
Quality and sensory properties of beef treated with papaya (*Carica papaya* L.) juice and oregano (*Origanum vulgare* L.) extract under different marinating times

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Abstract This study explored the efficacy of papaya juice and oregano extract as natural beef tenderizers and determined its effects on the quality and sensory properties under different marinating times. The sensory evaluation revealed statistically significant differences among the treatments in terms of aroma ($p < 0.01$), juiciness ($p < 0.01$), flavor ($p < 0.01$), tenderness ($p < 0.01$), and texture ($p < 0.01$) across the majority of the panelists. Nonetheless, no significant differences were observed among teenage panelists ($p > 0.05$) for all its sensory parameters indicating a distinct sensory response that can be associated with higher sensitivity to the characteristic herbal aroma conveyed by oregano extract. This sensitivity showed to influence their perception of the aroma and flavor of beef. Among the marination treatments, beef marinated for 12 hours revealed the most desirable physical and sensory characteristics implying that this duration provided sufficient time for the natural tenderizing compounds present in papaya juice to act on the muscle proteins while preserving its quality. This apparent and improved tenderness and softer texture were primarily attributed to the proteolytic activity by the enzyme present in papaya juice called papain that facilitates hydrolysis of muscle proteins and connective tissues. Oregano extract has contributed to the aromatic profile of the marinated beef in the presence of bioactive volatile compounds particularly thymol, a phenolic monoterpene responsible to influence flavor and aroma. The marinated beef revealed a more desirable reddish appearance after cooking. The findings showed that papaya juice and oregano extract are efficient natural tenderizing agents with the potential of improving the sensory properties and physical quality of beef. Application of these natural tenderizers provide a sustainable alternative to synthetic meat tenderizers and chemical additives that uphold the development of healthier-label meat products with improved quality attributes.

Keywords: Beef, Gustatory, Oregano, Papaya, Tenderizer

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Introduction

Beef is one of the sources of high-quality protein containing essential amino acids, vitamins, and minerals that are vital and excellent components for growth and maintenance of the human body. According to Bastian *et al.* (2012) who reported that beef provides essential nutrients with approximately half of its fat content is monounsaturated similar to the heart-healthy fats that can be found in olive oil. Derived from domesticated cattle *Bos taurus*, beef is not only a versatile ingredient for various meat products but also valuable for its nutritious properties, texture, and rich flavor. Being classified as red meat, beef has a higher iron content than chicken or fish making it a preferred meat product among many Filipinos because of its palatability and nutritional benefits. Despite several common misconceptions unveiled, evidence indicates that both saturated and monounsaturated fats in beef offer protective benefits against heart disease. Trivedi (2006) has reported and eventually challenged the notion that saturated fat is harmful to human health. In modern food processing preserving the nutritive value of meat including its flavor and appearance has become increasingly important. Despite the fact that meat enhancements often possess antimicrobial properties still contamination can occur which leads to protein breakdown and spoilage. The flavor of meat plays a crucial role in determining quality and acceptability prompting extensive research regarding meat processing to achieve this purpose.

Nevertheless, the chemical additives used to enhance meat quality such as nitrates and nitrites pose significant various health risks. These chemicals can result in the formation of carcinogenic compounds (Lehr and Hannan, 2020). Consumers are advised to avoid processed meats containing multiple additives, preservatives, and enhancements due to their potential health hazards and detrimental effects (Abdulummeen *et al.*, 2012).

This study conforms to the growing interest in searching safer alternatives to chemical enhancements during meat processing. One such alternative is the use of natural preservatives and flavor enhancers such as papaya (*Carica papaya* L.) juice and oregano (*Origanum vulgare* L.) extract. Papaya is often referred to as a versatile fruit being recognized for its health benefits that contains papain, an enzyme that effectively tenderizes and softens meat fibers (Islam, 2005). In addition, oregano is a widely used herbal plant being used to marinate beef (He *et al.*, 2023). These natural ingredients provide a healthier alternative than chemical enhancements that can contribute both flavor and quality of beef while providing significant health benefits.

This study explored the quality and sensory properties of marinated beef in terms of aroma, juiciness, flavor, tenderness, and texture treated with the

combination of papaya juice and oregano extract under different marinating times. This objective provides perspective into the potential benefits of using papaya juice and oregano extract as natural meat tenderizers and flavor enhancers.

Materials and methods

Experimental design and treatments

This experiment employed a Completely Randomized Design (CRD) to evaluate the effects of different marination durations on the quality and sensory properties of beef. A total of three kilograms of beef (round) was procured and was cut into four equal sizes, each weighing seven hundred fifty grams and was distributed over different time durations, divided into three corresponding to its replication, containing two hundred fifty grams each. The experimental meats were subjected to different times of marination as follows:

Treatment 1 = 250 grams of beef alone not marinated (Control),
Treatment 2 = 250 grams of beef + 250 mL papaya juice and oregano extract + 4 hours of marinating, Treatment 3 = 250 grams of beef + 250 mL papaya juice and oregano extract + 8 hours of marinating, and Treatment 4 = 250 grams of beef + 250 mL papaya juice and oregano extract + 12 hours of marinating.

Preparation of papaya juice

Fresh unripe papaya was collected. The collected papaya was peeled using knives and a chopping board. The peeled papaya was chopped into pieces then blended using a blender. The grinded papaya was poured or placed into a thin white cloth and was filtered to obtain its juice and its residues eliminated. A clean plastic container was prepared where the papaya juice was stored for a while. A total of one thousand one hundred twenty-five mL of pure papaya juice obtained.

Preparation of oregano extract

The stalks and leaves of oregano were collected. After collection, the stalks and leaves were washed and chopped accordingly. Its stalks and leaves were blended using a blender. The pounded stalks and leaves were placed in a thin white cloth in separating the extract from the solid oregano residues. A clean plastic container was prepared where the oregano extract was stored for a while. A total of one thousand one hundred twenty-five mL of pure oregano extract was collected.

Preparation of the combined papaya juice and oregano extract

A mixture was prepared using papaya (*Carica papaya* L.) juice and oregano (*Origanum vulgare* L.) extract in a 1:1 ratio consisting of 1,125 mL of papaya juice (Kafuko, 2021) and 1,125 mL of oregano extract (Hernández-Hernández *et al.*, 2009) resulting in a total volume of 2,250 mL. The mixture was thoroughly homogenized in a single and clean container. This formulation was applied to all experimental treatments except Treatment 1 which served as the control. Each treatment from two to four had seven hundred fifty mL of the combined papaya juice and oregano extract. Each treatment distributed 750 mL corresponds to its replications of about 250 mL each replication.

Preparation of the beef

Meat samples with an identified profile were purchased from the market. The part of the beef carcass was obtained from the round. Eventually, the meat was brought to the food laboratory for further processing. After that, the meat was washed thoroughly and dripped accordingly. The meats were cut into four equal sizes, weighing seven hundred fifty grams. Each cut was divided into three equal sizes of about two hundred fifty grams each, which corresponds to all replications. Equal sizes of all meat samples were placed in a non-reactive container. The combined papaya juice and oregano extract was added to each treatment. However, before applying the marinade, the meat was pierced six times using a fork for the easy penetration of papaya juice and oregano extract, which was poured directly into the meat and marinated according to its treatment. The marination of beef samples was conducted at a controlled temperature of 3°C following the recommended range for refrigerated marination to inhibit microbial growth and maintain meat quality (Martin *et al.*, 2013). After marination, the marinated meats were briefly dripped onto a tray. Afterwards, it was wrapped in aluminum foil and placed in the preheated oven. It was being monitored for synchronized cooking time.

Cooking the samples

The marinated meat samples wrapped in an aluminum foil where the upper portion was opened. These were arranged into a preheated oven accordingly together with the replications. The prepared meats were subjected and exposed in an oven and were roasted at a heat temperature of about 200°C within one hour (Fencioglu *et al.*, 2022).

Measures of parameters (Sensory evaluation)

The roasted meat samples were evaluated after being warmed and well-cooked enough. The meats were placed in clean and coded containers for the panelists to evaluate and determine. The evaluation and voting were conducted after roasting the samples using a simple consumer test. The panelists evaluated the meats' aroma, juiciness, flavor, tenderness, and texture in score sheets. There were seventy panelists (n=70) selected and were classified according to their age and highest educational attainment who were non-smokers and non-alcohol drinkers using the Hedonic Scale. The panelists were randomly selected based on their qualifications such as teenager (n=10), professional young adult (n=10), professional adult (n=10), professional chef (n=10), non-professional young adult (n=10), non-professional adult (n=10), and non-professional chef (n=10).

Table 1. Hedonic scale for meat evaluation

Rating	Description					Continuum
	Aroma	Juiciness	Flavor	Tender-ness	Texture	
5	Extremely desirable beef odor	Very juicy	Extremely desirable beef flavor	Very tender	Extremely disintegrated	4.24-5.00
4	Moderately desirable beef odor	Moderately juicy	Moderately desirable beef flavor	Tender	Moderately disintegrated	3.43-4.23
3	Just normal beef odor	Just juicy	Just normal beef flavor	Just tender	Just intact fiber	2.62-3.42
2	Moderately undesirable beef odor	Moderately dry	Moderately undesirable beef flavor	Tough	Moderately intact fiber	1.81-2.61
1	Extremely undesirable beef odor	Extremely dry	Extremely undesirable beef flavor	Very tough	Extremely intact fiber	1.00-1.80

Results

Average weighted mean for the aroma of roasted beef

Results showed that Treatment 4 had the highest mean score across the treatments and all the panelists rated it as moderately desirable beef odor while Treatment 1 not being added with any of the mixture was rated with just normal beef odor (Table 2). This has signified that the application of papaya juice and

oregano extract significantly affect the aroma of beef since there was a highly significant difference across treatment means. However, in the category of teenagers, they were not significantly affected by papaya juice and oregano extract in terms of the beef's aroma. Thus, the professional chef responded as the highest among all panelists in sensory evaluation and rated the beef's aroma as moderately desirable beef odor with an average mean score of 4.02.

Table 2. Response to aroma of roasted beef sample

AROMA Category	OBSERVATION				
	T1	T2	T3	T4	Mean
1. Teenager	4.00	4.20	3.77	4.00	3.99 ^{ns}
2. Professional young adult	3.30 ^c	3.27 ^c	3.80 ^b	4.30 ^a	3.67 ^{hs}
3. Professional adult	3.20 ^d	3.47 ^c	4.30 ^b	4.60 ^a	3.89 ^{hs}
4. Professional chef	3.10 ^d	4.03 ^c	4.23 ^b	4.73 ^a	4.02 ^{hs}
5. Non-professional young adult	3.20 ^c	3.50 ^b	4.03 ^a	4.17 ^a	3.73 ^{hs}
6. Non-professional adult	2.87 ^d	3.23 ^c	4.20 ^b	4.77 ^a	3.77 ^{hs}
7. Non-professional chef	2.67 ^c	3.60 ^b	3.93 ^b	4.73 ^a	3.73 ^{hs}

^{a-d} Means with different superscript small letters in a row within observation per treatment differ significantly ($p < 0.01$), ^{hs} Means highly significant, ^{ns} Means not significant ($p > 0.05$)

Average weighted mean for the flavor of roasted beef

The findings revealed that Treatment 4 obtained the highest mean score among all treatments, with panelists consistently rated its beef flavor as moderately desirable beef flavor. In contrast, Treatment 1, which did not include any mixture, was rated as exhibiting a normal beef flavor (Table 3). These results underscored the significant impact of papaya juice and oregano extract on beef flavor, as indicated by a highly significant difference among treatment means. Professional chef provided the highest ratings in the sensory evaluation, rating the beef flavor as moderately desirable beef flavor with an average mean score of 3.88.

Average weighted mean for the juiciness of roasted beef

The results indicated that Treatment 4 achieved the highest mean score among all treatments, with the majority of the panelists rated it as very juicy (Table 4).

Table 3. Response to flavor of roasted beef sample

FLAVOR Category	OBSERVATION				
	T1	T2	T3	T4	Mean
1. Teenager	3.93	3.73	3.83	3.50	3.75 ^{ns}
2. Professional young adult	3.07 ^c	3.37 ^c	3.90 ^b	4.30 ^a	3.66 ^{hs}
3. Professional adult	3.13 ^c	3.37 ^c	4.13 ^b	4.40 ^a	3.76 ^{hs}
4. Professional chef	3.10 ^d	3.63 ^c	4.07 ^b	4.73 ^a	3.88 ^{hs}
5. Non-professional young adult	3.03 ^c	3.90 ^b	3.77 ^b	4.63 ^a	3.83 ^{hs}
6. Non-professional adult	2.90 ^d	3.70 ^c	4.10 ^b	4.63 ^a	3.83 ^{hs}
7. Non-professional chef	2.60 ^d	3.53 ^c	4.03 ^b	4.73 ^a	3.72 ^{hs}

^{a-d} Means with different superscript small letters in a row within observation per treatment differ significantly ($p < 0.01$), ^{hs} Means highly significant, ^{ns} Means not significant ($p > 0.05$)

Table 4. Response to juiciness of roasted beef sample

JUICINESS Category	OBSERVATION				
	T1	T2	T3	T4	Mean
1. Teenager	3.37	3.27	3.43	3.50	3.39 ^{ns}
2. Professional young adult	2.60 ^c	3.33 ^b	3.53 ^b	4.30 ^a	3.44 ^{hs}
3. Professional adult	2.43 ^d	3.23 ^c	3.87 ^b	4.47 ^a	3.50 ^{hs}
4. Professional chef	2.77 ^c	3.80 ^b	3.87 ^b	4.50 ^a	3.74 ^{hs}
5. Non-professional young adult	2.30 ^c	3.70 ^b	4.27 ^a	4.57 ^a	3.71 ^{hs}
6. Non-professional adult	2.23 ^c	3.57 ^b	4.10 ^{ab}	4.77 ^a	3.67 ^{hs}
7. Non-professional chef	2.17 ^c	3.53 ^b	3.80 ^b	4.73 ^a	3.56 ^{hs}

^{a-d} Means with different superscript small letters in a row within observation per treatment differ significantly ($p < 0.01$), ^{hs} Means highly significant, ^{ns} Means not significant ($p > 0.05$)

In contrast, Treatment 1, which did not include any mixture, was rated as just juicy. This has highlighted the significant influence of papaya juice and oregano extract on the juiciness of beef, as evidenced by the highly significant differences among treatment means. Notably, professional chef provided the highest ratings during the sensory evaluation, categorizing the beef's juiciness as moderately juicy, with an average mean score of 3.74.

Average weighted mean for the tenderness of roasted beef

The data revealed that Treatment 4 evaluated with the highest mean score across all treatments as panelists consistently rated it as tender (Table 5). In contrast the Treatment 1 which did not include any of the mixture was rated as just tender. It showed that the application of papaya juice and oregano extract significantly influenced the tenderness of beef indicated by a highly significant difference across treatment means. The teenager provided the highest ratings during the sensory evaluation categorizing the tenderness of beef as very tender with an average mean score of 4.24.

Table 5. Response to tenderness of roasted beef sample

TENDERNESS Category	OBSERVATION				
	T1	T2	T3	T4	Mean
1. Teenager	4.07	4.17	4.23	4.50	4.24 ^{ns}
2. Professional young adult	3.93 ^{bc}	3.83 ^c	4.17 ^{ab}	4.37 ^a	4.08 ^{hs}
3. Professional adult	3.37 ^d	3.80 ^c	4.20 ^b	4.77 ^a	4.04 ^{hs}
4. Professional chef	3.27 ^c	4.00 ^b	4.30 ^b	4.77 ^a	4.09 ^{hs}
5. Non-professional young adult	2.43 ^d	3.43 ^c	4.33 ^b	4.80 ^a	3.75 ^{hs}
6. Non-professional adult	2.27 ^d	3.37 ^c	4.17 ^b	4.90 ^a	3.68 ^{hs}
7. Non-professional chef	2.43 ^d	3.60 ^c	4.27 ^b	4.90 ^a	3.80 ^{hs}

^{a-d} Means with different superscript small letters in a row within observation per treatment differ significantly ($p < 0.01$), ^{hs} Means highly significant, ^{ns} Means not significant ($p > 0.05$)

Average weighted mean for the texture of roasted beef

The findings indicated that all treatments were consistently rated by the panelists as having a moderately disintegrated beef texture (Table 6). Statistical analysis revealed that the application of papaya juice and oregano extract had a significant impact on the beef texture, as evidenced by a highly significant difference among treatment means. Notably, the teenager provided the highest ratings in the texture's sensory evaluation for beef, assigning an average mean score of 3.98, which categorized the beef texture as moderately disintegrated.

Table 6. Response to texture of roasted beef sample

TEXTURE Category	OBSERVATION				
	T1	T2	T3	T4	Mean
1. Teenager	4.00	3.90	3.73	4.30	3.98 ^{ns}
2. Professional young adult	3.33 ^c	3.50 ^c	3.97 ^b	4.30 ^a	3.78 ^{hs}
3. Professional adult	3.03 ^d	3.53 ^c	3.93 ^b	4.57 ^a	3.77 ^{hs}
4. Professional chef	3.13 ^c	3.53 ^c	4.10 ^b	4.70 ^a	3.87 ^{hs}
5. Non-professional young adult	3.00 ^d	3.47 ^c	4.23 ^b	4.80 ^a	3.88 ^{hs}
6. Non-professional adult	2.43 ^d	3.33 ^c	3.83 ^b	4.83 ^a	3.61 ^{hs}
7. Non-professional chef	2.47 ^c	3.63 ^b	3.90 ^b	4.83 ^a	3.71 ^{hs}

^{a-d} Means with different superscript small letters in a row within observation per treatment differ significantly ($p < 0.01$), ^{hs} Means highly significant, ^{ns} Means not significant ($p > 0.05$)

Discussion

Results showed that the average weighted mean for the aroma of roasted beef treated with the combination of papaya juice and oregano extract under different marinating times. The data indicated that the majority of panelists rated the aroma of beef in Treatment 4, which was marinated for 12 hours, as having an extremely desirable beef odor. This finding is corroborated with the study by Mockute *et al.* (2001), which highlighted the role of oregano leaves in enhancing the flavor of meat. The presence of thymol, a compound called phenolic monoterpene found in oregano, is identified as a key aromatic precursor that significantly influences the aroma of meat when marinated with oregano extract. The statistical analysis further supported the highly significant differences among the treatments, indicating that the duration of marination and the combination of papaya juice and oregano extract affected the aroma of the roasted beef. However, an exception was observed among teenage panelists, who exhibited a different perception of the beef's aroma compared to other age and educational attainment group panelists. Furthermore, the results reported that the presence of thymol in oregano influenced the enhanced aroma of the roasted beef while the papain, an enzyme in papaya known for its meat-tenderizing properties did not significantly affect the odor of the beef post-roasting. This effect stressed the role of oregano in aroma enhancement whereas the contribution of papaya is likely limited to improve texture of the beef rather than its aroma. These findings are crucial for understanding the sensory attributes of beef marinated with natural

ingredients stressing perspective into how compounds like thymol can elevate the consumer's perception of meat quality.

Treatment 4 soaked on a 12-hour marination period has received the highest general mean score of 4.44 showing that panelists found the beef flavor to be extremely desirable. This was followed by Treatment 3 with an 8-hour marination period. According to Ba *et al.* (2012) who reported that the profile of beef is primarily perceived through olfactory receptors before and after chewing. The cooking process further developed this flavor as the interaction of various precursors within the meat has led to the formation and accumulation of complex aromatic compounds. Statistical analysis revealed highly significant differences between treatments emphasizing the effect of marination duration on the flavor of the beef. The prolonged marination of beef to papaya juice and oregano extract in Treatment 4 appeared to enhance its palatability significantly. The enzymatic activity of papain from papaya is likely broken-down muscle fibers more effectively over extended periods that allows the thymol of oregano to infuse deeply into the meat that thereby resulting in a more robust and appealing flavor profile. In addition, consistent ratings between different panelists groups regardless of their age and educational attainment indicated that the enhanced flavor was generally appreciated. These findings revealed that the combination of papaya juice and oregano extract particularly with extended marination times can significantly enhance the flavor of beef. The papaya juice contributed to the meat's tenderization has allowed the oregano extract to penetrate and impart its distinct flavor more thoroughly. This process not only improved the entire sensory experience but also aligned with consumer preferences for natural flavor enhancers that contribute a viable alternative to synthetic additives in meat processing.

Treatment 4 being soaked in a 12-hour marination period received the highest mean score of 4.48 indicating that the beef was rated as very juicy. On the contrary, the unmarinated sample (Treatment 1) was rated the lowest. The data revealed that prolonged marination in a natural tenderizer such as papaya juice and oregano extract enhance the juiciness of the meat. This enhanced juiciness is likely due to the tenderizer's ability to penetrate deeply into the meat fibers eventually allowing for better moisture retention during cooking. Meat juiciness is widely regarded as the most critical factor contributing to the entire quality of the eating experience (Winger and Hagyard, 1994). Furthermore, juiciness as a key attribute plays a significant role in this context as it directly influences the perception of meat texture. The relation between juiciness and texture is evident in this study where the enhanced juiciness of the meat also contributed to an improved texture making the beef more palatable to consumers. The statistical analysis revealed highly significant differences among the

different treatments emphasizing the effect of marination duration on the sensory attributes of the beef. Specifically, the longer marination period in Treatment 4 not only improved the juiciness of the meat but also enhanced its overall texture, strengthening the importance of marination in meat preparation. These findings emphasized the effectiveness of natural tenderizers like papaya juice and oregano extract in enhancing the juiciness and overall quality of beef. This study highlighted the importance of marination duration in achieving desirable sensory attributes particularly juiciness which is closely linked to consumer satisfaction and meat quality.

The data demonstrated the varying levels of tenderness across the different treatments. The general numerical ratings for tenderness were 3.03 for Treatment 1 (control), 3.70 for Treatment 2 (4 hours), 4.21 for Treatment 3 (8 hours), and 4.73 for Treatment 4 (12 hours). Notably, Treatment 4 with a 12-hour marination period received the highest rating showing that the beef was perceived as very tender. On the contrary, the control group (Treatment 1) received the lowest rating revealing that the absence of marination resulted in less tender meat. These findings are compared with the study by Grover *et al.* (2005), which reported the interactive effects of papain from papaya and sodium tripolyphosphate in enhancing meat tenderness. Papain, a proteolytic enzyme present in papaya is known for its ability to break down muscle fibers and thereby tenderizing tough meat. This study supports the efficacy of papain as a natural tenderizer supporting the idea that prolonged exposure to papaya juice can significantly improve the tenderness of beef. The highly significant differences in tenderness across the treatments emphasized the effect of marination duration on meat quality. The extended marination period in Treatment 4 allowed for deeper penetration of papain into the meat fibers that showed a more pronounced tenderizing effect compared to shorter marination times. These results emphasized the effectiveness of using natural tenderizers such as papaya juice in enhancing the quality of beef. This research not only demonstrated the significant effect of marination duration on meat tenderness but also suggested that papain is a powerful agent for improving the palatability of tough cuts of meat. This has significant implications for both consumers and the meat processing industry as it provides a natural health-conscious alternative to chemical tenderizers resulting in a higher-quality and more palatable meat product.

The texture of roasted beef across different treatments were evaluated by the panelists. Treatment 4 which involved a 12-hour marination period was rated the highest with panelists describing the meat texture as extremely disintegrated. It has revealed that the extended marination led to a significant breakdown of the meat fibers resulting in a very tender texture. However, the control group (Treatment 1), which was not marinated, received the lowest rating described as

just intact fiber with a numerical mean score of 2.96. Koknaroglu and Akunal (2013) reported and defined meat texture as a key attribute of meat quality encompassing its fineness and coarseness which can be assessed through visual inspection, touch, or chewing. They further explained that meat texture is influenced by several factors including the state of rigor mortis, water holding capacity (WHC), and the presence of tenderizing agents like papain. In this research, the extended marination in papaya juice and oregano extract allowed papain to act on the meat fibers over time, leading to a softer and more disintegrated texture. Statistical analysis revealed highly significant differences among the treatment means applied indicating that the duration of marination had a profound effect on the texture of the beef. The observed disintegration of meat fibers in Treatment 4 was consistent with the expected outcome when meat becomes very tender due to prolonged exposure to natural tenderizers. This research has emphasized the effectiveness of using papaya juice and oregano extract as a marinade for beef not only in enhancing its texture but also in improving its quality and health benefits. Panelists rated Treatment 4 (12 hours) the highest showing the efficacy of papaya as a natural tenderizer and oregano as an enhancer of meat aroma. In general, the findings indicated that natural marination particularly with papaya juice and oregano extract can significantly enhance the sensory qualities of beef making it more appealing to consumers.

This study concluded that papaya juice and oregano extract are efficient natural marinades for enhancing the quality and sensory properties of the beef. The results showed that beef marinated for 12 hours (Treatment 4) in a storage temperature of 3°C received the highest ratings from the panelists demonstrating the efficacy of papaya as a tenderizer and oregano as an aroma enhancer. Additionally, the marinated beef in Treatments 2 (4 hours), 3 (8 hours), and 4 (12 hours) exhibited a more appealing reddish color after roasting compared to the dark brown color of the non-marinated beef likely due to the action of papain from papaya juice. Moreover, the study found that the panelists regardless of their age and educational attainment shared similar perceptions of the treated beef indicating a broad consumer acceptance of these natural enhancements in terms of both olfactory and gustatory attributes. Further research to validate and strengthen the findings of this study on the use of papaya juice and oregano extract is highly recommended. Furthermore, to promote healthy food practices applying these natural ingredients is encouraged.

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Conflict of interest

The author declares no conflict of interest.

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