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# Consumers' Preferences between Natural MD2-Based and Commercial Meat Tenderizers

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**Abstract**
This study evaluates consumer preference between a natural meat tenderizer made from MD2 pineapple, herbs, and spices, and a commercial product. Sensory evaluation by 25 panelists showed significantly higher scores for the MD2-based tenderizer in appearance, taste, texture, aroma, and overall acceptability. The superior performance is attributed to bromelain's enzymatic action and the flavor-enhancing properties of herbs. While limited by sample size and scope, the findings support the potential of MD2-based tenderizers as a natural, clean-label alternative, aligning with current consumer trends toward healthier and more natural food products.

Keywords: Meat; Pineapple; Sensory; Tenderizer


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## 1.0 Introduction

Consumer demand for high-quality meat products continues to grow, with tenderness, flavor, and juiciness consistently ranked as the most important attributes influencing satisfaction and repeat purchases (Amin et al., 2020). To meet these quality expectations, various tenderization methods have been developed, including mechanical, chemical, and enzymatic treatments. Among these, enzymatic tenderizers have gained particular interest for their ability to break down muscle fibers and connective tissue, thereby improving meat texture. Commercial meat tenderizers, often made from synthetic compounds or isolated enzymes such as papain and bromelain, have long been used to improve meat tenderness. However, increasing consumer awareness of health and food safety has shifted preferences toward more natural and clean-label alternatives (Asioli et al., 2017).

Natural tenderizers derived from fruits and plants offer a promising solution, providing not only functional benefits but also additional flavor, aroma, and consumer appeal. Pineapple, particularly the MD2 variety, is an excellent example due to its high content of bromelain which is an effective proteolytic enzyme capable of hydrolyzing myofibrillar and collagen proteins (Ketnawa et al., 2018). When combined

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with traditional herbs and spices, MD2-based tenderizer formulations may enhance not only texture but also taste and aroma, creating a more holistic sensory experience for consumers.

Despite the functional potential of natural tenderizers, limited studies have explored how they perform in comparison to commercial products in terms of consumer sensory preferences. As clean-label products become more popular, understanding consumer selection between natural and commercial tenderizers is crucial for product development and industry innovation. This study addresses that gap by evaluating consumer preferences for meat treated with an MD2 pineapple-based tenderizer versus a commercial tenderizer, focusing on five key sensory attributes: appearance, taste, texture, aroma, and overall acceptability.

## 2.0 Literature Review

*2.1 Meat Tenderness and Consumer Expectations*

Tenderness remains one of the most vital quality attributes influencing meat consumption and satisfaction. Studies consistently show that consumers judge meat quality primarily through its tenderness, with flavor and juiciness being secondary considerations (Miller, 2020). The positive association between tender meat and consumer satisfaction has prompted ongoing efforts to develop methods to improve tenderness, both naturally and synthetically. Hwang et al. (2025) emphasized that tenderness determines not just the eating experience, but also long-term customer loyalty. If consumers consistently experience tender and flavorful meat, they are more likely to become repeat buyers and brand advocates. This behavioral insight drives the meat industry's interest in developing tenderizing agents that balance effectiveness with health and sensory acceptability.

Over the last decade, a notable trend has emerged toward natural, minimally processed food products. Modern consumers increasingly seek clean-label alternatives which are products free from artificial preservatives, synthetic chemicals, and genetically modified organisms. This behavior is driven by rising health consciousness, environmental awareness, and concerns about chemical residues in processed foods (Hossain, 2016). Tenderizers made from natural sources such as fruits, herbs, and spices align well with this trend. Among these, pineapple-derived enzymes, especially from MD2 pineapple, are particularly favored because of their dual benefits: tenderization and flavor enhancement. Rani et al. (2024) noted that the MD2 variety, commonly cultivated in Southeast Asia, offers not only high bromelain activity but also desirable sensory attributes like sweetness and aroma that contribute positively to meat palatability.

*2.2 Mechanisms of Tenderization*

The primary mechanism behind natural tenderization using pineapple is the proteolytic action of bromelain. Bromelain is a cysteine protease enzyme capable of hydrolyzing muscle fiber proteins (actin and myosin) as well as connective tissue proteins such as collagen. This enzymatic activity weakens structural bonds, leading to a softer, more palatable meat texture (Banerjee et al., 2020). MD2 pineapple stands out among cultivars due to its higher bromelain activity. In a comparative study by Ketnawa et al. (2018), bromelain extracted from MD2 pineapple exhibited significantly greater tenderizing capacity compared to other pineapple types. The high sugar content in MD2 also contributes to improved caramelization and flavor complexity during cooking, enhancing overall meat quality.

Commercial tenderizers often contain a mix of plant enzymes for example, papain from papaya, bromelain from pineapple, and ficin from figs alongside additives like sodium chloride, starch, or phosphates. These synthetic or semi-synthetic formulations are engineered for consistency, rapid action, and extended shelf life (Kaur et al., 2016). One advantage of commercial products is the predictability of their enzymatic strength, which is often quantified and clearly labeled. This allows for precise dosing and minimizes the risk of over-tenderization. However, this same strength can be a drawback if misused. Overexposure can lead to disintegration of muscle fibers, resulting in unappealing mushy textures, especially in poultry or thin cuts (Gagaoua et al., 2021). In addition, phosphate-containing commercial tenderizers enhance juiciness and water-holding capacity, but there is growing concern about their long-term health effects, particularly in individuals with renal or cardiovascular conditions (Kaur et al., 2016).

*2.3 MD2 Pineapple-Based Tenderizer*

MD2 pineapple is a hybrid cultivar known for its superior sweetness, low acidity, and extended post-harvest shelf life. From a functional perspective, it contains higher levels of bromelain compared to older varieties like Cayenne or Queen (Rani et al., 2024). This makes MD2 a potent, dual-purpose tenderizer, contributing both enzymatic action and sensory appeal. In addition to bromelain, MD2 pineapple contains antioxidants like vitamin C, phenolic, and flavonoids. These compounds offer additional health benefits, such as reducing oxidative stress and improving immune response. When used in marinades, these bioactive compounds can help reduce lipid oxidation in meat during storage and cooking (Hossain, 2016).

Experimental studies support the efficacy of MD2 pineapple paste or extract in meat tenderization. Razali et al. (2023) reported a significant reduction in shear force values in beef samples treated with MD2 paste compared to untreated controls. Optimal results were observed with marination durations between 30 and 60 minutes. Longer exposures led to over-softening, emphasizing the importance of controlled application. In another study, the combined use of MD2 pineapple and local herbs (ginger, garlic, and turmeric) was tested for synergistic effects. Results showed improvements not only in texture but also in flavor profile, microbial stability, and antioxidant activity, attributes highly valued by both consumers and food safety regulators (Rani et al., 2024).

Sensory evaluations generally reveal favorable consumer responses to MD2-based tenderizers. Razali et al. (2023) conducted a blind test with 25 panelists, showing that meats marinated with MD2 pineapple paste scored higher in tenderness, flavor, and overall

acceptability compared to those treated with commercial tenderizers. Consumers noted the natural fruity aroma and subtle sweetness of the MD2-treated samples as appealing, especially when paired with grilled or pan-fried cooking methods.

*2.4 Commercial Meat Tenderizers: Utility and Limitations*

Commercial tenderizers enjoy widespread use due to their stability, availability, and standardized enzyme content. Products are typically marketed in powder form, making them convenient for both home cooks and industrial-scale processors. Dosing instructions are provided to mitigate risks of overuse, and consistent results are one of their strongest advantages (Kaur et al., 2016). In fast-paced food service environments, the rapid action of commercial tenderizers reduces preparation time and improves throughput. However, despite these conveniences, health-conscious consumers are becoming increasingly cautious about artificial additives and synthetic enzymes, especially when they are not clearly labeled.

While commercial tenderizers are effective, their impact on sensory characteristics can vary. Some users report an artificial aftertaste or excessively soft textures when dosage is not accurately measured. Moreover, repeated use of chemical-based tenderizers may lead to negative health outcomes due to the accumulation of sodium or phosphate compounds (Gagaoua et al., 2021). Kaur et al. (2016) discussed potential side effects of phosphate intake, including elevated serum phosphate levels, which may impair bone health and kidney function. This growing body of evidence has motivated some consumers to explore natural alternatives that offer comparable tenderization without these risks.

*2.5 Comparative Sensory Evaluation Studies*

Numerous studies have compared the performance of natural and commercial tenderizers. Gagaoua et al. (2021) conducted a comprehensive study using beef samples treated with MD2 pineapple extract, a phosphate-based commercial tenderizer, and a papain-based product. The MD2 sample scored highest in overall sensory performance, particularly for tenderness and flavor balance. Participants noted that the natural tenderizer delivered a cleaner, more desirable taste and retained more of the meat's original flavor. Razali et al. (2023) confirmed similar findings in a local consumer trial, where MD2 pineapple-treated meats were preferred over commercially treated counterparts. However, they also highlighted the importance of optimizing marination time to avoid over-tenderization.

Cultural familiarity with ingredients plays a crucial role in consumer preferences. In regions like Southeast Asia, including Malaysia, natural fruit and herb-based marinades are part of traditional culinary practices, making MD2 pineapple a highly acceptable option (Rani et al., 2024). In Western markets, while awareness of fruit-derived tenderizers is growing, adoption may still depend on consumer education and proper labeling. Clean-label trends and increasing awareness of health impacts are shifting attitudes even in markets traditionally reliant on commercial additives. Younger consumers, in particular, show more willingness to experiment with plant-based or functional food ingredients, including natural meat tenderizers.

*2.6 Nutritional and Functional Implications*

Bromelain and phenolic compounds in MD2 pineapple possess natural antioxidant activity that can help preserve meat quality by inhibiting lipid peroxidation. This is particularly important for meat products stored under chilled or frozen conditions. Hossain (2016) found that MD2-treated samples had lower TBARS values after cooking, indicating reduced oxidative degradation and better flavor retention. When herbs and spices are added to the MD2 marinade, this effect is amplified, creating a functional product that not only tenderizes but also enhances nutritional value and food safety.

Enzymatic hydrolysis of proteins by bromelain enhances meat digestibility and improves amino acid availability. This could benefit populations with impaired digestion, including the elderly or individuals with gastrointestinal issues (Banerjee et al., 2020). In contrast, the presence of chemical preservatives or excess sodium in commercial products may negatively influence nutrient retention and metabolic outcomes, especially in individuals with chronic health conditions.

*2.7 Challenges in Natural Tenderizer Application*

One of the key challenges in using MD2 pineapple-based tenderizers is batch-to-batch variability in bromelain content. Factors such as fruit ripeness, storage, and processing method influence enzyme concentration and activity. Unlike commercial products, natural tenderizers may require preliminary testing or pre-application adjustments to ensure consistent performance (Ketnawa et al., 2018).

MD2 pineapple paste, being perishable, must be refrigerated or preserved through drying or encapsulation techniques. Without these, microbial growth and enzymatic degradation can shorten shelf life and compromise safety. Techniques such as freeze-drying and microencapsulation have shown promise but increase production costs (Razali et al., 2023). Further research is needed to strike a balance between stability and cost-effectiveness.

*2.8 Market Trends and Future Directions*

Innovative formulations combining MD2 pineapple extract with other plant-based preservatives and stabilizers are under development. These aim to address limitations such as short shelf life and inconsistent enzyme activity. Research is also exploring the potential of delivering bromelain in encapsulated or powdered form for extended usability (Hossain, 2016).

Transparent labeling and consumer education play vital roles in increasing acceptance of natural tenderizers. Highlighting health benefits, usage instructions, and ingredient sources can help build consumer trust. Regulatory bodies are also encouraged to establish clearer guidelines on what constitutes a "natural" tenderizer to avoid misleading claims and protect consumers.

## 3.0 Methodology

A convenience sampling method was employed for this study. The sensory evaluation aimed to assess consumer acceptance of a newly developed natural meat tenderizer and compared it with a commercial counterpart. A total of 25 panelists participated in the evaluation. Each participant assessed two cooked meat samples, one treated with the commercial meat tenderizer and the other with the MD2 pineapple-based tenderizer formulated with herbs and spices. Six key sensory attributes were evaluated: color, flavor, appearance, texture, aroma and overall acceptability. A 9-point hedonic scale was used, where 1 represented “extreme dislike” and 9 represented “extreme like”. To prevent taste interference, panelists were instructed to cleanse their palates with water between samples.

## 4.0 Findings

25 participants contributed to the findings of this study. The findings are shown in Table 1 and Fig. 1 as below:-

Table 1: Average scores of sensory parameters for meat treated with commercial meat tenderizer and meat treated with natural MD2 pineapple-based tenderizer formulated with herbs and spices

| Parameter | Commercial meat tenderizer | MD2-based meat tenderizer |
|---|---|---|
| Appearance | 3.12±1.77 | 7.12±1.07 |
| Taste | 3.04±1.97 | 6.68±1.64 |
| Texture | 2.84±1.71 | 6.52±2.16 |
| Aroma | 2.96±1.71 | 6.92±1.29 |
| Overall Acceptance | 2.88±1.70 | 6.88±1.58 |

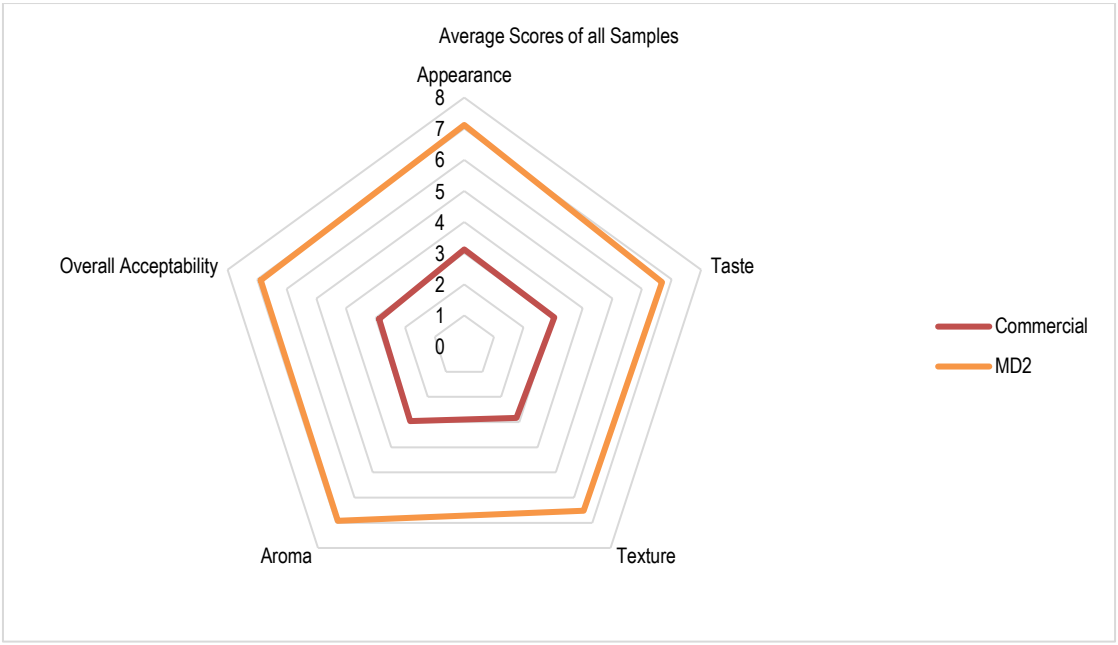


Fig. 1: Average scores of sensory parameters for meat treated with commercial meat tenderizer and meat treated with natural MD2 pineapple-based tenderizer formulated with herbs and spices.

The meat samples treated with MD2 pineapple-based natural meat tenderizer had received overall higher average scores in all criteria including appearance, taste, texture, aroma, and overall acceptability as compared to the average scores of the commercial meat tenderizer.

## 5.0 Discussion

The sensory evaluation conducted in this study aimed to assess consumer preferences for meat treated with a natural tenderizer made from MD2 pineapple, herbs, and spices, in comparison to a commercial meat tenderizer. The analysis focused on five critical sensory attributes which are appearance, taste, texture, aroma, and overall acceptability and are evaluated by a panel of 25 participants using a 9-point hedonic scale. The findings revealed that the MD2-based tenderizer was significantly more preferred across all parameters, reflecting the growing appeal of natural, functional ingredients in meat processing.

Appearance is a primary determinant in food selection, as it shapes consumers' initial expectations regarding taste and quality. In this study, meat treated with the MD2-based paste received a substantially higher than the commercially treated meat. This superior appearance may be attributed to the presence of natural sugars in pineapple, which promote Maillard reactions during cooking, thereby enhancing browning and color development (Gok & Bor, 2016). Moreover, the herbs and spices in the formulation may have contributed to a more appealing color and surface texture, providing a natural, freshly marinated look, which is often more visually acceptable to consumers compared to processed or chemically treated meats.

Taste is another critical determinant of consumer satisfaction. The MD2-based sample recorded a taste score more than double that of the commercial tenderizer. The enhancement in taste can be attributed to the synergistic flavor contribution of the selected herbs and spices, as well as the pineapple's natural sugars and acids, which can help balance savory notes in meat (Kadioğlu et al., 2019). Additionally, bromelain, a proteolytic enzyme naturally present in pineapples, not only tenderizes meat but also modifies protein structures, potentially exposing more flavor compounds and improving palatability (Ketnawa et al., 2018).

Texture was also significantly improved in the MD2-treated sample compared to the commercial product. This can largely be explained by the enzymatic action of bromelain, which breaks down muscle fiber and connective tissue, resulting in a softer, more desirable meat texture (Ha et al., 2016). Bromelain hydrolyzes peptide bonds in myofibrillar and collagen proteins, facilitating a more tender meat structure without the fibrous toughness often associated with untreated or synthetically treated samples (Arshad et al., 2016). This enzymatic tenderization is generally more effective and safer than chemical tenderizers like phosphates or papain, which may over-soften meat or alter its sensory profile unfavorably.

In terms of aroma, the MD2-based formulation achieved a score compared to the commercial variant. The pleasing aroma of the natural tenderizer is likely due to the combined volatile compounds from both pineapple and the incorporated herbs and spices. Herbs such as lemongrass, turmeric, or ginger which are commonly used in Southeast Asian meat preparation have well-documented aromatic qualities that enhance the overall smell and perceived freshness of cooked meat (Kittisakulnam et al., 2016). In contrast, synthetic tenderizers may lack this complex aroma profile and may even carry undesirable chemical odors, detracting from the overall consumer experience.

Finally, the MD2-treated sample's overall acceptability was far exceeding the commercial sample. This comprehensive score integrates all sensory aspects and reflects the consumer's holistic impression of the product. The natural tenderizer's higher ratings across all individual attributes suggest a positive cumulative effect, leading to a more favorable eating experience. This aligns with recent consumer trends that favor clean-label products made with natural and recognizable ingredients, which are often perceived as healthier and more trustworthy (Asioli et al., 2017).

In summary, the findings of this study support the effectiveness of MD2 pineapple-based meat tenderizers as a natural alternative to commercial products. The enhanced appearance, taste, texture, and aroma are attributed to the presence of bromelain and flavor-enhancing herbs and spices. These results are consistent with prior research emphasizing the functional and sensory advantages of using fruit-based enzymes in meat processing. However, further investigation is needed to evaluate the shelf-life, microbiological stability, and cost-effectiveness of such formulations before widespread adoption in the food industry.

## 6.0 Conclusion& Recommendations

Based on the sensory evaluation conducted, it is evident that the natural meat tenderizer formulated using MD2 pineapple, herbs, and spices demonstrated superior performance across all evaluated attributes including appearance, taste, texture, aroma, and overall acceptability when compared to the commercial tenderizer. The incorporation of bromelain from MD2 pineapple not only improved meat texture through enzymatic tenderization but also contributed to enhanced flavor and aroma through protein hydrolysis and interaction with natural aromatic compounds. The presence of herbs and spices further enriched the organoleptic profile of the meat, aligning with consumer preferences for natural, clean-label, and minimally processed food products. The significantly higher acceptability scores observed in the natural formulation highlight its potential to meet growing consumer demands for healthier and more flavorful meat products. In light of these findings, it is recommended that future studies focus on optimizing the formulation for industrial scalability, including evaluations of product shelf-life, storage stability, and microbial safety. Additionally, cost-benefit analyses should be performed to determine the economic viability of commercializing MD2 pineapple-based tenderizers. Incorporating variations in herb and spice combinations may also enhance product versatility and cater to regional taste preferences. Overall, this study supports the application of natural functional ingredients in meat tenderization and encourages further research and development to facilitate their adoption within the meat processing industry.

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## Paper Contribution to Related Field of Study

This study contributes to the growing body of research on natural meat tenderizers by demonstrating the superior sensory performance of an MD2 pineapple-based formulation. It highlights the functional potential of fruit-derived enzymes and traditional herbs in enhancing meat quality, supporting clean-label trends in food choice behaviors among the public.

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