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Physical Properties and Sensory Quality of Roasted Meltique Beef Injected with Palm Oil

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ABSTRACT

Meltique beef was created by injecting vegetable oil emulsions into regular beef, but the high cost and oxidation susceptibility of canola oil limit its practicality. Palm oil, characterized by higher stability and local availability, was explored to improve physical properties and sensory qualities. The aim of this reserach was to analyze physical properties and sensory quality of roasted meltique beef injected with palm oil emulsion. Brahman cross sirloin cuts were injected with emulsions comprising oil, water, and soy protein isolate, prepared with different concentrations. The injected meats were grilled for 10 minutes and assessed for pH, texture, cooking loss, and sensory attributes. Results showed that palm oil significantly enhanced texture and sensory properties, with palm oil at higher concentration being the most similar to Wagyu beef in marbling, tenderness, and flavor. The findings indicate that palm oil was a cost-effective and stable alternative to canola oil for producing high-quality meltique beef, offering a viable solution for enhancing local beef products.

Keywords: meltique beef, palm oil, physical properties, sensory quality

ABSTRAK

Daging meltique dibuat dengan menyuntikkan emulsi minyak nabati ke dalam daging sapi biasa. Namun, tingginya biaya dan kerentanan oksidasi minyak kanola membatasi penggunaannya. Minyak sawit yang lebih stabil dan mudah diperoleh secara lokal dieksplorasi untuk meningkatkan sifat fisik dan kualitas sensori. Penelitian ini bertujuan mengevaluasi karakteristik fisik dan kualitas sensori dari penggunaan minyak sawit sebagai alternatif minyak kanola dalam produksi daging meltique, yaitu produk yang meniru *marbling* dan tekstur daging Wagyu. Potongan has luar sapi *Brahman cross* diinjeksi dengan emulsi yang mengandung minyak, air, dan isolat protein kedelai pada berbagai konsentrasi. Daging yang telah disuntik kemudian dipanggang selama 10 menit dan diuji untuk nilai pH, tekstur, susut masak, serta atribut sensori. Hasil menunjukkan bahwa minyak sawit secara signifikan meningkatkan tekstur dan kualitas sensori, dengan konsentrasi tertinggi menghasilkan karakteristik paling mirip dengan daging Wagyu dalam hal marbling, keempukan, dan cita rasa. Temuan ini menunjukkan bahwa minyak sawit merupakan alternatif yang lebih ekonomis dan stabil dibandingkan minyak kanola untuk menghasilkan daging meltique berkualitas tinggi, serta berpotensi meningkatkan nilai produk daging lokal.

Kata kunci: daging meltique, karakteristik fisik, minyak kelapa sawit, mutu hedonik

INTRODUCTION

Beef is a significant source of animal protein in the human diet. It consists of approximately 16-22% protein, 1,5-13% fat, 65-80% water, 1,5% non-protein substances, and 1,0% minerals, making it a valuable source of essential nutrients (Widodo *et al*. 2015). hotels and restaurants tend to serve Wagyu beef produced in Kobe, Japan. Consumer preference tests indicate that foreign tourists prefer Wagyu beef over local beef, as Wagyu is recognized for its exceptional flavor and quality. This breed of cattle produces high-quality beef with naturally delicious flavor and excellent tenderness, resulting in a premium price (Subagja *et al.* 2022). Compared to Bali cattle or Brahman Cross, which have lower quality in terms of flavor and texture, has driven innovation such as the production of Meltique beef to produce beef quality as close as possible to Wagyu.

Meltique beef is created by injecting regular beef with plant-based fats, such as canola oil, to mimic the marbling of Wagyu beef. This process results in a more tender texture and distinct marbling, characterized by fine white fat tissues resembling marble (Anjany 2023). However, the use of canola oil in Meltique beef is expensive because it is not produced locally in Indonesia and must be imported (Abdullah 2024). As a result, the price of Meltique beef is comparable to regular beef. This has highlighted the need for research into alternative, more affordable vegetable oils, such as palm oil.

Palm oil is derived from the extraction of the mesocarp of oil palm fruit (Purnama *et al*. 2020). Widely used for its relatively lower cost and abundant availability (Taufik and Seftiono 2018). Palm oil is primarily composed of palmitic acid, stearic acid, myristic acid, and oleic acid (Marliyati *et al.* 2022). Additionally, palm oil is rich in provitamin A carotenoids, vitamin E, antioxidants, and phytosterols (perdani *et al.* 2016). In contrast to canola oil, palm oil has higher oxidative stability during high temperature processing (Allam *et al*. 2023). This stability is critical as the heating process can produce toxic compounds that pose carcinogenic risks with prolonged consumption. This supports the potential of palm oil as a viable alternative for producing Meltique steak, as it not only offers health-related benefits but also demonstrates greater thermal stability and safety compared to canola oil.

The aim of this reserach was to analyze physical properties and sensory quality of roasted meltique beef injected with palm oil emulsion. Meltique steak is widely available in the market, both in frozen and ready-to-eat forms. However, research on the meltique beef still limited, leading to ongoing debates regarding its quality. Previous studies on meltique beef have primarily focused on the use of canola oil and the physical characteristics of the meat, leaving a gap in research on alternative local oils, such as palm oil and its nutritional value. Therefore, further research is needed to develop meltique beef using palm oil, ensuring a safer product with good physical properties and sensory quality with lower production costs. This approach is also expected to promote the consumption of high-quality beef in Indonesia.

MATERIALS AND METHODS

Materials and Instrument

The meat sample used was Brahman cross (BX) beef. The meat used comes from the sirloin cuts, with palm oil and canola oil sourced commercially. Wagyu beef with MB9 grade (Misela) and meltique beef (Gourmet Master) were obtained commercially. The equipment used for sample preparation in this study includes an injector (Chunyu Suru - PRC), grill, stove (grill pan), meat tongs, digital scale, blender, meat thermometer (Taffware, Indonesia), and freezer (GEA, Indonesia). The equipments used for testings included pH meter (Ionix, Indonesia) and texture analyzer (TVT 6700, Perten Instruments, Sweden).

Methods

Meltique beef preparation. Oil injection was carried out following Anjany's (2023) study with modifications. The Brahman Cross (BX) beef sirloins were cut and weighed to 1000 grams. The fat, muscle, and connective tissue were then trimmed to tenderize the meat. The emulsion formulation used for meat injection follows the modified research of Anjany (2023). The ratio of emulsion used is 1I:5O:5W (1 Isolate Soy Protein: 5 Oil: 5 Water). For each sample concentrate, the amount of Isolate Soy Protein used is 9.09% of the total volume, both oil and water are 45.45% of the total volume. Formula 2 was 2 times formulation than formula 1.

The trimmed meat was injected with a pre-formulated emulsion using a specialized tool resembling a comb, consisting of 30 injection needles per 38 cm base. The injection was done at several points to achieve marbling effect, after which the meat was wrapped in plastic, air removed, and sealed using a vacuum sealer. The injected meat was then frozen at -24°C for 24 hours before grilled, allowing the injected emulsion to solidify and form marbling. The meltique beefs were grilled to achieve a medium-well doneness.

pH testing. The pH value was measured using a pH meter according to AOAC (2005).

Texture analysis. Texture profile analysis was determined according to AOAC (2005). Texture analysis was done by using TPA test with cylinder probes to assess springiness, cohesiveness, gumminess, chewiness, and hardness.

Cooking loss measurement. The cooking loss of the meat followed the method by Silaban *et al*. (2021) with modifications. The meat samples were first weighed to obtain the initial weight, then pierced with a bimetal thermometer and boiled until the internal temperature of the meat reached 80-82°C. The meat was then removed and cooled to room temperature. The cooled samples were weighed again to obtain the final weight of the sample.

Sensory quality evaluation. The sensory evaluation consisted of hedonic quality tests conducted by 35 semi-trained panelists. The samples included roasted BX beef, roasted wagyu, roasted meltique with canola oil, and roasted meltique with palm oil. The parameters evaluated included taste, color, aroma, tenderness, texture, characteristic beef flavor, oil/fat content of the meltique beef. The sensory evaluation was approved by the Ethics Committee of the Ministry of Health Republic Indonesia (Authority no: LB.01.03/6/107/2024).

The hedonic quality test was done following Nisak et al. (2023) for roasted meltique beef was conducted using a scoring method with a scale from 1 to 6. Attributes evaluated included color brightness intensity, meltique beef flavor intensity, coconut oil aroma intensity, and tenderness. For color brightness, scores were: 1 (Pink), 2 (Red), 3 (Neutral), 4 (Reddish Brown), 5 (Brown), and 6 (Dark Brown). Aroma intensity was rated as: 1 (Oil Aroma), 2 (Slight Oil Aroma), 3 (Neutral), 4 (Slight Beef Aroma), 5 (Beef Aroma), and 6 (Strong Beef Aroma). Texture was scored as: 1 (Very Coarse), 2 (Coarse), 3 (Neutral), 4 (Slightly Soft), 5 (Soft), and 6 (Very Soft). Tenderness was rated: 1 (Very Hard), 2 (Hard), 3 (Neutral), 4 (Slightly Tender), 5 (Tender), and 6 (Very Tender). The characteristic beef flavor was scored from 1 (Very Weak) to 6 (Very Strong), and oiliness was rated as: 1 (Very Low Oil), 2 (Low Oil), 3 (Neutral), 4 (Slightly Oily), 5 (Oily), and 6 (Very Oily).

Best formula test. After hedonic quality tests conducted, the data were then used to select the most similar treatment to wagyu using the Exponential Comparison Method (ECM) (Juhardi *et al*. 2019).

RESULTS AND DISCUSSION

pH values of meltique beef samples treated with different types and concentrations of oil emulsions. The pH values ranged from 6.01 ± 0.02 to 6.50 ± 0.29. There were no statistically significant differences (P>0.05) between the control (C) and the treatment groups. Samples treated with canola oil (K1 and K2) showed slightly higher pH values than the Wagyu beef (W) and the commercial meltique beef (MK), but these differences were not significant. This difference in pH values may be due to the addition of water used in the emulsion preparation. According to Subagja et al. (2022), a high water content provides a favorable environment for microbial growth, leading to a decrease in pH. In addition to water content, the pH differences between the treatments, wagyu beef, and commercial meltique may be attributed to the varying glycogen content in each type of meat, which affects the rate of glycolysis. The slower the glycolysis process, the higher the ultimate pH value.

Springiness of meltique meat with different oils and concentrations exhibits no significant differences (P>0.05) among treatments. Springiness refers to the extent to which a deformed product returns to its original size and shape. According to Table 2, samples K1, K2, and S1 have higher springiness values than commercial wagyu and meltique and is very similar, but lower than the control meat. Kamani *et al.* (2019) found that adding vegetable fat to meat can reduce springiness due to the filling of interstitial protein spaces with fluids and fats. This is reflected in the control meat (C), which has the highest springiness value since it was not injected with emulsion. Xiong *et al*. (2015) suggests that springiness in meat can be influenced by muscle structure and biochemical components, such as moisture and myofibrillar proteins. Additionally, Gardner *et al.* (2020) reported that cooking meat at high temperatures increases springiness due to the tightening of muscle fibers.

Table 1. pH value of meltique beef

Group	pH Value
C	6.39 ± 0.09
K1	6.24 ± 0.09
K2	6.20 ± 0.09
S1	6.20 ± 0.07
S2	6.50 ± 0.24
W	6.50 ± 0.29
MK	6.01 ± 0.02

Note: Different superscripts in the same column shows significant (p<0.05). C = Regular beef (control); MK = Commercial meltique beef; W = Wagyu beef; K1 = Meltique beef injected with canola oil emulsion concentration 1; K2 = Meltique beef injected with canola oil emulsion concentration 2; S1 = Meltique beef injected with palm oil emulsion concentration 1; S2 = Meltique beef injected with palm oil emulsion concentration 2.

Cohesiveness of meltique meat with different oils and concentrations reveals no significant difference (P>0.05). The treatment that most closely resembles wagyu meat is K2, with a cohesiveness value of 0.63. According to Indiarto *et al.* (2012), cohesiveness is the degree to which a material is mechanically broken down. This value reflects the irreversible damage to the internal structure and elasticity of a material after the first compression treatment. The lower the cohesiveness value, the greater the irreversible damage to the sample (Dreher *et al*. 2020).

Gumminess of meltique beef exhibit significant differences (P>0.05) with values ranges from 706 – 1690. According to Table 2. Notably, S2 meat had the closest gumminess value to Wagyu while MK had the lowest value across all samples. Gumminess is a characteristic of semi-solid foods with low hardness and high cohesiveness (Indiarto *et al.* 2012). Gumminess is an indication of the energy required to transition a semi-solid food into a ready-to-swallow state and is particularly relevant to foods with low hardness. the higher the value, the more energy needed to transition to ready-to-swallow state (Novakovi´c and Toma˘sevi´c 2017).

Chewiness values of meltique meat with different oils and concentrations exhibit significant differences (P<0.05) among the treatments. The chewiness values range from 1469 to 2060, with K1 being the closest to wagyu at 1662. According to Table 2, S1 has a lower chewiness value than wagyu but higher than commercial meltique. The control meat (C), K1, S1, and S2 all have higher chewiness values compared to wagyu and commercial meltique. The significant variation in chewiness can be attributed to the amount and distribution of fat introduced through the oil emulsion injection. Chewiness is defined as the energy required to chew a solid food until it is ready to swallow (Novaković and Tomašević 2017), and it depends on factors such as hardness, cohesiveness, and gumminess (Bulgaru *et al*. 2022). Higher oil concentrations (like in K2) can

Table 2. Texture profile of meltique beef

Group	Parameter				
	Springiness (%)	Cohesiveness	Gumminess (N)	Chewiness (N)	Hardness (N)
C	0.95 ± 0.06	0.63 ± 0.01	1690 + 60.1a	1927 + 305ab	2655 ± 49.1
K1	0.81 ± 0.09	0.56 ± 0.01	1452 + 11.3a	1662 + 101ab	2588 ± 66.8
K2	0.81 ± 0.00	0.63 ± 0.02	1658 + 85.9a	2060 + 60.4a	2624 ± 39.2
S1	0.81 ± 0.21	0.59 ± 0.03	1469 + 20.6a	1469 + 21ab	2464 ± 116
S2	0.64 ± 0.07	0.66 ± 0.01	1650 + 73.3a	1694 + 130ab	2483 ± 54.2
W	0.73 ± 0.01	0.63 ± 0.01	1551 + 101a	1643 + 14.8ab	2507 ± 0.005
MK	0.74 ± 0.01	0.60 ± 0.08	706 ± 38b	704 ± 0.07c	2459 ± 0.007

Note: Different superscripts in the same row shows significant (p<0.05). C = Regular beef (control); MK = Commercial meltique beef; W = Wagyu beef; K1 = Meltique beef injected with canola oil emulsion concentration 1; K2 = Meltique beef injected with canola oil emulsion concentration 2; S1 = Meltique beef injected with palm oil emulsion concentration 1; S2 = Meltique beef injected with palm oil emulsion concentration 2.

increase internal structure rigidity by filling interstitial spaces (Kamani *et al*. 2019), which raises gumminess and thus chewiness. However, excessive hardness may also contribute, as seen in the control meat (C), which had high hardness and high chewiness.

Table 2 also shows that the hardness values of meltique meat with different oils and concentrations do not show significant differences (P>0.05). Hardness is force obligatory to compress a food between molars. Definite as power needed to reach given deformation with higher value means higher power needed. (Novakovi´c and Tomaˇsevi´c 2017). The highest hardness value is found in the control meat (C), while the lowest, and closest to wagyu, is in S2. Hardness is influenced by the fat content in the meat; the higher the fat content, the lower the hardness value (Gardner *et al.* 2020).

Cooking loss is an indicator of the nutritional value of meat, related to the juice content in the meat, which is the water bound within and between muscle fibers (Rompis 2015). The average cooking loss data for each treatment can be seen in Table 3.

The differences in cooking loss may be attributed to muscle fibers shrinking primarily in a longitudinal direction, leading to significant water losses. The degree of this contraction intensifies with rising temperatures (Ježek *et al*. 2019). The loss in meat weight during cooking is caused by the contraction of muscle fibers and intramuscular tissue (Torun *et al.* 2023). Modzelewska-Kapitula *et al.* (2022) explained that high cooking loss causes denaturation of collagen and actin proteins, which shrinks muscle fibers and squeezes out water from between the fibers when temperatures exceed 60°C. The cooking loss of S1 meat was very close to that of Wagyu beef, whereas S2 meat exhibited a much higher cooking loss compared to the other treatments, Wagyu beef, and commercial meltique. This significant difference may be attributed to the fatty acid composition of the oil used. According to Suciati (2015), although palm oil has a high smoke point (220°C), its high content of unsaturated fatty acids reduces its thermal stability, leading to a higher rate of oil degradation and consequently greater cooking loss.

The sensory quality of Meltique beef with different types and concentrations of oil covering attributes such as color, aroma, texture, tenderness, flavor, and oil content. The results of the organoleptic characteristics of Meltique beef are presented in Table 4.

Table 3. Average cooking loss value

Group	Cooking loss (%)
C	26.79 ± 2.52ab
K1	19.54 ± 5.00ab
K2	27.00 ± 0.05ab
S1	10.00 ± 0.05b
S2	29.66 ± 8.56a
W	10.71 ± 5.04b
MK	29.16 ± 5.89ab

Note: Different superscripts in the same column shows significant (p<0.05). C = Regular beef (control); MK = Commercial meltique beef; W = Wagyu beef; K1 = Meltique beef injected with canola oil emulsion concentration 1; K2 = Meltique beef injected with canola oil emulsion concentration 2; S1 = Meltique beef injected with palm oil emulsion concentration 1; S2 = Meltique beef injected with palm oil emulsion concentration 2.

The color of Meltique beef shows a significant difference (P<0.05) in terms of color characteristics. The hedonic quality test for color showed significant differences between treatments (P<0.05). According to Table 4, S2 had a color similar to Wagyu, i.e., reddish-brown. K1 had a reddish-brown color leaning towards brown, while K2 and S1 had similar reddish-brown hues. According to Kiki *et al.* (2020), meat color is influenced by myoglobin (Mb), which is susceptible to auto-oxidation in processed meats. The reddish-brown color observed in some treatments may be due to the degradation of myoglobin. Suciati (2015) stated that the intensity of color in foods processed with oil is affected by temperature, cooking duration, and the chemical composition of the food's surface. In contrast, the type of oil used has a minimal impact on the surface color of the product.

Table 4 shows that the addition of oil does significantly affect (P>0.05) **the aroma** of meltique beef. According to Shahrai *et al.* (2021), fat content affects the aroma of roasted beef. this component is crucial in producing meat aroma, where higher fat content generally

Table 4. Sensory quality test score of meltique beef

Parameter	Group					
	C	K1	K2	S1	S2	W
Color	3.00 ± 1.52a	4.60 ± 0.81c	3.80 ± 1.29b	3.88 ± 1.36bc	4.32 ± 0.67bc	4.28 ± 1.52bc
Aroma	3.00 ± 1.47a	3.52 ± 1.26ab	3.84 ± 0.94b	3.96 ± 0.67b	3.96 ± 1.01b	3.84 ± 1.79b
Texture	2.80 ± 0.95a	4.32 ± 1.24b	4.72 ± 0.89b	4.20 ± 1.15b	4.48 ± 1.35b	4.40 ± 1.44b
Tenderness	2.96 ± 1.02a	4.36 ± 1.25b	4.80 ± 0.95b	4.48 ± 1.08b	4.52 ± 1.35b	4.32 ± 1.34b
Meatiness	4.00 ± 1.29	4.12 ± 0.97	4.12 ± 1.13	4.08 ± 1.05	4.24 ± 1.07	4.72 ± 1.27
Oilliness	3.32 ± 1.24a	3.64 ± 1.15a	4.40 ± 1.11b	3.96 ± 1.17ab	4.44 ± 1.19b	4.60 ± 1.38b

Note: Different superscripts in the same column shows significant (p<0.05). C = Regular meat (control); W = Wagyu meat; K1 = Meltique meat injected with canola oil emulsion concentration 1; K2 = Meltique meat injected with canola oil emulsion concentration 2; S1 = Meltique meat injected with palm oil emulsion concentration 1; S2 = Meltique meat injected with palm oil emulsion concentration 2. Hedonic quality scale: color: 1 (Light pink), 2 (Red), 3 (Neutral), 4 (Reddish-brown), 5 (Brown), 6 (Dark brown); aroma: 1 (Oily smell), 2 (Slightly oily smell), 3 (Neutral), 4 (Slightly meaty smell), 5 (Meaty smell), 6 (Very meaty smell); texture: 1 (Very rough), 2 (Rough), 3 (Neutral), 4 (Slightly soft), 5 (Soft), 6 (Very soft); tenderness: 1 (Very tough), 2 (Tough), 3 (Neutral), 4 (Slightly tender), 5 (Tender), 6 (Very tender); characteristic meat flavor: 1 (Not noticeable at all), 2 (Not noticeable), 3 (Neutral), 4 (Slightly noticeable), 5 (Noticeable), 6 (Very noticeable); oiliness: 1 (Not oily at all), 2 (Not oily), 3 (Neutral), 4 (Slightly oily), 5 (Oily), 6 (Very oily).

leads to more favorable aroma perception by panelists as seen with control beef and the rest. Additionally, cooking at high temperatures influences meat aroma by forming various volatile compounds through chemical reactions such as fat oxidation and Maillard reactions between amino acids and reducing sugars (Wang *et al*. 2023).

The texture characteristics of Meltique beef also showed significant differences (P<0.05). Table 4 indicates a trend where higher oil concentrations (K2 and S2) have a slightly softer texture compared to lower concentrations (K1 and S1). This finding aligns with the texture profile test results in Table 2, where K1 and S2 are closer to Wagyu in terms of springiness, gumminess, and chewiness. K2 has a higher tenderness score than Wagyu, which could be attributed to the more even distribution of oil in the meat, as reflected in Table 2 showing higher scores in springiness, cohesiveness, gumminess, and chewiness compared to Wagyu. Texture in meat can be influenced by several factors, such as fat content. According to Table 4, the high fat content in Wagyu results in lower hardness and chewiness parameters, creating a softer texture preferred by panelists (Gardner *et al.* 2020).

The tenderness of Meltique beef, as shown in Table 4, significantly affects the tenderness characteristics of the meat (P<0.05). Table 4 demonstrates that oil injection affects the tenderness, with control meat being hard compared to the somewhat tender Meltique meats. Additionally, Table 4 shows a positive trend between meat tenderness and the amount of oil injected, consistent with the texture. This is also in line with Shahrai *et al*. (2021), that the increase in intramuscular fat, in consequently marbling changes results in changes of the collagen content and solubility, mechanical strength of intramuscular connective tissue, fiber diameter, disorganization of perimysia, and avoidance of sacrcomere shortening, account for the improvement in beef tenderness.

The meatiness, as shown in Table 4, did not significantly differ (P>0.05). The lack of significant differences in meat flavor, despite higher oil concentrations, could be due to the use of fresh oil that has not been previously used for cooking. According to Astuti (2019), repeated use of oil can cause deterioration due to oxidation, resulting in aldehydes and ketones that produce rancid smells and flavors. Table 4 shows significant differences (P<0.05) in the fat content of the meat, with the control meat having the lowest fat content due to the absence of oil injection and low IMF. There is a positive trend between the concentration of oil used and the perceived fat content in the meat, as evidenced by the higher fat content in K2 and S2 compared to K1 and S1. The high fat content in wagyu is due to the natural fat contained in the meat (Gotoh and Joo 2016), whereas in meltique meat, the fat used is plant-based.

The oiliness of meltique beef showed a Wagyu beef had the highest fat content score (4.60 ± 1.38), followed by S2 (4.44 ± 1.19), showing that panelists recognized and appreciated the fat-rich nature of these samples. In contrast, the control group (3.32 ± 1.24) had the lowest fat content rating, indicating that oil injection, particularly with palm oil, successfully enhanced perceived fat levels. The high oil content in Wagyu beef is due to the natural intramuscular fat present in the meat (Gotoh and Joo 2016). In contrast, meltique beef uses vegetable fat as its fat source. This oil content affects the perception of oiliness or moisture. Oiliness refers to the intensity of oily or fatty sensations in the mouth and whether the product provides a smooth mouthfeel and forms an oily coating on the palate (Fuhrmann *et al.* 2020). Therefore, the greater the amount of oil used, the more intense the perception of oiliness compared to meltique beef with lower oil concentrations.

The determination of the best formulation for Meltique beef was conducted using the exponential comparison method, taking into account both physical characteristics and organoleptic quality parameters. Each parameter was evaluated based on analytical test results and ranked on a scale of 1 to 2, with a score of 1 assigned to the most favorable result. Equal weighting (7.69%) was applied to all parameters, reflecting the equal importance of each attribute in determining overall quality.

The superior performance of sample S2 suggests that palm oil emulsion at a higher concentration can positively influence various physicochemical and sensory parameters.

Table 5. Calculation for best formula

Parameter	Value	Formula							
		K1		K2		S1		S2	
		Rank	Score	Rank	Score	Rank	Score	Rank	Score
pH	7.69%	2	0.038	3	0.025	3	0.025	2	0.077
Cooking loss	7.69%	2	0.038	3	0.025	1	0.076	2	0.019
Springiness	7.69%	1	0.076	1	0.076	1	0.076	2	0.038
Cohesiveness	7.69%	4	0.019	1	0.076	3	0.025	2	0.038
Gumminess	7.69%	4	0.019	2	0.038	3	0.025	1	0.077
Chewiness	7.69%	1	0.076	4	0.019	3	0.025	1	0.038
Hardness	7.69%	3	0.025	4	0.019	2	0.038	1	0.077
Color	7.69%	2	0.038	4	0.019	3	0.025	2	0.077
Aroma	7.69%	3	0.025	1	0.076	2	0.038	1	0.038
Texture	7.69%	1	0.076	3	0.025	2	0.038	2	0.077
Tenderness	7.69%	1	0.076	3	0.025	2	0.038	2	0.038
Meatiness	7.69%	2	0.038	2	0.038	3	0.025	1	0.077
Oiliness	7.69%	4	0.019	2	0.038	3	0.025	2	0.077
Total	100%		0.57		0.506		0.487		0.75
Ranking			2		3		1		4

Note: K1: Meltique beef injected with canola oil emulsion concentration 1; K2: Meltique beef injected with canola oil emulsion concentration 2; S1: meltique beef with palm oil emulsion concentration 1; S2: Meltique beef with palm oil emulsion concentration 2.

Palm oil's semi-solid nature at room temperature may help improve oil retention and mouthfeel, thereby enhancing attributes such as fat content, color, and texture perception. This is supported by S2's top rank in parameters like pH, aroma, gumminess, oiliness, and meaty impression. Interestingly, while K1 (with lower canola concentration) performed better than K2 (with higher concentration), it still did not surpass the effectiveness of palm oil treatments. These findings indicate that palm oil, especially at higher concentrations, may be more suitable than canola oil for improving the quality attributes of injected Meltique beef, both in terms of consumer acceptability and texture stability.

CONCLUSION

The injection of palm oil into fresh sirloin meat was able to improve texture and sensory properties of meltique beef and close similar compared to wagyu beef. At higher concentration, palm oil provided the best tenderness, flavor, while also reducing hardness. Therefore, Palm oil can be used as an alternative oil in making meltique beef.

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