abattoirs generally have antemortem and post-mortem inspections for cattle to be slaughtered, while in community-run abattoirs there is no such inspection. Differences in the handling of resting livestock, as well as handling and arching techniques will cause differences in the quality of the meat produced (Zebeli et al., 2012; Hejnfelt & Angelidaki, 2009). This study was intended to map the physical, chemical and microbiological quality of meat from several abattoirs operating in the cities of Denpasar and Badung. The abattoirs managed by the government and the community in Denpasar City and Badung Regency are the abattoirs with the largest number of cattle slaughtering among regencies in the province of Bali. The annotation above is very important for meat consumers in selecting quality meat (Mach et al., 2008; Nagaraja & Titgemeyer, 2007).

Research Methods

Materials and Methods

Bali beef loin portion of the LD (*longisimus dorsi*) muscle originates from the government-owned RPH where this RPH is managed by the Badung Regency government, namely the Mambal RPH and the Denpasar City Government, namely the Pesanggaran RPH and the community-owned RPH Darmasaba which are managed by individuals located in Banjar Bersih Darmasaba, Abiansemal District, Badung Regency. The three RPH have so far been known as the largest Balinese beef supplier RPH to Denpasar City. The beef from the three abattoir management systems will be tested physically, chemically and microbiologically at the Livestock Product Technology and Microbiology Lab, Faculty of Animal Husbandry, Udayana University.

Research Design

The design used was a completely randomized design (CRD) with 3 treatments and 10 replications. The replications used were male Bali beef which was slaughtered with relatively the same weight and age in the three abattoirs. The three treatments are as follows:

P1: Bali beef cut at the Mambal RPH
P2: Bali beef that is cut at the Pesanggaran RPH
P3: Bali beef slaughtered at RPH Darmasaba

Physical Quality Test Method
Flesh color

The color of the meat was observed by comparing the color of the meat sample with the standard of meat color. The comparison color standard used is "Photographic Color Standard For Muscle and Fat Color", Department of Agriculture, Western Australia with the following color scores: light brown (1), pale pink (2), pink (3), pink (4), bright red (5), (6) dark red.

Degree of acidity (pH)

Measurement of meat pH using a pH meter, starting with standardization of a pH meter with a buffer solution of pH 4 and pH 7. Then, ± 10gram meat samples were crushed and then put in a glass beaker and added with aquadest with a ratio of meat samples: aquadest (1:1). The sample was stirred and then allowed to stand for 1 minute. After that, the pH meter was immersed in the sample solution.

Water holding capacity

Measurement of water holding capacity using a Clement 2000 centrifuge. A total of ± 10 grams of meat samples were crushed, then weighed and recorded as initial weight. Furthermore, the meat was wrapped in Whatman 41 filter paper, put into a centrifuge at a high speed of 36,000 rpm for 60 minutes. Then the sample was weighed without filter paper to obtain the final weight. The percentage (DIA) is calculated by the formula:

$$\text{Water Holding (\%)} = 100 - \left(\frac{(Meat\ Residue\ Weight)}{Sample\ Weight}\ x\ 100\right)$$

Cooking loss

Meat cooking loss measurement begins with preparing a sample of ±30 grams of meat, then the sample is put in a plastic bag. The plastic bag was folded and clipped, after that, it was boiled at 80°C for 60 minutes. The sample was then taken and wiped with a tissue without pressing it and weighed as the final weight. The percentage of cooking loss is calculated by the formula:

$$SM\ (\%) = \frac{(Weight\ before\ cooking - Weight\ after\ cooking)}{\text{weight before cooking}}\ x\ 100\ \%$$

Meat Chemical Quality Test Method
Water content

Moisture content was determined directly using an oven at 105^0C. First, the empty cup was dried in an oven at 105^0C for 15 minutes and cooled in a desiccator, then weighed. A total of 1.5 grams of the sample was put in a weighing cup and then dried in an oven at 105^0C for 3-4 hours. The cup containing the dried sample was then transferred to a desiccator, cooled for 30 minutes and then weighed. Drying was carried out until a constant weight was obtained. Calculation of water content can be calculated by the formula:

$$\text{\% Water content} = \frac{\text{(Initial weight of sample} - \text{Final weight of sample)(g)}}{\text{Initial weight of sample (g)}}\ \text{x } 100\%$$

Protein Level

A total of 0.3 grams of sample, was placed in a vapodest tube and added 1 grain of selenium catalyst and 5 ml of concentrated H2SO4, then carried out destruction (heating in a boiling state) for 1.5 hours until the solution is clear. After cooling, 50 ml of distilled water and 20 ml of 40% NaOH were added, then distilled. The results of the distillation were accommodated in an Erlenmeyer flask containing a mixture of 20 ml H3BO3 and 2 drops of pink green bromine cresol. After the distillate volume (distillate) became 100 ml and turned bluish in color, the distillation was stopped and the distillate was titrated with 0.1 N HCL until pink. The same treatment was carried out for the blanks. With this method, crude protein content is obtained which is calculated by the formula:

$$\% \text{ Crude Protein Level} = \frac{(S-B)\ x\ 0{,}1\ x\ 14\ x\ 6{,}25}{W\ x\ 1000} \text{ x } 100\%$$

Annotation:
S: sample titrant volume
B: Volume of blank titrant
W: dry sample weight

Fat level

Determination of fat content by Soxhlet method. 2 grams of meat sample (A) were weighed and wrapped in filter paper and put in a lead, dried in an oven for 9 hours at a temperature of 105^0C. The soxtherm tube was dried in an oven for 3 hours at 105^0C, then cooled in a desiccator and weighed (B). The lead containing the sample after being dried was put into a soxtherm tube, filled the soxtherm tube with 200 ml of n-Hexane until the sample was completely immersed. Extraction for 4 hours in a soxtherm apparatus, then air dry the soxtherm tube in a forced oven for 15 minutes then dry for 3 hours in a dry oven at 105^0C, cool in a desiccator for 30 minutes, weigh the soxtherm tube containing fat extract (C). The percentage of fat content is calculated as follows:

$$\text{Fat level (\%)} = \frac{\text{C} - \text{B}}{\text{A}}\ x\ 100\%$$

Annotation:
A: sample weight (grams)
B: weight of soxtherm tube (grams)
C: soxtherm tube weight + fat extract (grams)

Ash Level

The porcelain dish was heated in an oven at 100-105^0C for 30 minutes, then cooled in a desiccator and weighed to a constant weight. A total of 1 gram of the meat sample was put into a porcelain dish and weighed, then burned until it no longer smoked and ashed in a kiln at 600^0C for 3 hours until it was white and the weight was constant. Turn off the furnace, leave for 12 hours and then cool in a desiccator for 30 minutes. After that, the sample was weighed.

$$\text{Ash content (\%)} = \frac{\text{ash weight}}{\text{sample weight}} \text{ x } 100\%$$

Microbiological Quality Test
Total Plate Count (TPC)

The TPC test steps are: smoothing the sample (beef), weighing the sample as much as 5 grams. According to Waluyo (2008), the dilution stage starts from making a sample solution of 10 ml (a mixture of 1 ml/gram sample and 9 ml of peptone solution). From this solution, 1 ml was taken and put into the next test tube so that the desired dilution was obtained. Next, take the solution from the last 2 test tubes (10^{-7} and 10^{-8}), pour it into a petri dish then add agar in the form of media and rotate it like number 8 so that the sample and media are well mixed and solidified then the tube is incubated at 37ºC for 2 x 24 hours. The number of bacterial colonies can be calculated using the following formula:

$$\text{CFU} = \frac{number\ of\ bacterial\ colonies}{dilution\ factor} \times poured\ sample$$

Total *Coliform* and *Escherichia coli*

The method used to obtain total Escherichia coli and Coliform bacteria is the spread method Fardiaz (1989), using EMBA media, which is 5 grams of beef put into an Erlenmeyer tube which already contains 0.1% peptone water solution with a volume of 45 ml, so that a dilution of 10^{-1} was obtained. The 10^{-1} dilution was then homogenized and diluted again by taking 1 ml through a pipette and then put into a test tube which already contained 9 ml of peptone solution to obtain dilutions of 10^{-2} and 10^{-3}.

From a dilution of 10^{-1} taken using a sterile pipette as much as 0.1 ml was then poured on the surface of the solid EMBA media into a petri dish and then incubated at 37^0C in an inverted state, and the results can be calculated after 24-48 hours. Planting was carried out at dilution levels of 10^{-1}, 10^{-2} and 10^{-3}. To count bacterial colonies that grew using the plate count method, namely by selecting the number of colonies that grew in petri dishes ranging from 30-300 colonies (Fardiaz, 1989).

$$\text{Formula: Colonies/gram} = \text{Number of Colonies per cup x } \frac{1}{faktorpengencer}$$

Statistical analysis

The data on the physical and chemical quality of the meat obtained were analyzed using a variance. If there was a significant difference (P<0.05) between treatments, the analysis was continued with Duncan's multiple-distance test (Steel & Torrie, 1993). Meat microbiological data were analyzed descriptively. The analysis was assisted by the SPSS 20 program.

Results and Discussion

Physical quality of meat

The value of the physical quality of the meat (Table 1) which is reflected in the variables of pH, color, water binding capacity of the meat and the cooking loss value of the meat produced by the three abattoirs are as follows:

Table 1
The physical quality of Bali beef slaughtered at different abattoirs

Variable	RPH Mambal	RPH Pesanggaran	RPH	Variable	RPH Mambal
pH	5,77[a 2)]	5,73[a]	5,93[b]	0,03	5,4-5,8
Color	5[a]	5,25[a]	6[a]	0,15	1-5 SNI 3932:2008
Water Holding Capacity (%)	23,48[a]	23,35[a]	27,44[b]	0,48	20-60%
Cooking Loss (%)	32,84[a]	33,17[a]	31,99[b]	0,16	15-40%

Annotation:
1. SEM is “Standard Error of Treatment”
2. Values with different letters in the same row, significantly different (P<0.05)

The pH values of Bali beef slaughtered at the Mambal RPH (P1), Pesanggaran RPH (P2) and Darmasaba RPH (P3) were 5.77, 5.73, 5.93, statistically significantly different (P<05). The highest PH value was found in meat slaughtered at Darmasaba RPH, which was 5.93. This pH value is above the ultimate meat pH from 5.4 to 5.8 (Soeparno, 2011). It is suspected that the meat produced from the slaughter of the Darmasaba abattoir is produced from Bali cattle which are thought to be under stress. It is suspected that the animals experienced stress during slaughter and handling before slaughter. The handling of cows at the Darmasaba RPH before slaughter when the cow is laid down still uses the manual method, namely by using rigging. The cow is tied on all four legs then the rope is pulled together and causes the cow to fall. When a cow falls, it is slaughtered by a butcher. In contrast to the handling of cows at the Mambal and Pesanggaran RPH, in these two government-owned abattoirs, the handling or laying down of cows before being slaughtered uses mechanization, namely with a threshing machine. Cows that are ready to be slaughtered are put into a threshing machine and slowly the machine will lay down the cow perfectly without violence. The slaughtering at the Darmasaba RPH is carried out by uncertified or untrained butchers. Meanwhile, the cuts at RPH Mambal and Pesanggaran are carried out by Juleha (halal slaughter attendant) who has been certified from MUI (Indonesian Ulema Council).

Factors that affect the rate and magnitude of the decrease in pH are divided into two, namely intrinsic factors consisting of species, muscle type, muscle glycogen, and variability among livestock. While extrinsic factors include environmental temperature, cutting treatment, cutting process and stress before cutting. When cattle are stressed, a

lot of energy will be used to cope with stress, so glycogen reserves are almost depleted. As a result, at the time of cutting only a little glycogen is converted into lactic acid so that the pH of the meat remains high. This is in accordance with the opinion of Judge et al. (1989) namely stress before slaughter, aggressive behavior among cattle or excessive movement has a major influence on the decrease or depletion of muscle glycogen and will produce dark meat with a high pH (Thyagaraju, 2016; Jamuna, 2015).

A high pH value of meat will result in a higher or darker color of the meat. This is reflected in the color of meat slaughtered at Darmasaba RPH which has the highest/darkest value compared to the color of Bali beef slaughtered at Mambal RPH and Pesanggaran RPH which was statistically significantly different, ($P<0.05$). A high pH value of meat will cause the meat to be dark in color. Mounier et al. (2006) stated that stress conditions can increase blood cortisol concentrations and are accompanied by glycogen depletion in muscles. This causes a decrease in postmortem lactic acid production and the pH of the meat remains high. The high pH value of meat results in a closed meat structure, so that the water holding capacity is high (Buckle et al., 2007).

The water-holding value of Balinese beef slaughtered at RPH Mambal, RPH Pesanggaran and RPH Darmasaba were 23.48%, 23.35% and 27.44% statistically significantly different ($P<0.05$). The value of the water holding capacity of the meat in this study was influenced by the pH value of the meat. This is in accordance with the opinion of Jamhari (2000), that several factors can cause variations in the water holding capacity of meat including: pH factor. The increased pH value results in high water holding capacity Sunarlim & Usmiati (2009), this is due to the high pH value of the meat resulting in a closed structure of the meat so that the high water holding capacity of the low pH value of the meat results in the open structure of the meat thereby reducing the water holding capacity. Table 1 shows that the increase in the pH value was followed by an increase in the water holding capacity of the meat. The value of the meat binding capacity of the three abattoirs was still in the normal range of 20-60% (Soeparno 2011).

According to Soeparno (2011), cooking loss is influenced by water holding capacity, high water holding capacity causes low cooking loss, and vice versa. The increase in the value of water holding capacity in this study on meat slaughtered at the Darmasaba RPH was followed by a decrease in the cooking loss value. This is also in accordance with the opinion of Tambunan (2009) that the cooking loss value is closely related to the binding capacity of water. The higher the water binding power, the less water and nutrient liquid will come out or wasted during the heating process, so that the mass of the meat will decrease slightly. A low cooking loss value will make the quality of the meat better. This is confirmed by Yanti et al., (2008), that meat that has a low cooking loss value below 35% has good quality because the possibility of releasing nutrients from the meat during cooking is also low. In accordance with this statement, the data of this study showed that all meat slaughtered in the three abattoirs was within the normal range of 15-40%.

Chemical quality of meat

Moisture content is the percentage of water content of a material which can be expressed by wet weight or dry weight. The results of variance showed that Bali beef with different slaughterhouse treatments at different abattoirs had no significant effect ($P<0.05$). Although there was a difference in the water holding capacity of the meat, namely the highest water holding value of Balinese beef slaughtered at the Darmasaba RPH, it did not affect the water content of the meat. This is because the range of water-holding capacity of the meat in the three treatments is still in the normal range (20-60%). Muscle contains about 75% water with a range of 68-80%, if the water content of the meat exceeds the normal water content (75%) it can reduce the quality of the meat. Fausiah & Al Buqhor (2019), research found that the water content of Bali beef in the traditional market of Polewali Mandar district, South Sulawesi, 74.85-77.98% Meat with high water content will look pale, runny and have a soft texture because a lot of water is bound to come out of meat. The high water content in meat causes less water-soluble protein so the water-holding capacity of meat protein will decrease.

Table 2
Chemical quality of Bali beef slaughtered at different abattoirs

Variable	RPH Mambal	RPH Pesanggaran	RPH Darmasaba	SEM
Water content (%)	70,88[a]	71,54[a]	70,64[a]	0,20
Protein Content (%)	25,93[a]	26,09[a]	26,19[a]	0,13
Fat level (%)	1,57[a]	0,88[b]	1,65[a]	0,09
Ash content (%)	1,04[a]	0,98[a]	1,06[a]	0,01

Annotation:
1. SEM is “Standard Error of Treatment”
2. Values with different letters in the same row, significantly different (P<0.05**)**

Along with the water content which was not significantly different, the protein content of Bali beef slaughtered at the three abattoirs also showed results that were not significantly different (P<0.05). Protein is the largest chemical component in meat that has an important role for growth, cell maintenance and as a source of calories. Different water content can cause differences in protein content, because protein has a close relationship with the water content of meat, especially the hydrophilic nature of muscle protein in binding meat molecules. In general, meat contains relatively constant amounts of protein and there may be no difference between breeds. According to Soeparno (2011) the protein content of meat ranges from 16-22%. The results in this study protein levels can be said to be very good because the number is above the normal value. The fat content of meat in this study was Bali beef slaughtered at the Mambal RPH 1.57%, at the Pesanggaran RPH 0.88% and at the Darmasaba RPH 1.65% statistically significantly different (P<0.05). The lowest fat content in Balinese beef slaughtered at the Pesanggaran RPH. This is because the water content of the meat slaughtered at the Pesanggaran RPH is the highest. Body water content is inversely proportional to body fat content. According to Soeparno (2011) the fat content of meat ranges from 1.5-13%. Research by Abustam & Ali (2004) found that the fat content of Bali beef ranged from 1.56 to 4.31%.
Ash content is a component of inorganic substances that are not burned in the combustion process. The results of variance showed that Bali beef slaughtered at different abattoirs had no significant effect (P>0.05) on the ash content of Bali beef. According to Sugeng (2004), foods derived from animal sources have a high ash content, this is due to some of the minerals contained in them such as calcium, iron, and phosphate. The high and low ash content is determined by the presence of minerals that are difficult to dissolve in the meat. In general, the chemical quality of Bali beef slaughtered at different abattoirs did not have a significant effect. These results are consistent with previous studies where meat quality is more influenced by extrinsic factors such as feed and rearing management (Guerrero et al. 2013).

Table 3
Microbiological quality of Bali beef slaughtered at different abattoirs

Variable	RPH Mambal	RPH Pesanggaran	RPH Darmasaba
TPC *cfu/g*	$7{,}1 \times 10^2$	$9{,}5 \times 10^2$	$1{,}2 \times 10^3$
Coliform *cfu/g*	2×10^1	1×10^1	3×10^1
E- Coli	-	-	-
Salmonella	Negative	Negative	Negative

Meat is a source of protein that is very susceptible to microbial contamination. Although the muscles of healthy animals are not contaminated with microbes, the surface of the meat can be contaminated during several stages of slaughter and transportation (Ercolini et al., 2010). This is in accordance with Syukur (2006), report that foodstuffs of animal origin (meat, eggs, and milk) and their processed products are easily damaged and are excellent media for microbial growth. Some microbial contamination can be caused by the sanitation of equipment, workers, exposure to floor surfaces, contamination of digestive tract contents, and water use in abattoirs, and can also increase during packaging, transportation, and distribution processes. Microbial contamination of meat can occur before and after the animal is slaughtered. According to Gustiani (2009), shortly after the cattle are slaughtered, the blood is still circulating throughout the animal's body, so using an unclean knife can cause microorganisms to enter the blood. Meat contamination can be prevented if the slaughtering process is carried out hygienically.

Based on the results of microbiological data in this study (Table 3), it was found that the highest TPC and coliform contents were in Bali beef slaughtered at Darmasaba RPH. RPH Darmasaba is a community managed RPH whose management is simple and of course the level of sanitation is still low. Based on observations in the field, slaughtering livestock on the floor and then proceeding with grounding on the floor without hanging, of course resulted in a high level of bacterial contamination. The absence of a special viscera also allows contamination to occur. It is different with the RPH Mambal and Pesanggrana which are managed by the government with more adequate facilities. In these two RPH, the garages are hung by hanging and there is already a special innards room so that contamination can be minimized. Based on the provisions set by the National Standardization Agency (BSN), the microbiological requirements for beef circulating in Indonesia are a total plate count (TPC) of 1×10^6 cfu/g,

Coliform bacteria 1 x 10^2 cfu/g, and Escherichia coli bacteria 1 x 10^1 cfu/g and Salmonella were negative (SNI 7388, 2009). If you look at the data in Table 3, the microbiological quality of Bali beef at the three abattoirs has good quality because it is below the SNI threshold. So, microbiologically, the meat of the three abattoirs is still safe for consumption

Conclusion

The physical quality of Balinese beef slaughtered at the Darmasaba RPH has the lowest physical quality compared to the Mambal and Pesanggaran abattoirs, especially on the pH and meat color variables. The chemical quality of Bali beef slaughtered at the three different abattoirs had no significant difference in water content, protein content, and ash content. The total plate count, colliform was below the SNI threshold while e-colli was not identified and salmonella was negative.

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