https://doi.org/10.1051/bioconf/202515303006

Organoleptic and physicochemical of meltique beef steak injected with varying concentrations of coconut oil

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Abstract. Meltique is a processed type of beef created by injecting vegetable fat to create marbling similar to the appearance of Wagyu beef. This technique enhances tenderness, and juiciness, while imparting a distinct flavor through the injected emulsion. However, the research on Meltique beef remains limited. This study aims to analyze the physicochemical and organoleptic properties of Meltique beef injected with coconut oil emulsions at two concentrations (365 g and 730 g) and to compare them with Wagyu beef. The study included malondialdehyde (MDA) analysis, antioxidant properties, Texture Profile Analysis (TPA), and a hedonic sensory test. Data were analyzed using a completely randomized design (CRD), with Tukey and Duncan tests employed for sensory analysis. The results demonstrated that varying coconut oil concentration affected the physicochemical and organoleptic properties of the beef. Notably, the 730 g coconut oil emulsion exhibited the highest antioxidant activity and the lowest MDA content. In the sensory evaluation, the meat injected with the 730 g emulsion was preferred for its aroma and tenderness. The use of coconut in the formulation retains beneficial high lauric acid content, presents a promising alternative for emulsion blends, and exhibits characteristics similar to Wagyu.

1 Introduction

Beef is one of the most commonly consumed sources of protein in Indonesia, with an average protein content of approximately 18.8 grams per 100 grams [1]. This nutritional value makes beef a popular choice among consumers and a key product in the market for processing and consumption. Beef consumption has shown a steady annual increase, driven in part by the rising popularity of steak. Premium meats, such as Wagyu, constitute 10-15% of the total national meat demand. According to the Directorate General of Animal Husbandry and Animal Health of the Ministry of Agriculture, Indonesia's national meat demand reached nearly 950,000 tons in 2017. As a result, the demand for premium meat alone could account for approximately 143,700 tons. The increasing public demand for beef has led to a

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corresponding rise in the overall meat demand, creating a gap between supply and market demand. This disparity has made it challenging for the available supply to meet all market needs, highlighting the need for innovative solutions to address protein requirements. In response, numerous innovations in processed meat products, including meatballs, patty, *dendeng,* and fermented sausages [2], have emerged to help meet the population's protein demands.

An alternative innovation for protein products to be investigated is meltique meat. This product involves injecting vegetable or animal fats to create marbling and tenderness resembling Wagyu beef. The injection process enhances the tenderness and juiciness of the meat, making it easier to consume and imparting a distinct flavor. Injection is defined as the introduction of liquid into tissue using a syringe and needle through a certain depth, allowing certain materials to be incorporated into the tissue [3]. The process of injecting fat or oil into meat aims to improve the flavor, tenderness, and moisture of the meat. By injecting fat into the muscle fibers of the meat, the total fat content increases, providing a sensation of tenderness during consumption. Fat can also help to soften connective tissues, such as collagen, in meat. Normally, canola oil is used to inject into the Meltique meat, but its use increases the cost of the meat as the raw materials need to be imported. As an alternative in Indonesia, coconut oil emerged as a viable option for artificial marbling and remains largely unexplored in research. Coconut oil, rich in lauric acid (approximately 40%), is heat-stable and possesses antimicrobial and antioxidant properties [4].

In contrast to canola oil, the saturated fatty acid in coconut oil demonstrated relative stability against oxidation during high-temperature processing. This stability is critical, as the baking process can produce toxic compounds that pose carcinogenic risks with prolonged consumption [5]. High-temperature processing can produce free radical compounds influenced by the naturally occurring lipids in meat, leading to lipid oxidation reactions [6]. One by-product of lipid oxidation is malonaldehyde (MDA), a carcinogen that poses significant risks to human health. The fat content or emulsion in beef meltique consists of a mixture of vegetable oils injected into the meat to create artificial marbling [7]. An emulsion is defined as a stable mixture of two normally immiscible liquids, facilitated by a small quantity of surfactant that serves as an emulsifier [8]. The emulsion to be injected into meat consists of coconut oil, water, and uses Isolate Soy Protein (ISP) powder as the emulsifier, which helps maintain its stability, allowing for the formation of artificial marbling [9]. This study aims to enhance the understanding of meltique meat injected with coconut oil, hypothesizing that using coconut oil as an alternative could reduce costs without compromising quality.

2 Materials and methods

2.1 Materials

The primary ingredient for preparing Meltique beef was fresh sirloin, sourced from Balqis Agro Persada (BAP), located in Cibanteng, Bogor, West Java, Indonesia. Sirloin is a commonly preferred cut of meat due to its desirable texture and flavor. For comparison, Wagyu beef of grade MB9 was used. The ingredients for the emulsion included Isolated Soy Protein (ISP) from Paraagri in Bandung, coconut oil (Barco) from Dramaga market in Bogor, and water. The chemical agents utilized in the study included methanol, sodium hydroxide (NaOH), hydrochloric acid (HCl), aquades, antifoaming agent, propyl gallate (PG), tetra ethoxy propane (TEP), 2,2-diphenyl-1-picrylhydrazyl (DPPH), ethylene diamine tetra acetic acid (EDTA), thio barbituric acid (TBA), and ascorbic acid. These ingredients and chemicals

https://doi.org/10.1051/bioconf/202515303006

were carefully selected to ensure the desired properties and stability of the Meltique product, as well as to facilitate various analytical procedures throughout the study.

2.2 Methodology

2.2.1 Preparation of produce meltique

The production of the meltique with coconut oil followed a method as outlined by Anjany [10] with slight modifications to the ratio for emulsion. Materials used for making the emulsion were a mixture of water, coconut oil, and ISP powder, with the first formulation (K1) having a ratio of 1I (ISP):5O (Oil):5W (Water), and the second formulation (K2) using a 2(1I:5O:5W) ratio. For the first emulsion formulation, for 1000 g of meat, the total emulsion weight was 365 g, consisting of 33 g ISP, 165 g coconut oil, and 165 g water. The second emulsion formulation totaled 730 g, consisting of 66 g ISP, 331 g coconut oil, and 331 g water which were then mixed using a food processor until they fused and became an emulsion that was ready to be injected into the meat. Prior to the injection process, fresh sirloin meat was trimmed of fat, muscle, and tendons. Trimmed meat was then injected with the prepared emulsion using a syringe, positioned above the entire surface of the meat until the emulsion liquid enters the meat fibers. This injection is performed using a comb-shaped meat injection tool. After that, it was vacuum-sealed to allow the emulsion to be absorbed and bound to the meat fibers, then frozen at -20^{o}C for 24 hours. The next step involves cutting the meat and roasting the meat to become steak. The roasting process uses a preheated pan, maintaining a temperature of 62-70 ^{o}C for 10 minutes by turning the side of the meat for approximately 5-7 minutes [11]. After the roasting process, the meat is rested for approximately 10 minutes [12] and prepared for later analysis.

2.2.2 Malondialdehyde (MDA), antioxidant, texture and organoleptic analysis

Malondialdehyde was calculated from TBARS value [13], and antioxidant properties were assessed using DPPH method. Texture profile analysis (TPA) was conducted following the Association of Official Analytical Chemist (AOAC) with a texture analyzer. The samples, cut to a size of 3x1 cm are placed under the texture analyzer plate. The start button is pressed to activate the tool, and the load cell moved the probe downward to compress the sample before returning to its original position. The parameter observed was the texture of grilled meltique beef. The measurement results in the form of numbers in units of force (g/f) will be displayed on the computer and recorded [14]. Organoleptic sensory tests was conducted using the hedonic quality method. The organoleptic assessment of meltique meat included color, aroma, tenderness, texture, taste, and oil content. A rating scale of 1 (Strongly Dislike), 2 (Dislike), 3 (Neutral), 4 (Somewhat Like), 5 (Like), 6 (Strongly Like) was used with 25 semi trained panelists at the Integrated Laboratory, Faculty of Animal Science, Bogor Agricultural University.

3 Results and discussion

3.1 Organoleptic values

Table 1. Duncan Hedonic Test of meltique beef

Parameters	Sample			
	W	**B**	**K1**	**K2**
Colour	4.56±1.55^{b}	4.44±1.38^{b}	3.64±1.28^{a}	3.52±1.19^{a}
Aroma	4.72±1.13^{c}	4.08±1.07^{a}	4,04±1.06^{a}	4.20±1.15^{bc}
Tenderness	4.64±1.31^{c}	3.00±1.44^{a}	3.80±1.19^{b}	4.28±1.02^{bc}
Taste	4.88±1.24^{b}	4.04±1.24^{a}	3.80±1.19^{b}	4.28±1.02^{bc}
Oil content	4.72±1.24^{b}	4.00±1.19^{a}	3.96±1.06^{a}	3.92±1.38^{a}
Texture	4.80±1.29^{c}	3.44±1.47^{a}	3.68±1.21^{a}	4.24±1.20^{b}

Note: The value with the same letter of the same line indicates no different significance (P>0.05). W = Wagyu B = Control beef, K1 = ratio of 1I:5O:5W first formulas meltique coconut oil with 365 g emulsion, K2 = ratio of 2(1:5O:5W) second formulas meltique coconut oil with 730 g emulsion. The value with the same letter of the same line indicates no different significance (P>0.05). Hedonic scale; 1 (Strongly Dislike), 2 (Dislike), 3 (Neutral), 4 (Somewhat Like), 5 (Like), 6 (Strongly Like).

Based on the organoleptic test (Table 1), Wagyu consistently scored 4, indicating that it was widely preferred by all panelists. For the aroma, tenderness, taste and texture parameters, the 730 g coconut emulsion meltique meat (K2) was preferred over the 365 g coconut oil emulsion meltique meat (K1) and was similar to Wagyu. Coconut oil meltique meat formulation 2 (K2) achieved the highest score with 4.20 ± 1.15 compared to coconut meltique meat formulation 1 (K1) at 4.04 ± 1.06 and regular beef (B) at 4.08 ± 1.07. This preference may be attributed to coconut oil's high lauric acid and myristic acid content, with lauric acid consisting 45-50% of the total fatty acids [15]. When heated, lauric acid produces a distinctive aroma, which can influence panelists' preferences. [16].

The results for the taste parameter showed a significant difference (P<0.05) between coconut oil meltique meat formulation 2 (K2) that produced the highest value at 4.28 ± 1.02 compared to coconut oil meltique meat formulation 1 (K1) at 3.80 ± 1.19, and control beef (B) at 4.04 ± 1.24. The formulation of K2 yielded the closest value to the panelists' most preferred Wagyu, which was 4.88. These results indicate that the meltique meat injected with coconut oil formulation 2 (K2) was preferred due to its more pronounced meat flavor compared to the coconut oil meltique meat formulation 1 (K1). However, the meltique meat injected with coconut oil (K1 and K2) had an average of 4.28, which was classified as 'somewhat liked'. This shows that the addition of oil with different concentrations to the meat remains acceptable for the panelists. Based on this organoleptic result, further antioxidant testing will focus on K2, as it achieved higher organoleptic values and was preferred by panelists compared to K1.

For tenderness and texture, meltique formulation 2 (K2) exhibited values comparable to Wagyu. Wagyu exhibited the most favorable results for tenderness, due to its high fat content, even fat distribution, and muscle fibers arranged in a regular, elongated pattern. Histological analysis reveals that Wagyu consists mainly of natural intramuscular fat, which acts as a protective layer around the muscle fibers. This fat preserves the meat's integrity during the cooking, thereby enhancing the overall tenderness of the meat [17]. These results align with the results of the Texture Analysis Profile (TPA) results in Table II, where Wagyu achieved the highest scores, followed by meltique injection with coconut oil.

3.2 Physicochemical characteristics

The TBARS method, utilizing thiobarbituric chemicals (TBA), is employed to measure the level of lipid oxidation in samples, particularly to assess the quality and stability of food products containing fats or oils subjected to heating. Lipid oxidation leads to the formation of toxic compounds, such as Malondialdehyde (MDA) [18]. MDA levels serve as a marker of oxidative stress, where higher levels indicate increased lipid peroxidation. Elevated TBARS values correspond to greater MDA production, which may contribute to product deterioration and adverse health effects. Elevated MDA levels may indicate the presence of cellular damage due to free radicals and excessive lipid peroxidation, which contributes to various conditions such as heart disease, cancer, diabetes, and premature aging. Indicators influencing MDA level include heat processing, exposure to free radicals, and the fat content of food.

Table 2. Physicochemical characteristics of meltique beef

Parameters	Sample			
	W	B	K1	K2
TBARS (mg/kg^{-1})	3.08±0.003^{a}	3.27±0.009^{ab}	2.62±0.004^{b}	1.41±0.0004^{c}
Antioxidant (%)	1.57±0.001^{c}	4.34±0.19^{b}	-	9.75±0.004^{a}
Texture Profile Analysis (TPA)				
Hardness	2.50±0.005	2.65±0.05	2.50±0.02	2.21±0.43
Chewiness	1632±0.7^{b}	1927±8.88^{a}	1664±88.8^{b}	1380±484^{c}
Cohesiveness	0.64±0.0007	0.63±0.01	0.61±0.06	0.59±0.06
Springiness	0.73±0.0007	0.95±0.06	0.76±0.02	0.67±0.11
Gumminess	1662.8±0.7^{a}	1690.4±60.1^{a}	1547.8±136.3^{b}	1324±404^{c}

Note: The value with the same letter of the same line indicates no different significance (P>0.05). W = Wagyu B = Control beef, K1 = ratio of 1I:5O:5W first formulas meltique coconut oil with 365 g emulsion, K2 = ratio of 2(1:5O:5W) second formulas meltique coconut oil with 730 g emulsion.

Table 2 presents the physicochemical characteristics of beef injected with coconut oil. The malondialdehyde (MDA) value, as measured by the TBARS assay, showed significant differences among the samples, with the K2 formula (730 g emulsion) exhibiting the lowest MDA level compared to the other meat samples. The reduced TBARS value in meat treated with coconut oil can be attributed to the antioxidant properties present in coconut oil. In addition to its fatty acids, virgin coconut oil contains several other chemical components, including sterols, vitamin E, and polyphenolic compounds, such as phenolic acids [19]. These components have been reported to possess antioxidant activity in various plant materials, food products, and biological systems [20]. The normal range for malondialdehyde levels is typically between 2.02 and 4.65 MDA/kg, signifying acceptable freshness without rancidity. Based on this, it can be concluded that the TBARS value of Meltique beef injected with coconut oil, as well as the Wagyu (W) and control beef (B), remained within the normal range, indicating that no rancidity was observed in the meat samples.

Based on Table 2, there is a significant difference (P<0.05) in antioxidant activity among the meat sample, with Meltique formulation 2 (K2) demonstrating the highest antioxidant activity at 9.74%. A higher percentage of inhibition indicates a greater ability of the compound to scavenge DPPH radicals, reflecting enhanced antioxidant properties. Despite the low antioxidant activity observed in the young coconut meat, coconut oil, rich in phenolic compounds, significantly contributes to the overall antioxidant activity. The difference in antioxidant capacity may also be influenced by the heating process, as the meat roasting temperature exceeding 60°C can influence the stability of the antioxidants present in both the meat and the coconut oil. It is important to note that an inhibition percentage below 30% is generally classified as low antioxidant activity [21], a classification that also applies to Wagyu (W), control beef (B), and meltique 365 g emulsion (K1). The results of this study, with inhibition percentages below 30%, indicate a low to moderate antioxidant capacity. Previous studies suggest that moderate antioxidant activity typically falls within the range of 100-200 mg EVC g^{-1} [22], while the antioxidant capacity observed in this study was below 100 mg EVC g^{-1}, further supporting the categorization of these samples as having relatively low antioxidant potential.

Texture measurements on meltique meat injected with coconut oil are presented in Table 2. The results indicate no significant differences (P>0.05) in hardness, cohesiveness, or springiness across the samples. However, gumminess values showed significant differences (P<0.05), with coconut oil meltique meat formulation 2 (K2) having the lowest gumminess value of 1324.0 ± 404 compared to the other meats. The lower gumminess reflects a softer texture, making the meat easier to chew. Injection of meat with vegetable fat, hollowing or cutting treatment can increase tenderness because it can damage muscles [23]. This can be attributed to the mechanical damage caused to meat fibers during the injection process, as the syringe pierces the meat and introduces a significant amount of oil emulsion. Similar to gumminess, chewiness showed significantly different results (P<0.05), with coconut oil meltique meat formulation 2 (K2) exhibiting the lowest gumminess value of 1380 ± 484 compared to the other samples. Gumminess reflects the ease of chewing, with lower values indicating less toughness. Variations in oil injection affect chewiness, with canola oil increasing chewiness due to its high smoke point, which helps maintain the meat's texture during processing [24].

4 Conclusion

Meltique meat injected with coconut oil formulation 2 (K2) outperformed meltique meat formulation 1 (K1) in several tests, including aroma, tenderness, and organoleptic texture. The low gumminess and chewiness values indicate that K2 is more tender and easier to chew, as confirmed by the Texture Profile Analysis. In addition, meltique meat formulation 2 (K2) exhibited better antioxidant properties and the lowest TBARS value, suggesting that this meat is safer for consumption with lower malondialdehyde (MDA) levels compared to the other meats. Formulation K2 meltique meat shares physicochemical and some organoleptic properties as Wagyu, offering improved food safety and a more affordable price.

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