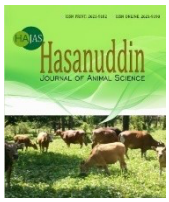

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Meat Quality Assessment for Meatball Production: Influence of Sales Volume Category and Location

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ABSTRACT

Meat outlook data for 2023 indicate that approximately 79.51% of total beef and around 35.47% of total chicken meat are utilized by the food industry. Variations in meatball quality can be attributed to the quality of raw meat used. This study aims to determine the quality of meat used as raw material for meatball production sold in traditional markets in Makassar City. A comparative observational study was conducted by analyzing chicken meat samples from six meat traders in these markets. Data were analyzed using analysis of variance (ANOVA) followed by the least significant difference (LSD) test. The results showed that factors of sales volume, location, and their interaction had a significant effect ($P<0.05$) on pH value, tenderness, and L* color of the meat. Sales volume and location also had a significant effect ($P<0.05$) on cooking loss. However, the interaction between these factors did not significantly affect ($P>0.05$) on cooking loss. The sales volume had a significant effect ($P<0.05$) on a* color value, while location and its interaction had no significant effect ($P>0.05$) on a*. Additionally, sales volume did not significantly affect ($P>0.05$) on b* color value, whereas location and its interaction had significant effects ($P<0.05$) on b*. In general, the quality of the meat is within normal limits, while the combination of chicken and beef heart as raw materials for meatballs shows significant variation with the dominant use of chicken.

Keywords: Meat quality, meatballs, traditional market

INTROODUCTION

Meat is a major food commodity that has helped improve people's intake of animal protein. According to meat outlook data for 2023, around 79.51% of total beef is used by the food industry, while the remaining 20.49% is for household consumption [1], and about 35.47% of total chicken meat is used by the food industry, with the remaining 64.53% meant for household consumption [2]. These figures highlight the importance of industrial-scale beef and chicken production.

Meat quality is affected by various physical, chemical, and microbiological factors that influence its characteristics as a food ingredient. Generally, high-quality meat has a bright color, an elastic texture, a fresh aroma, and a stable pH within the normal range. Additionally, good water-holding capacity and optimal tenderness are important indicators of meat quality. However, meat quality can decline due to several reasons. These include pre-slaughter stress, improper handling after slaughter, storage at unsuitable temperatures, exposure to open air, and microbial contamination from poor sanitation during distribution and sales, all of which significantly reduce meat quality.

The traditional markets in Makassar City are a compelling setting for investigation, given their central role in meeting people's food needs. While the processed food industry in traditional markets continues to grow, questions about the quality of the meat used and its suitability for processed food production are becoming increasingly relevant. Consumers can get various kinds of meat in traditional markets. One of the popular processed food products in Makassar City is meatballs. Currently, many processed meat products are found, especially meatball products, whose quality varies [3]. This could be due to the quality of the raw meat used. Consumers seek quality meat, expecting that it will be processed into a meatball product whose quality is guaranteed. Meanwhile, traditional markets are often associated with deficiencies, including poor sales premises, cleanliness, and meat freshness.

Food ingredient processing serves various goals, including extending shelf life, enhancing added value, improving nutritional content, increasing product appeal, and diversifying processed foods. In this context, research was conducted to evaluate the suitability of meat quality and composition as raw materials for meatballs in traditional markets in Makassar City, with the aim of producing the desired meatball products.

MATERIALS AND METHODS

The tools used in this research were a coolbox, a pH meter, a bimetal thermometer, a Warner-Bratzler shear force, a colorimeter, scales, pans, stoves, vacuum plastic, labels, knives, tweezers, containers, masks, gloves, cellphones, and stationery. The materials used in this research were chicken meat, pH 4.0 and 7.0 buffer solutions, and distilled water. This research was conducted from May to June 2024. The research data were collected from the traditional market in Makassar City. Meat samples taken in the market were brought to the Livestock Product Technology Laboratory, Faculty of Animal Husbandry, Hasanuddin University, for quality testing.

This research is a comparative observational study that samples 100 grams of chicken meat from 6 meat traders in traditional markets in Makassar City. Chicken meat samples were

collected from three locations in the market: location 1 is inside Pasar Daya, location 2 is in the Pasar Niaga Daya shophouse, and location 3 is on Jalan Niaga Daya, divided into the west and east sides. At each location, there are two categories of trader sales volume, namely small traders with sales <1,000 head/day and large traders with sales ≥1,000 head/day, with each category represented by three traders. The data were analyzed using analysis of variance (ANOVA), followed by the LSD test when significant differences were detected.

Research Procedure

In this study, meat purchased at the market is tested for quality, and pH is measured directly at the market where the samples are collected. Meanwhile, samples for testing cooking loss, tenderness, and color are put in airtight plastic and stored in a coolbox. It was then taken to the laboratory for testing of cooking loss, tenderness, and meat color.

RESULTS AND DISCUSSIONS

Quality of Meat

Potential Hydrogen (pH)

The pH value measures the acidity or basicity of a solution, indicating whether it is acidic, basic, or neutral. The pH level is closely linked to meat quality because it can affect meat attributes [4]. The pH levels of raw meat ingredients used in making meatballs at the Makassar City Traditional Market are shown in Table 1.

Table 1. Potential Hydrogen (pH) of Meat Raw Materials in Making Meatballs in the Market, Traditional Makassar City.

Sales Volume Category	Location			Mean
	1	2	3	
Small	5.69±0.06	5.79±0.16	7.03±0.31	**6.17±0.67^{a}**
Big	6.61±0.18	6.49±0.10	6.81±0.11	**6.64±0.18^{b}**
Mean	**6.15±0.52^{x}**	**6.14±0.40^{x}**	**6.92±0.24^{y}**	

Description: Location 1: inside Pasar Daya, location 2: PND shophouse, location 3: Jalan Niaga Daya. Numbers followed by different superscripts in the same row and column indicate significant differences (P<0.05)

Based on the results of the variance analysis, merchant sales volume, location, and their interaction significantly impact meat pH (P < 0.05). Additionally, LSD tests showed significant differences in meat pH between location 1 and location 3, as well as between location 2 and location 3 (P<0.05), while the difference between location 1 and location 2 was not significant (P>0.05). Therefore, it can be concluded that both sales volume and location, as well as their interaction, significantly influence meat pH. Small traders in location 3 have the highest pH, followed by wholesalers in locations 3, 1, and 2; the lowest pH is observed among small traders in locations 1 and 2. This difference results from faster stock turnover and higher sales volumes at wholesalers, which help keep the meat fresh and prevent significant glycolysis after slaughter. Conversely, small traders tend to retain stock longer due to lower sales, resulting in a greater decrease in pH caused by lactic acid buildup, particularly from microbial growth or meat

degradation during storage [5]. Excessive storage time can also lower the pH of meat [6]. The sales location also significantly impacts the pH level of chicken meat. Meat from the interior areas of Pasar Daya and PND shophouses generally has a lower pH than meat from Jalan Niaga Daya. This is because the local market environment is more enclosed, poorly ventilated, and hot, thereby accelerating anaerobic metabolic processes and lactic fermentation in muscle tissue. This accelerates the decline in pH due to lactic acid accumulation. Conversely, meat sold in off-market locations tends to have a higher pH because of better storage conditions, such as improved air circulation, which slows down the decrease in pH. The interaction between the trader's sales volume and location significantly influences the pH of chicken meat. Meat sold by large traders on Jalan Niaga Daya has the highest pH, while meat from small traders in the inner parts of Pasar Daya and PND shophouses exhibits a lower pH. This indicates that sales volume and location interact to affect meat pH. Wholesalers on Jalan Niaga Daya, with quick stock turnover and a more open environment, keep meat fresh and maintain a more stable pH. In contrast, small traders in the interior sections of Pasar Daya and PND shop houses tend to store meat longer under less ideal conditions, resulting in lower pH levels.

The pH value of normal chicken meat ranges from 5.3 to 5.9 [7]. Soeparno [8] states that the pH standard for chicken meat is 5.4-5.8. Additionally, a high pH in meat can result from stress and fatigue during transport to the slaughterhouse, which reduces muscle glycogen levels [9]. If the animal is not rested and is slaughtered immediately, the minimum pH achieved is only around 6-7 [10]. Microbial growth can also increase the pH; this occurs due to bacterial stimulation and activity, leading to a high final pH [11]. Conversely, low pH is typically caused by pre-slaughter stress, as reported in other studies [8]. Under stress, animals produce more lactic acid, which lowers the meat pH.

The hydrogen potential (pH) of meat significantly affects the quality of meatballs. If the pH is too high, it promotes faster microbial growth [11], resulting in spoilage and reduced meatball quality. Additionally, a high pH can make meatballs too tough because meat proteins become denser, and water retention increases [12]. This is consistent with the findings of researcher Lukman [10], who noted that meat with a high final pH (i.e., a slow pH decline) tends to be Dark, Firm, and Dry (DFD). Conversely, meat with a low final pH (i.e., a rapid pH decline) exhibits PSE (Pale, Soft, and Exudative) characteristics. If the pH is too low, the water-holding capacity decreases (Firahmi et al. [6]), resulting in juicier, softer meatballs with a less firm texture due to protein denaturation, producing a less desirable product. Therefore, it is essential to maintain meat pH within an optimal range to ensure meatballs have good texture, water retention, flavor, and durability.

Cooking Loss

Cooking loss is a factor in determining meat quality because it reflects the extent to which water is lost and the nutrients retained during cooking. The cooking loss of raw meat used to make meatballs at the Makassar City Traditional Market is presented in Table 2.

Table 2. Cooking Loss of Raw Meat Ingredients in Making Meatballs in Traditional Markets Makassar City.

Sales Volume Category	Location			Mean
	1	2	3	
Small	31.67±2.89	33.33±7.64	23.33±2.89	**29.44±6.35^{b}**
Big	25.00±0.00	28.33±2.89	21.67±2.89	**25.00±3.54^{a}**
Mean	**28.33±4.08^{y}**	**30.83±5.85^{y}**	**22.50±2.74^{x}**	

Description: Location 1: inside Pasar Daya, location 2: PND shophouse, location 3: Jalan Niaga Daya. Numbers followed by different superscripts in the same row and column indicate significant differences (P<0.05)

Based on the results of the variance analysis, it is clear that factors such as merchant sales volume and location significantly influence (P<0.05) the amount of meat cooking loss. The interaction between merchant sales volume and location did not significantly affect meat cooking loss (P > 0.05). Additionally, the LSD further test revealed a significant difference in meat cooking loss between location 1 and location 3 (P<0.05), as well as between location 2 and location 3 (P<0.05), while the difference between location 1 and location 2 was not significant (P>0.05). Therefore, both merchant sales volume and sales location significantly impact meat cooking loss, while their interaction does not. The findings indicate that small traders experience higher meat cooking losses than wholesalers. Among locations, wholesaler location 3 has the lowest cooking-loss value, followed by small traders in location 3 and large traders in locations 1 and 2; small traders in locations 1 and 2 have the highest cooking losses.

The results of this research show that meat sold by large traders has a lower cooking-loss percentage than meat from small traders. Lower cooking losses in wholesale meat are attributable to its freshness and higher intramuscular water content, which is more tightly bound to protein. In meat that is not fresh enough, as often found in small traders, the protein structure changes due to degradation, reducing the muscle tissue's ability to retain water. As a result, when heated, the meat loses more liquid, leading to a higher cooking-loss percentage. The sales location also significantly impacts the cooking loss of chicken meat. Meat sold in PND markets and shophouses has a higher cooking-loss value than meat from Jalan Niaga Daya. This may be caused by environmental conditions in the market, such as a more enclosed environment and higher temperatures, which can accelerate protein denaturation before cooking. This denaturation reduces water retention in muscle tissue, so during heating, more fluid is released from the meat. In contrast, meat from Jalan Niaga Daya exhibits lower cooking losses due to storage and environmental conditions that better preserve the structure of muscle tissue prior to cooking. The interaction between the trader's sales volume and location is not significant, suggesting that cooking losses are more affected by individual factors than by sales volume or location alone, with no interaction that amplifies or diminishes either factor.

The analysis results show that the average cooking loss for all tested meats is within normal limits, indicating good meat quality. The protein structure in meat helps bind the water within the meat [13]. Typically, good cooking losses range from 15% to 35%. According to Soeparno [8], meat with a cooking loss below 35% is considered of good quality because nutrient loss during cooking is also minimal. This range is ideal because it can produce meatballs with a chewy, juicy texture and good nutritional value. Suwiti et al. [14] stated that meat with a low

cooking loss has relatively better quality than meat with a high cooking loss [15], because the nutrients in the meat remain plentiful and have not leached out [16].

Cooking loss in meat varies with several factors. Low cooking losses can be attributed to high water-holding capacity (Suwiti et al., [14]). The higher the DIA, the lower the cooking loss. Apart from that, the pH of the meat is optimal, Soeparno [8], and sufficient intramuscular fat content. On the other hand, high cooking losses can occur due to low water-holding capacity; low meat pH, which is not optimal, leads to greater water loss during cooking, resulting in high cooking losses [14]. Understanding these factors is important for controlling cooking losses and optimizing the quality of meatball products.

The impact of cooking loss on meatball products is very important. The lower the cooking loss, the better the product quality because there is less nutritional loss; conversely, the higher the cooking loss, the lower the product quality. The smaller the cooking loss, the better the quality in terms of taste, organoleptic properties, and economic value [17]. By paying attention to factors that influence cooking losses and keeping values within the optimal range, meatball producers can create high-quality products and improve production efficiency. This will not only increase consumer satisfaction but also maximize producers' economic profits.

Tenderness

Tenderness is a measure of meat quality and an important factor influencing consumer acceptance of meat [18]. Low meat quality is characterized by low tenderness. The tenderness value of raw meat used for making meatballs at the Makassar City Traditional Market is shown in Table 3.

Table 3. Tenderness of Raw Meat in Making Meatballs in Traditional Markets Makassar City.

Sales Volume Category	Location			Mean
	1	2	3	
Small	0.37±0.02	0.29±0.32	0.39±0.62	**0.35±0.06^{a}**
Big	0.37±0.09	0.60±0.15	0.96±0.04	**0.64±0.27^{b}**
Mean	**0.37±0.58^{x}**	**0.45±0.19^{x}**	**0.67±0.31^{y}**	

Description: Location 1: inside Pasar Daya, location 2: PND shophouse, location 3: Jalan Niaga Daya. Numbers followed by different superscripts in the same row and column indicate significant differences (P<0.05)

The research results also indicate that meat sold by large traders tends to be more tender than that from small traders. This is likely due to the meat's freshness, as fresher meat has more pliable muscle tissue and has not hardened due to quality loss. Meat from small traders tends to be tougher because of longer storage times, protein denaturation, and increased cross-linking in muscle tissue. The sales location also significantly affects the tenderness of chicken meat. Meat from outside the market is more tender than meat from inside the market and PND shophouses. This difference may be attributable to environmental factors, with higher temperatures and humidity inside the market accelerating protein structural changes, thereby increasing firmness. The interaction between the trader's sales volume and location also plays a significant role in the tenderness of chicken meat. Meat from large traders outside the market generally has the best tenderness, while meat from small traders inside the market tends to be the least tender.

Meat tenderness can be evaluated using the Warner-Bratzler method, which classifies tenderness into several categories [19]. These categories include: very tender meat with a Warner-Bratzler breaking strength of less than 4.15 kg/cm², tender meat with a breaking strength between 4.15 and less than 5.86 kg/cm², slightly tender meat with a breaking strength of 5.86 to less than 7.56 kg/cm², somewhat tough meat with a breaking strength of 7.56 to less than 9.27 kg/cm², tough meat with a breaking strength of 9.27 to less than 10.97 kg/cm², and very tough meat with a breaking strength of 10.97 kg/cm² or more. The ideal chicken meat for meatballs is moderately tender—neither too hard nor too soft. Several factors can cause chicken meat to be tough or low in tenderness, including chicken from older animals, which tends to be tougher due to increased collagen cross-linking [8]; high muscle activity, especially in parts like thighs that move more and tend to be tougher [20]; and high collagen and elastin content, which can impact tenderness [22]. Conversely, factors that lead to overly tender or soft chicken meat include meat from younger animals, which generally has better tenderness because of smaller size and less connective tissue, as older animals tend to have more connective tissue that decreases tenderness [19]. Tenderness is also influenced by chilling, refrigeration, aging, cooking methods, freezing, and processing techniques [24], as well as by proteolytic enzymes such as papain, which decrease tenderness [25].

The tenderness of the meat influences the quality of the meatballs made. If the meat is too tender (or too tough), the meatballs tend to be tough and less appealing. Conversely, meat that is too soft can yield meatballs that are overly soft and prone to falling apart. This is due to the low myofibrillar protein content, which contributes to the meatball's structure. The optimal meat tenderness yields meatballs that are chewy, firm, yet tender—a texture that consumers prefer. Therefore, the ideal tenderness for chicken meat in meatballs is medium, neither too hard nor too soft [3].

Color

The color of the meat used as raw material for making meatballs is very important because it can affect the quality and attractiveness of the final meatball product produced. The meat color values of raw materials in making meatballs at the Makassar City Traditional Market are presented in Table 4.

Table 4. L Color of Raw Meat in Making Meatballs at The Makassar City Traditional Market.

Sales Volume Category	Color L			
	Location			Mean
	1	2	3	
Small	53.32±2.31	52.11±0.60	48.08±0.67	**51.17±2.68^{a}**
Big	51.86±0.43	53.29±0.96	53.37±0.75	**52.84±0.98^{b}**
Mean	**52.59±1.69^{y}**	**52.70±0.96^{y}**	**50.73±2.97^{x}**	

Note: Location 1: inside Pasar Daya, location 2: PND shophouse, location 3: Jalan Niaga Daya. The notation L (lightness) with a value range from 0 - 100 indicates from dark to light. Numbers followed by different superscripts in the same row and column indicate significant differences (P<0.05)

Based on the results of the variance analysis, merchant sales volume, location, and the interaction between merchant sales volume and location significantly influence the L color value of meat (P < 0.05). Furthermore, the LSD further test showed that there was a significant

difference in the L color value of meat between location 1 and location 3 (P=0.015) as well as location 2 and location 3 (P<0.05), while the difference between location 1 and location 2 was not significant (P>0.5). Location 3 wholesalers have the highest L color, followed by small traders in location 1 and large traders in location 2; wholesalers in location 2 are next; and the lowest L color is large traders in location 1 and small traders in location 3.

Table 5. Color a* of Raw Meat in Making Meatballs at the Makassar City Traditional Market.

Sales Volume Category	Warna a*			
	Location			Mean
	1	2	3	
Small	-2.66±0.24	-3.38±0.69	-2.13±0.62	**-2.72±0.73^{a}**
Big	-1.80±1.22	-0.85±0.31	-1.52±0.53	**-1.39±0.80^{b}**
Mean	**-2.23±0.91^{x}**	**-2.12±1.47^{x}**	**-1.82±0.62^{x}**	

Note: Location 1: inside Pasar Daya, location 2: PND shophouse, location 3: Jalan Niaga Daya. The notation a* (Redness) with a value range from (-80) to (+80) indicates from green to red. Numbers followed by different superscripts in the same row and column indicate significant differences (P<0.05)

Based on the results of the variance analysis, the factor of merchant sales volume has a significant effect (P < 0.05) on the a* color value of meat. Meanwhile, location and the interaction between merchant sales volume and location did not have a significant effect (P > 0.05) on the a* color value of meat. Furthermore, the LSD post hoc test showed that there was no significant difference in the a* color value of the meat between location 1 and location 3 (P>0.05), between location 2 and location 3 (P>0.05), and between location 1 and location 2 (P>0.05). Wholesalers in location 2 have the highest a* color, followed by those in location 3 and location 1; small traders in location 3 are next; and the lowest values are among small traders in locations 1 and 2.

Table 6. Color b* of Raw Meat Ingredients for Making Meatballs at the Makassar City Traditional Market.

Sales Volume Category	**Warna b***			
	Location			**Mean**
	1	**2**	**3**	
Small	1.51±0.75	1.26±0.94	4.09±1.27	**2.28±1.61^{a}**
Big	5.44±0.20	0.04±0.28	2.40±0.53	**2.63±2.37^{a}**
Mean	**3.48±2.21^{y}**	**0.65±0.91^{x}**	**3.23±1.27^{y}**	

Note: Location 1: inside Pasar Daya, location 2: PND shophouse, location 3: Jalan Niaga Daya. The b* (yellowness) notation, with a value range from (-70) to (+70), shows from blue to yellow. Numbers followed by different superscripts in the same row and column indicate significant differences (P<0.05)

Based on the variance analysis, the factor merchant sales volume did not have a significant effect on the b* color value of meat (P>0.05). While the interaction between merchant sales volume and location has a significant effect (P<0.05) on the b* color value of meat. Furthermore, the LSD further test showed that there was a significant difference in the b* color value of the meat between location 1 and location 2 (P<0.05) as well as location 2 and location 3 (P<0.05), while the difference between location 1 and location 3 was not significant (P>0.05).

Location 1 wholesalers have the highest b* color, followed by small traders in location 3 and large traders in location 3, followed by small traders in locations 1 and 2, and the lowest color b* is the wholesaler location 2.

The research results show that traders' sales volume significantly influences the color L* and a* of chicken meat, but does not significantly influence the color b*. Meat sold by large traders has a higher L value, which indicates that the meat is brighter and fresher compared to meat from small traders. This is due to faster stock turnover, resulting in meat sold that is fresher. Storing meat for longer will also cause a decrease in the brightness of the meat color (L* value) [19]. In addition, the a* (redness) value is also higher in meat from wholesalers, which indicates that the meat is fresher and has higher oxymyoglobin levels. On the other hand, meat from small traders tends to experience a decrease in the a* value due to oxidation of the pigment to metmyoglobin, which causes the red color to fade. However, the sales volume of traders does not have a significant influence on the b* (yellowish) value of chicken meat. This suggests that other factors, such as chicken feed before slaughter or meat fat content, play a greater role in determining the extent of yellowing than the scale of traders' sales. The sales location also significantly influences the color L* and b* of chicken meat, but does not significantly influence the color a*. Meat sold at the Jalan Niaga Daya location has a lower L value compared to meat sold inside the Daya Market and PND shophouses. This indicates that meat sold on Jalan Niaga Daya tends to be less bright. Environmental factors, such as direct exposure to elevated temperatures and suboptimal lighting, can accelerate color change, resulting in meat appearing darker. In contrast, the b* value is higher for meat sold on Jalan Niaga Daya and inside Pasar Daya compared to PND shophouses. This can be attributed to exposure to higher environmental temperatures, which accelerate the oxidation of fats and carotenoid pigments, thereby increasing the meat's yellowish color. The interaction between merchant sales volume and location shows a significant influence on the colors L and b*, but not on the color a*. Meat from wholesalers on Jalan Niaga Daya has higher L* and b* values than other meat, indicating that a combination of sales volume and location factors influences meat color.

These results indicate that the mean L value of all meat tested is within normal limits, while the mean a* value of all meat shows a tendency to green color, and the mean b* value of all meat shows a tendency to yellow color. The L, a, b values have scale intervals that indicate the color level of the material being tested. The notation L denotes the brightness parameter, with a range from 0 to 100, indicating increasing brightness from dark to light. The notation a* (Redness) with a value range from (-80) to (+80) indicates from green to red. The notation b* (yellowness) with a value range from (-70) - (+70) indicates from blue to yellow [26]. The reddish and yellowish color of processed meat products is related to the amount of myoglobin contained in them, while the level of brightness is related to the structural characteristics of the muscle [27].

Variations in chicken meat color can be caused by different factors. A low L* (brightness) value might result from increasing maturity levels in livestock, which can lead to a decrease in meat brightness [28]. Storing meat for longer periods also reduces the meat color's brightness (L* value) [19]. Livestock fed low-energy diets tend to produce meat with a darker reddish hue, while those fed medium or high-energy diets produce meat with a brighter red color [29]. Additionally, low marbling affects color. An L* value that is too low (dark) can also be caused by poor handling during slaughter or decreased meat quality due to pre-slaughter stress in chickens. Meat that undergoes a rapid pH drop may also appear darker, a condition known as "dark, firm,

dry" (DFD). Conversely, an L* value that is too high (too bright) is often linked to high water content or reduced muscle tissue quality, resulting in softer, paler meat—known as pale, soft, exudative (PSE). An a* value that is too low may indicate low myoglobin levels, a pigment responsible for the red coloration of meat. This can occur if chickens are slaughtered too young or are malnourished. Tahuk et al. [28] noted that increasing livestock age can increase myoglobin concentration, although not in a linear manner. The higher the myoglobin content, the darker the meat will be [30]. Chicken meat color that falls outside standard specifications can significantly impact meatball quality. Differences in a* redness values are also affected by muscle type and activity level. A high b* value might indicate subcutaneous fat accumulation or poor handling after cutting, which can influence the visual appeal of meatballs and give an undesirable yellowish appearance.

An L color that is too low* will make the meatballs look darker, which is visually less attractive to consumers, because good meatballs are generally expected to be bright in color. Meanwhile, an L color that is too high can make the meatballs appear too pale, thereby reducing visual appeal and creating the impression that the product contains excessive water, thereby compromising texture quality. A* color that is too low will produce meatballs that are pale and not fresh, reducing the perception of product quality, especially in relation to the freshness of the meat. And a* b* color that is too high (too yellow) can cause the meatballs to look old or oxidized and will reduce consumer appeal. Selecting chicken meat with A* color that meets standards is very important to produce meatballs of optimal quality.

CONCLUSIONS

The quality of meat (pH, cooking loss, tenderness, color) sold in traditional markets in Makassar City is influenced by the type of trader and sales location. The type of trader, location, and their interactions significantly affect pH and meat tenderness. The type of trader and the sales location have significant effects on meat cooking loss, while their interaction does not. Regarding color, the trader type, location, and the interaction between merchant type and location significantly influence the L* color value of meat. The trader significantly affects the meat's color value. However, neither the location nor the **i**nteraction between merchant type and location has a significant effect on the a* color value of meat. The trader type factor does not significantly affect the b* color value of meat. Conversely, the location and the interaction between merchant type and location significantly influence the b* color value. Larger traders tend to offer higher-quality meat than smaller traders, with higher mean pH and tenderness and lower cooking loss. Overall, the values for cooked shrinkage, tenderness, color L, and color b* of all the meat sold fall within normal limits.

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AUTHORS' CONTRIBUTIONS

All authors designed the study and drafted and revised the manuscript, performed the experiments, and analyzed the data. All authors have read and approved the final manuscript.

COMPETING INTERESTS

The authors have to declare that they have no competing interests.

ETHICAL CLEARANCE

Authors must have ethical clearance to use animals as research objects, either in the form of direct contact with animals or in the use of their products in research.

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