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A study on the effect of using tamarind (*Tamarindus indica* L.) fruit extract in improving the quality of red meat

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Abstract

The objective of this study was to determine the efficacy of using tamarind fruit extract (*Tamarindus indica* L.) as a solution for increasing the quality of red meat at 20% and 30; these concentrations were then analyzed in terms of performance on sensory characteristics like tenderness, juiciness, flavor, and overall texture in comparison with untreated samples. To do so, they measured the meat's moisture content, pH value, cooking loss and water-wash-release capacity as well as the effect of extracts on bacterial growth. The meat samples were immersed in tamarind fruit extract at concentrations of 20 and 30%, held for 12 h, cooled at 4°C for the same period. Meat quality grading showed a significant different enhancement in the meat treated with 30% tamarind fruit extract to the control and 20% treatment. This slight decrease in pH to 4.4 helps inhibit bacterial growth, and it enhances flavor and tenderness. In parallel, the water content rose to 79.6%, the retention of which improved by 42.4%, and weight loss during cooking decreased by 22.8%. As a consequence of the application, the number of bacteria in the colony was reduced by 88%, coliforms by 85% and *Escherichia coli* by up to 90%. The results suggest that tamarind fruit extract can be used to improve the sensory, physicochemical, and microbiological quality of red meat.

Keywords: Tamarind plant, quality improvement, bacterial growth reduction

Introduction

The human body demands for vital ingredients to build up cells as well as to support important physiological and biological processes. Thus, the body does require small quantities of these ingredients. These are meats of all kinds including beef, goat meat, fish or poultry because here contain the most important ingredients and in the required quantities needed by the human body. The components are variable and their physical and chemical properties and benefits vary according to the type, age of the animal, method of slaughter, storage and processing conditions (McAfee *et al.*, 2010) [21].

As per Wu (2021) [34]: Meat has a wide range of amino acids, especially essential amino acids with 15-22%. Meat is a rich source of many proteins (Actin and myosin proteins) that the human body requires to build and maintain cells, especially muscle cells and body tissues for which there are no internal synthesis or plant sources unable to provide in sufficient amounts due to low levels of some essential amino acids (Barr & Gollahon, 2025) [7]. Furthermore, meat is rich in artificial and apparent fats that gives the taste of meat as well further they provide high source of energy. Protein is also a key source of many important vitamins, including the B-group vitamins such as B1, B2, B6 and particularly B12 which has a significant role in metabolism and nervous system function. Besides, meat contains zinc and iron indispensable for the maintenance of immunity and the blood. Several studies have also shown that meat promotes satiety and decreased appetite ergo is relevant for weight management (Wyness, 2016) [35].

With so many benefits of meat, therefore, make sure you are not consuming in high quantity or continuous. Meat is risky to human health: Excessive or unhealthy meat-eating can lead to a whole host of diseases such as heart disease, colorectal cancer and more. To this end, the World Health Organization encourages a judicious use of meat in the diet (Lescinsky *et al.*, 2022) [19].

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One of the most important criteria addressed in this study and required for better quality meat products are tenderness, storage stability, microbiological parameters and flavor. One of the critical traits that promotes meat consumption in consumers is tenderness, and it associates with muscle structure which comprises several connective tissues. Finally, the quantity of these tissues, the muscle structure responsible for amino acid bonding in proteins and its water holding capacity will contribute to tenderness (Jayan *et al.*, 2024)^[17].

Additionally, Dave and Ghaly (2011)^[10] of the studied processes reported changes in meat that result during these treatments modifying their chemical and physical composition resulting in lower nutrient value. Of all these changes, loss of tenderness is one of the leading factors responsible for reducing the willingness to consume meat among consumers. Common situations which deteriorate the tenderness are meat from old animals, exercising animals and methods that are not correct for storing meats. Moreover, degradation of muscle structural composition causes the decrease in vitamin concentration as well as water content in meat, via long-term storing (De Corato, 2020)^[11]. On the other hand, the bacteria related with human diseases like coliforms and *Escherichia coli* increase their growth, which induce meat spoilage and deterioration that affects on consumer behavior when they buy it. This decreases the demand causing a negative effect on the economies for some Meat exporting countries who needs foreign currency, and also deprive consumers of their health benefits from consuming meat (Ferdouse, 2018)^[28].

These factors have prompted many researchers and scientists to take necessary measures to prevent or reduce causes of meat deterioration. One such measure is the use of natural chemical components to eliminate many causes of spoilage and quality degradation related to tenderness, juiciness, flavor, muscle structure, and microbial spoilage (Kaya, 2024)^[18].

Many researchers have pointed out the role of various natural components such as lemon juice, ginger extract, pineapple, and kiwi fruit in improving meat quality by increasing tenderness, enhancing flavor, reducing microbial content, and extending the shelf life of meat (Anaducts *et al.*, 2023)^[5].

Passos *et al.* (2025)^[29] reported the significance of tamarind fruit (*Tamarindus indica* L.) in nutrition as well as in diverse medical applications. Tamarind is common in many tropical regions, growing wild and also is cultivated on a large scale in India, other South Asian countries as well as the Philippines, Venezuela, Myanmar, Bangladesh. For consumption as well as for industrial purposes, the pulp is most vital part that contains many acids such as tartaric, malic and citric acids through which a strong sour taste is provided owing to the enrichment of these acids (Limsangouan *et al.*, 2019)^[20].

Furthermore, the natural sugars and phenolic compounds as well as those dietary fibers present in its pulp have a substantial impact on water absorption while cooking. It also acts as an important antioxidant which helps in decreasing fat rancidity. It also has aroma compounds at 0.8%, giving it the taste only unmistakable by folks in Flint

Michigan. Tamarind pulp also serves as an antibacterial agent and is hyperconscious perfect diet minerals potassium calcium magnesium for enriching the various diets that humans consume. It also consists of approximately 14 percent natural fibers that can make one feel full. Leaves, seeds and bark of the plant are used in many fields like medicinal and therapeutic areas (Nagar *et al.*, 2023)^[22].

This study focuses on the use of tamarind fruit to improve the quality of red meat by employing tamarind fruit extract and investigating its effect on the physicochemical and sensory properties of red meat.

Materials and Methods

Preparation of Meat Sample

The thigh area of a calf aged 24-36 months was selected as the sample for testing. The meat was cut into small pieces approximately (2 × 2) cm, then washed with distilled water and stored in a refrigerator at 4°C until use.

Preparation of Tamarind Extract

Less acidic extract was made from whole dried tamarind pods, Cleaned fruits: they were stripped of impurities, seeds and bristles. Tamarind in powder (100.00 g) was subjected to maceration in 500 ml of hot distilled water with manual stirring each 6 h until complete mixing and all tamarind juice extraction. The solution was subsequently extracted by sterile, clean muslin cloth. Extracts were prepared at concentrations of 20% and 30% for use in the meat samples which was compared to no extract (control) treatments. These 3 samples were kept in a refrigerator (4 °C) for 10 hours (Farooq *et al.*, 2022)^[13].

Qualitative Tests

1. Moisture Content Measurement

A sample from each treatment was weighed using a sensitive balance before drying. Samples were placed in a drying oven at 105 °C for 6 hours. Each sample was then weighed separately, and the percentage of moisture content was calculated according to A.O.A.C. (1984)^[2] using the following formula:

$$\text{Moisture Percentage} = \frac{\text{Weight before drying} - \text{Weight after drying}}{\text{Weight before drying}} \times 10$$

2. Measurement of pH

Weighed 10 grams from each sample and minced thoroughly. Then, approximately 100 ml of distilled water was added separately to each sample and mixed using a magnetic stirrer. The mixture was left to settle, and the pH was measured using a pH meter (A.O.A.C., 2019).

3. Measurement of Water Holding Capacity (WHC)

Water loss was calculated as percentage for each meat sample (control, 20% extract-treated and 30% of extract treated) by mixing 100g of each treated sample with 100ml distilled water. Both the mixtures were then centrifuged at 1000 rpm for five minute. Using the difference in water weight before and after centrifugation, it was possible to calculate the Water Holding Capacity (WHC) of each meat sample according to Honikel (2004)^[16]:

$$\text{Water Holding Capacity (\%)} = \frac{(\text{Weight of water added to meat} - \text{Weight of the sample} - \text{Weight of water remaining after centrifugation})}{\text{Weight of the sample}} \times 100$$

4. Measurement of Cooking Loss Percentage

The percentage of weight loss was calculated following the method of Ortuño *et al.* (2021) [26]. Ten grams from each sample were weighed and placed in polyethylene bags, ensuring they were tightly sealed. All bags were then immersed in a water bath at 70 °C for 1.5 hours. After cooking, the bags were drained of liquid and stored in a refrigerator at 4 °C. The samples were then removed, weighed, and the percentage of weight loss was calculated using the following formula:

$$\% \text{ Weight Loss} = \frac{\text{Weight before cooking} - \text{Weight after cooking}}{\text{Weight before cooking}} \times 100$$

5. Measurement of Bacterial Contamination by Counting Bacterial Colonies

Culture media were prepared for each type of bacteria. Plate Count Agar (PCA) was used. Bacterial counts were determined in (TF) media, with the total bacterial

count using standard plate count agar (SPOG), coliform bacteria counts on Violet Red Bile Agar and *Escherichia coli* on MacConkey Agar. Peptone water at 0.1% concentration was used to make the necessary dilutions for other media and to inoculate with various concentrations of sample (20%, 30%, control sample). Incubation followed at 36 °C for 24 h, after which colony forming units (CFU/g) were enumerated on respective plates (APHA, 2001) [6].

Sensory Evaluation

Table 1: Sensory evaluation (tenderness, juiciness, flavor) of the meat samples which treated with tamarind extract in different concentrations by a group of specialized nutrition professors and some students from Al muthanna university /College of Agriculture/Department of Food Sciences. Weights of 30 g per sample were used, cubed to 2 cm thickness × 5 cm width then grilled at 165°C as per AMSA (1995) [23].

Table 1: Sensory Evaluation Model

Attribute	Control Sample	20% Extract Concentration	30% Extract Concentration
Tenderness			
Juiciness			
Flavor			
Overall Texture			

Results and Discussion

1. Qualitative Tests

The values of moisture content of meat samples increased in both treated samples compared to the control sample as shown in Table (2) with amount 73.2% for sample which treated by tamarind extract 20%, and increase to amount 79.6% for sample which treated by tamarind extract at a level of 30%. This increase may be due to the extract role in destruction of protein structure, releasing pores and it helps to fibrils wetting by bonding fibers with water and moisture retention (Cheok and Chin, 2012) [9].

Also a decrease in the PH value can be noted from results presented in Table 2 where the mean of pH for meat sample treated with tamarind extract 30% became significantly lower due to malic, tartaric and citric acid contained within tamarind extract. Cathepsin, which is the enzyme in charge of a form of meat softening, are activated by acids (Serदारoglu and Karaman, 2024) [32].

Data from Table (2) further highlights a substantial increase in the water-holding ability of meat. The water-holding capacity was 38.5% in the sample treated with 20% tamarind extract and 42.4% in a 30% treated sample. The

decrease in pH contributes to the stabilization of the protein matrix at a 30% concentration and depending on the organoleptic properties, which have acidic polysaccharides in tamarind seeds and pulp. The two diglucoses in wheat, amylose and amylopectin, bind with water and proteins to hold on more water and less cooking losses. Furthermore, the sugars present in tamarind (galactose, glucose) also aids in creating a viscous material which holds water along with protein fibers (Cheok and Chin, 2012) [9].

Table (2) also showed a significant reduction in cooking water loss as cooked samples contained 28.1% water; however, these losses were reduced to 24.7% in the flesh of treated fish at contrasting depot levels and to 22.8% with an intermediate level of depots. This decrease is a result of the reduced pH from tartaric, malic, and citric acids which increase water-protein binding strength also by affecting the muscle protein structure in cytoplasm, decreasing protein breakdown during heating (9). Also, this effect leads to the rebuilding of muscle fibers and reduced water exit pores that contribute directly towards moisture hold-up or otherwise release from meat while cooked and stored (Naveena *et al.*, 2004) [24].

Table 2: Values of Moisture Content, pH, Water-Holding Capacity, and Weight Loss Percentage for Meat Samples Treated with Tamarind Extract at Concentrations (20%, 30%) and Control Sample

Sample	% Moisture Content	pH	% Water-Holding Capacity	% Weight Loss
Untreated	68.1	5.9	16.2	28.1
30% Tamarind Extract	79.6	4.4	42.4	22.8
20% Tamarind Extract	73.2	5	38.5	24.7

2. Bacterial Count Estimation

The results shown in Table (3) showed a significant decrease in the number of bacterial colonies recorded with 30% Tamarind flesh extract by 85% Coliform count, 88% total bacteria count and 89.9% *E. coli*. The elevated acidity of the citric (pyruvic and malic acids) as well as palmitic acids are believed to contribute to growth inhibition of

bacteria, leading to a lower colony count (Over *et al.* in 2009) [27]. It also has polyphenolic compounds such as tannins, l-ferulic acid, and gallic acid. This mainly helps in harming the cell structure of bacteria by and hence modifying the permeability of bacterial cell walls and disrupting their membrane structure, leading to release of bacterial cell contents followed by ultimately death of

cells. Microbiologically, phenolic compounds are viewed as natural antimicrobials, capable of reducing the total

population of spoilage bacteria (Aengwanich *et al.*, 2009) [3].

Table 3: Bacterial colony counts for meat samples treated with tamarind extract at concentrations of 20%, 30%, and the control sample.

Type of Bacteria	Control Sample	20% Extract	30% Extract
Total Bacterial Count	6.5×10^5	1.4×10^5	0.8×10^5
Coliform Bacteria	3.1×10^3	9.1×10^2	4.6×10^2
<i>E.coli</i>	8.9×10^2	1.5×10^2	0.9×10^2

3. Sensory Evaluation

The results of the sensory evaluation, as shown in Table (4), indicated a noticeable improvement in the quality of meat treated with a 30% extract concentration. The results showed enhancement in tenderness, juiciness, flavor, and overall acceptability. This is attributed to the acids contained in tamarind extract, which play a role in increasing meat juiciness and breaking protein bonds, thereby enhancing meat tenderness and making it easier to chew and cut. Additionally, these acids provide a sour flavor and reduce the rancid taste resulting from fat oxidation (Hassan *et al.*, 2022) [15]. Moreover, phenolic compounds contribute a mildly bitter taste that is desirable when balanced with the sour flavor. The presence of polysaccharides in tamarind fruit extract also forms a gel network that enhances meat tenderness and increases moisture content (Elsayed *et al.*, 2016) [12].

Table 4: Sensory Evaluation Results

Attribute	Control Sample	20% Extract Concentration	30% Extract Concentration
Tenderness	5	7	8
Juiciness	6	8	8.5
Flavor	6.5	7.5	9
Overall Texture	6	7	9

Conclusion

Tamarind fruit can be used as an important source of essential minerals, nutritionally and health-beneficial nutrients, and phenolic compounds that contribute to enhancing the quality of red meat and extending its storage period by improving sensory properties and desirable characteristics. It also improves product quality and prolongs shelf life. Moreover, it is a potential natural source of antioxidants and can be applied in perishable food systems.

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