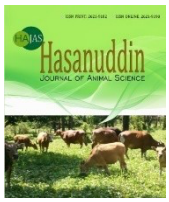

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Colour's Profile of Longissimus Dorsi Beef at Different Kluwek Addition Levels and Marinating Times

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ABSTRACT

Beef is a common food in everyday life. The longissimus dorsi muscle, known as rib eye, is one of the primary cuts of beef due to its tenderness and marbling, making it highly valued for culinary purposes. Meanwhile, kluwek (*Pangium edule*), a plant widely found in Southeast Asia and known locally as kepayang, is traditionally used as an antioxidant, preservative, and natural colouring agent in food preparation. This study aims to analyze the colour profile of *Longissimus dorsi* beef by evaluating the effects of different levels of kluwek addition and marination times. The experiment was designed using a 5x4 factorial pattern with three replications. The first factor was the kluwek level (L1 = 0%, L2 = 2%, L3 = 4%, L4 = 6%), and the second factor was the marination time (W0 = 0 minutes, W1 = 30 minutes, W2 = 60 minutes, W3 = 90 minutes, W4 = 120 minutes). Results indicated that the lightness (L*) of the beef was significantly affected ($P<0.05$) by the addition of 6% kluwek, with an interaction observed between kluwek levels and marination times. Redness (a*) was not significantly influenced ($P>0.05$) by any of the treatments, while yellowness (b*) was significantly reduced ($P<0.05$) with the addition of 6% kluwek. In conclusion, adding 6% kluwek effectively alters the lightness (L*) and yellowness (b*) of the beef, while redness (a*) remains stable. This study highlights the potential of kluwek as a local ingredient for enhancing the visual properties of beef during marination.

Keywords: Kluwek, Longissimus dorsi, Marinating time

INTROODUCTION

The fattening of beef cattle has been steadily increasing each year in response to the growing demand for beef. Meat is one of the foods that spoil easily due to microbial activity if no preservation measures are taken [1]. Beef is a high-nutrient food, making it an essential source of nutrients for humans [2]. Besides its nutritional value, the visual quality of beef, such as its color, is a key factor in consumer acceptance. Meat color can be affected by internal factors, like muscle type and myoglobin levels, as well as external factors, such as additives and processing methods. Firdaus et al. [3] stated that fresh beef is susceptible to bacterial contamination, which requires processing methods like marination. Marination involves soaking meat in spices or other natural ingredients to help prevent bacterial contamination and improve flavor.

Kluwek is a spice used in various dishes, especially Indonesian dishes like rawon, brongkos vegetables, and konro soup. Kluwek also helps give food a blackish-brown color. The content of kluwek includes beta-carotene, cyanide acid, hydnocarpate, and glaric acid [4]. Not only that, but kluwek also has flavonoid compounds that act as preservatives and inhibit bacterial growth. The addition of kluwek is often used as a natural preservative and to give it a distinctive flavor [5].

This research is crucial because adding kluwek to food requires knowledge of the appropriate concentration to achieve good product appearance, particularly for meat products. Likewise, the appropriate marinating time is crucial for achieving optimal performance for meat products before processing.

MATERIALS AND METHODS

Beef *Longissimus dorsi* was obtained from a slaughterhouse in Makassar City. The beef was weighed according to the researcher's needs. Kluwek was sourced from Soppeng Regency, which is a kluwek production site. The beef was placed in a container filled with marinade and kluwek at concentrations (L1 = 0%, L2 = 2%, L3 = 4%, and L4 = 6%), with marinade times of 0, 30, 60, 90, and 120 minutes. The measured variables were Brightness (L*), Redness (a*), and Yellowness (b*). Meat color values were measured using a digital color tester (T 135) that records L *, a *, and b * values. Color value L* ranges from 0 to 100 (black-white); a* from -60 (green) to +60 (red); and b* from -60 (blue) to +60 (yellow) [6].

Data Analysis

The data obtained were analyzed for variance using a completely randomized design (CRD) [7] with a 5 x 4 factorial pattern and 3 replications. The analysis of variance is based on the mathematical model used for the design, as follows:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

y_{ijk} = The observation value at factor A level i and B level j at the k-th replication.
μ = Additive component of the common mean.
α_i = Main effect of factor A.
β_j = Main effect of factor B.
$(\alpha\beta)_{ij}$ = Interaction component of factor A and factor B.
ϵ_{ijk} = Random component of the subplots.

RESULTS AND DISCUSSIONS

The Brightness Value L*

The results of the study showed that the addition of local kluwek levels had a significant effect (P<0.05) on the brightness level of Longissimus dorsi beef, as shown in Table 1. However, marination time did not have a significant effect (P>0.05). The interaction between the two factors had a significant effect (P<0.05) on the brightness (L*) of the beef.

Table 1. Brightness (L*) of Longissimus Dorsi Beef Using Different Levels of Kluwek Addition and Marination Times.

Marination Time (Minutes)	Kluwek Levels (%)				Average
	L1	L2	L3	L4	
W0	26.64±2.38	28.48±1.31	26.61±4.86	24.83±2.09	**26.64±2.87^{a}**
W1	37.58±1.34	28.37±1.29	27.33±5.41	20.77±2.18	**28.51±6.78^{ab}**
W2	34.37±4.57	31.27±1.58	27.83±2.84	23.26±3.37	**29.18±5.13^{ab}**
W3	30.24±6.51	29.18±1.34	27.14±3.49	26.44±0.62	**28.25±3.58^{ab}**
W4	34.85±1.16	30.81±0.62	30.35±3.23	23.71±2.74	**29.93±4.58^{b}**
Total	**32.74±5.11^{c}**	**29.62±1.64^{b}**	**27.85±3.71^{b}**	**23.80±2.79^{a}**	**26.64±2.87^{a}**

Descripion: ^{ab}superscript follow the average value in the same column indicates highly significant difference (P<0.05). (W0 = 0 Minute, W1 = 30 Minutes, W2 = 60 Minutes, W3 = 90 Minutes, W4 = 120 Minutes, L1 = 0% Kluwek, L2 = 2% Kluwek, L3 = 4% Kluwek, L4 = 6% Kluwek)

The brightness of beef caused by the level of kluwek addition and marination time showed significant differences. Kluwek contains various compounds, including beta-carotene, acids, cyanide, hydnocarpic acid, khulmograt acid, glorat acid, and tannins. Besides being a natural coloring agent, kluwek also acts as a source of antioxidants with antibacterial properties, helping preserve the meat [8]. The noticeable color change seen during marination with kluwek is due to these chemical compounds and the Maillard reaction [9]. Adding higher levels and prolonging marination time can change the meat's properties through chemical reactions that affect its color [10]. The brightness of meat is also influenced by feed intake, which can modify its color intensity [11]. According to Anshori et al. [12], the brightness level of broiler chicken meat that consumed a supplementary feed mixture of tofu waste and mung bean flour, along with standard feed, ranged from 58.95 to 65.63. This variation can be linked to the high protein content of the feed, which speeds up the whitening of the meat. Additionally, meat brightness can also be affected by differences in the anatomical parts of the livestock [13].

The L* brightness value of the beef changed during marination. The addition of kluwek at 6% resulted in a lower L* value of 23.80, indicating a darker color than at 2%, which had a brightness value of 29.62. The interaction between marination time and kluwek level significantly affected both factors (P<0.05), with 6% kluwek and 30 minutes of marination resulting in a

brightness value of 20.77. This change was caused by chemical reactions triggered by adding kluwek, which affected the L* value of the beef. Firdaus et al. [3] support this, stating that meat tends to darken due to natural color changes during marination, with longer marination times and higher levels of kluwek influencing the meat's color as local ingredients penetrate the meat. The color in meat is determined by the relative proportions and distribution of the three pigments, which cause metmyoglobin to appear on the surface [14]. During processing or marination, meat brightness changes. According to Izzah et al. [15], caramelization produces a sweet-tasting, brown-colored substance made of various compounds similar to carbohydrates, which form during processing or heating. Additionally, Tiven et al. [16] explained that the brown color of shredded meat (*abon*) results from adding sugar during cooking. When heated to high temperatures, sugar undergoes the Maillard reaction, a non-enzymatic browning process between sugars and proteins. Cooking time also affects abon's color (Abon is finely shredded meat, seasoned and fried, a typical Indonesian meat produc*t)*. The longer the cooking, the darker the color. Similarly, marination time and ingredients influence the meat's brightness. This is in line with Gaga et al. [17], who state that processing time significantly impacts meat color.

The Redness Value a*

The redness (a*) of Longissimus Dorsi beef with the addition of kluwek and marination time is shown in Table 2. In this study, neither the addition of kluwek nor marination time had a significant effect (P>0.05) on the redness (a*) of beef.

Fermented kluwek has a dark brown to black color. This color results from the fermentation process, which involves chemical changes in tannin compounds and natural pigments. Warnasih and Hasanah [4] stated that this physical property of kluwek makes it commonly used to impart a dark color and distinctive flavor to dishes such as rawon, semur, or spiced soups. According to Arteaga et al. [18], the phenolic compounds in kluwek interact with myoglobin. Ingredients like salt and acid in the marinade also affect the meat's color by speeding up pigment oxidation.

Table 2. Redness (a*) of *Longissimus dorsi* Beef Using Different Levels of Kluwek Addition and Marination Times.

Marination Time (Minutes)	Kluwek Levels (%)				Average
	L1	L2	L3	L4	
W0	16.10±4.55	10.74±3.37	16.10±4.55	13.19±2.33	**14.03±4.01**
W1	13.42±2.06	14.36±2.42	17.40±3.97	12.19±2.42	**14.34±3.13**
W2	14.90±4.04	14.78±0.92	11.69±4.15	16.18±1.34	**14.06±2.90**
W3	13.85±2.13	14.52±2.39	11.69±4.15	16.18±1.34	**14.06±2.86**
W4	12.79±1.50	12.89±1.39	12.35±1.16	11.72±1.26	**12.44±1.23**
Total	**14.21±2.89**	**13.46±2.47**	**14.14±3.78**	**12.76±2.57**	

Descripion: W0 = 0 Minute, W1 = 30 Minutes, W2 = 60 Minutes, W3 = 90 Minutes, W4 = 120 Minutes, L1 = 0% Kluwek, L2 = 2% Kluwek, L3 = 4% Kluwek, L4 = 6% Kluwek

Marination time and the addition of kluwek levels did not have a significant effect (P>0.05) on the redness (a*) value of the beef. This is because the phenolic compounds in kluwek interact

with myoglobin, causing the meat to darken, which does not affect its redness. The difference in a* color value depends on the amount of nitrosomyoglobin pigment, which gives a pink-red color [19]. The soaking or marination process using distilled water (*aquadest*) results in a decrease in the a* redness value during soaking and heating [20].

Konieczny et al. [21] state that the color of meat is influenced by the meat's own color. Good quality meat is bright red, resembling blood. Meat color is also affected by how the cattle are treated and their breed. A fresh, blood-red color indicates the meat is fresh and hasn't been stored for long. However, many factors can influence the ideal meat color, such as the meat's condition, the cattle's breed, and its fat content. Meat color is affected by various factors, including the molecular structure of myoglobin, its chemical state, and the condition of other components in the meat. Surface color variation in meat mainly comes from changes in the chemical state of the myoglobin molecule. According to Anshori et al. [12], the redness value (a*) of meat is influenced by the type and gender of the livestock. A decrease in the a* redness in treated meat results in a more chromatic red appearance. The reduction in a* redness is caused by boiling time, which leads to protein denaturation, forming metmyoglobin and giving a reddish-brown or blackish color [5]. The reaction between myoglobin and oxygen forms oxymyoglobin (MbO_2) in meat, affecting its red color. Additionally, adding nitrite during jerky production triggers reactions that form nitrosylmyoglobin (MbNO) [22]. Not only does the level of treatment affect the meat's redness, but marination and storage time also influence the a* value. As Heruwati et al. [8] state, prolonged refrigerated storage significantly impacts meat color.

The Yellow value b*

According to Pratama et al. [23], the chromatic yellow color value (b*) ranges from blue to yellow, with values from 0 to 70 for yellow and -70 to 0 for blue. A higher b* value signifies a stronger yellow coloration in the product. Based on the chromatic yellow scale (b*), the yellow intensity (b*) of *Longissimus dorsi* beef with added local *kluwek* and marination time can be seen in Table 2.

The results in Table 3 show a significant effect ($P<0.05$) of adding 6% *kluwek*, which decreases the yellow intensity (*b* value) to 6.65. However, marination time had no significant effect ($P>0.05$) on beef, and there was no interaction between the two factors. This is because chemical compounds in *kluwek* can influence meat color. Additionally, pH impacts the marination process, potentially changing myoglobin structure and triggering the Maillard reaction [24].

Adding raw materials or food additives during marination can change the yellow color (*b* value) of the meat [25]. According to Sorensen et al. [26], the increase in chromatic yellow (*b*) values in cooked meat may be linked to non-enzymatic browning reactions. During the initial stage of non-enzymatic browning, a condensation reaction occurs between free amino groups and carbonyl groups in reducing sugars, forming glycosylamine, which does not produce color. The reduction in yellow color is affected by the cooking process [27].

Table 3. Yellowness (b*) of *Longissimus dorsi* Beef Using Different Levels of Kluwek Addition and Marination Times.

Marination Time (Minutes)	Kluwek Levels (%)				Average
	L1	L2	L3	L4	
W0	6.24±3.87	6.24±3.87	9.30±4.23	7.13±2.09	**7.23±3.35^{a}**
W1	9.42±1.67	8.16±1.88	8.43±1.96	5.64±1.82	**7.91±2.13^{ab}**
W2	10.27±2.48	7.64±1.07	8.08±2.06	4.94±2.17	**7.73±2.61^{b}**
W3	9.47±1.18	8.05±0.84	6.38±2.42	9.12±2.12	**8.26±1.96^{ab}**
W4	10.04±1.09	9.90±1.74	12.36±1.37	6.41±2.87	**9.68±2.74^{b}**
Total	**9.09±2.46^{b}**	**8.00±2.19^{ab}**	**8.91±2.99^{b}**	**6.65±2.14^{a}**	

Descripion: ^{ab}superscript follow the average value in the same column indicates highly significant difference (P<0.05). (W0 = 0 Minute, W1 = 30 Minutes, W2 = 60 Minutes, W3 = 90 Minutes, W4 = 120 Minutes, L1 = 0% Kluwek, L2 = 2% Kluwek, L3 = 4% Kluwek, L4 = 6% Kluwek).

During storage, the *b* value decreases over time, with a noticeable drop on the fourth day, changing from yellow to dark. The darkening results from mold growth on the meat [28]. Meanwhile, Jaelani et al. [29] reported that the increase in chromatic yellow (*b*) values is due to oxidative damage caused by ozone exposure. Additionally, Soeparno [30] found that a temperature of 120°C significantly influences the release of iron (Fe) from meat, affecting color changes in later processes. If the temperature is below 120°C, Fe remains bound to myoglobin because the protein has not yet fully degraded.

CONCLUSIONS

The results of this study show that adding 6% kluwek significantly impacts the brightness (L*) of the beef, with a clear interaction between kluwek level and marination time. However, redness (a*) did not show a significant effect (P>0.05) from any of the treatments, whether it was the kluwek level or marination time. Conversely, yellowness (b*) was significantly influenced (P<0.05) by the addition of 6% kluwek, which noticeably decreased the yellowness of the meat. In conclusion, adding 6% kluwek significantly affects the brightness (L*) and yellowness (b*) of beef, while redness (a*) remains mostly unchanged.

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AUTHORS' CONTRIBUTIONS

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

COMPETING INTERESTS

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

ETHICAL CLEARANCE

This research does not involve direct contact with experimental animals or model animals.

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