

Effect of Pineapple Extract on Some Physicochemical Properties of Old Camel Meat

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Abstract: *This study evaluates the effect of pineapple extracts at different concentrations (5%, 10%, and 15%) on the physicochemical properties of old camel meat. 50-month-old camel meat samples measuring 5 × 5 × 3 cm (length × width × height) were prepared. The samples were immersed in the prepared solutions and remained at a refrigeration temperature of 4°C for 48 Hours. At the end of the experiment period, the samples were evaluated for pH, water-holding capacity (WHC), and proximate composition. It was observed that the pH values decreased from 6.3 in the control to 6.0, 5.5, and 5.0 following treatment with 5%, 10%, and 15% pineapple extract, respectively. The highest pineapple concentration applied to meat; the lowest pH value. The highest recorded WHC value was obtained with 5% pineapple extract (35.3), followed by 10% (33.5) and 15% (30.4), while the control recorded the lowest value (27.5). In contrast, the higher the pineapple concentration used, the higher the water-holding capacity (WHC) obtained. With 15% extract produced the highest moisture content (81.48%), the lowest crude protein content (11.27%), and relatively high fat and ash contents. Pineapple extracts in the experiment improved the quality of old camel meat.*

Keywords: Camel meat; Pineapple extract, Bromalin; Water holding capacity, Proximate composition

1. Introduction

Camels are among the most important livestock producers in arid and semi-arid regions due to their high adaptability to harsh environmental conditions and limited forage resources compared to other ruminants [1,2]. These characteristics have contributed to their importance as a meat source in many Middle Eastern countries such as Saudi Arabia [3-6], particularly in areas suffering from water scarcity and poor grazing land. Scientific literature indicates growing interest in camel meat due to its nutritional value and its potential contribution to food security in desert and semi-desert environments [7-9]. Camel meat possesses unique structural and nutritional characteristics that have made it a subject of increasing interest in meat science research. It contains a good proportion of protein with a relatively low-fat content compared to some other types of red meat. Studies have also shown that the chemical composition of camel meat is influenced by several factors, including age, diet, and muscle type [10-12]. However, it is generally considered a good source of important nutrients such as amino acids and essential minerals. These characteristics have contributed to the growing interest in using camel meat in the food industry and in processed meat products. Animal age is one of the most important factors affecting meat quality, as it is directly related to structural and chemical changes within muscle tissue. As animals age, collagen deposition in muscles increases, and cross-linking between fibers increases, reducing thermal solubility and increasing muscle tissue stiffness. Furthermore, advancing age is associated with a decrease in the activity of proteolytic enzymes within the muscle, reducing the efficiency of natural tenderization processes after slaughter and negatively impacting tenderness development during refrigerated storage [13,14]. Pineapple extract and bromelain enzyme produced from pineapple is used for meat for many purposes in several studies [15-19]. This study investigates the effect of pineapple extract of some quality properties of old camel meat.

2. Materials and methods

2.1 Meat Samples

Meat samples were obtained from the hindquarters muscle (longissimus dorsi) of male camels of the local breed, approximately 50 months old (senior camels), from an approved slaughterhouse in the Qassim region of Saudi Arabia. The samples were transported directly to the experimental meat laboratory at Qassim University in refrigerated boxes (4°C) to ensure preservation.

2.2 Method

2.2.1 Preparation of pineapple extract

Fresh fruits were purchased from local markets in the Qassim region of Saudi Arabia, ensuring they were fully ripe, physically sound, and free from any defects, fungal or insect infestations to guarantee the highest possible enzymatic activity. The fruit was thoroughly washed with running water to remove debris, then dried and peeled using sharp laboratory knives. The fruit was then cut into small, uniform cubes, and finally blended using a high-speed electric blender to obtain a homogeneous mixture of pulp and juice.

2.2.2 Preparation of camel meat samples

Fresh (recently slaughtered) meat cuts from the hindquarter muscle of male camels of the target age (50 months) were used. The muscle pieces were carefully selected to ensure uniformity and distribution of muscle tissue. The meat was thoroughly washed with distilled water to remove any remaining residues from the slaughtering process, and then the outer surfaces were completely dried using highly absorbent laboratory paper to prevent any unintended dilution of the enzyme extracts during subsequent application. The meat was then manually cut into uniform cubes with precise dimensions of (5 × 5 × 3) cm. Care

was taken to ensure that the cuts were made in the direction of the muscle fibers to guarantee a uniform surface area exposed to enzymatic action in all pieces. To ensure a liquid extract free of fibers and tissue residues that could hinder the steeping process, the resulting mixture was strained using a clean, multi-layered cheesecloth. The crude extract was used as a basis for preparing the concentrations required for the study, where it was diluted using distilled water to reach three concentrations (5%, 10%, and 15%).

2.2.3 pH measurement

The sample of meat homogenate suspension was prepared by mixing 10 g of the meat sample with 100 mL of chilled distilled water to obtain a homogeneous mixture. The pH was then measured using a digital pH meter pre-calibrated with standard solutions to ensure accurate readings. The measurements were performed. A pH device no. HI2211 pH/ORP Meter was used in the measurement.

2.2.4 Water holding capacity (WHC) Determination

The WHC was determined using the centrifugation method, where minced meat samples were placed in dedicated centrifuge tubes and subjected to a specific centrifugal force under constant cooling conditions. After the process was complete, the amount of expressible water was measured, and the percentage of water retained within the meat tissue was calculated. The device used in this measurement was a Laborzentrifugen GmbH Germany) centrifuge.

2.2.5 Proximate composition analysis

The AOAC ^[20] methods were used in the proximate analysis. The measurements include percentages of moisture, crude protein, crude fat, and crude ash. The carbohydrate percent was obtained by subtracting (moisture, crude protein, crude fat, crude ash) from 100%.

3. Results and Discussion

3.1 pH Measurement

The results of the pH values are shown in Figure 1. The values indicate a concentration-dependent decrease in meat pH following the application of pineapple extract. The control had the highest pH (6.3), whereas the meat treated with pineapple extracts at concentrations of 5%, 10%, and 15% showed progressively lower values of 6.0, 5.5, and 5.0, respectively. Compared with the control, the pH decreased by 0.3, 0.8, and 1.3 units at 5%, 10%, and 15% concentrations, respectively. This corresponds to a reduction of approximately 4.8%, 12.7%, and 20.6% in the numerical pH values. The lowest pH was recorded in meat treated with 15% pineapple extract, suggesting that increasing the concentration of the extract was associated with a greater acidifying effect under the conditions of this experiment. This finding agrees with Hussain et al. ^[21], who investigated the effects of pineapple core extract concentration and maceration duration on free-range chicken meat quality. The present findings are also consistent with Ramli et al. ^[22], who reported a reduction in pH following the application of proteolytic extracts derived from pineapple and jackfruit by-products to bovine meat. However, the magnitude of the pH reduction cannot be directly compared between these studies because of differences in animal species, extract composition, and treatment conditions. Furthermore, pineapple extract may contribute characteristic fruity or acidic flavors, particularly at higher concentrations. Previous research on pineapple-based meat treatments has examined textural and other quality attributes, supporting the need to evaluate the overall quality of treated meat rather than relying exclusively on pH measurements ^[17,21]. These findings are consistent with previous research on pineapple-derived treatments in beef, which also reported reductions in meat pH ^[21,22]. The results suggest that pineapple extract has potential as an acidifying ingredient in the processing of old camel meat.

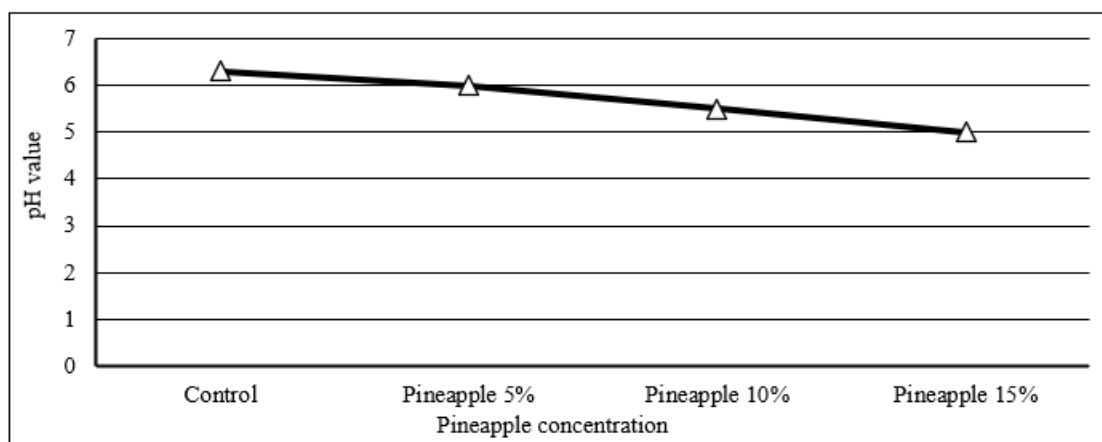


Figure 2: pH value of old camel meat treated with pineapple extract at different concentrations

3.2. Water holding capacity (WHC) determination

The reduction in WHC from 35.3 at 5% to 33.5 at 10% and 30.4 at 15% may indicate that the benefits associated with pineapple

extract were reduced at higher concentrations. One possible explanation is that more extensive proteolysis altered the integrity of muscle proteins and their ability to retain water. Excessive enzymatic activity can disrupt the structural

framework of muscle tissue, potentially allowing previously entrapped water to escape. Thus, the observed pattern may reflect a balance between the structural modification associated with moderate treatment and the potential loss of water-retaining capacity at higher treatment levels. The results presented in the attached table show that the addition of pineapple extract at different concentrations affected the water-holding capacity (WHC) of fresh meat obtained from old camels. The control sample recorded a WHC value of 27.5, whereas the addition of pineapple extract at 5%, 10%, and 15% resulted in values of 35.3, 33.5, and 30.4, respectively. These results indicate that pineapple extract improved the water-holding capacity of camel meat compared with the untreated control, although the magnitude of improvement varied according to the concentration used. The findings indicate that increasing the pineapple extract concentration beyond 5% was associated with a progressive decline in WHC. This may reflect concentration-dependent changes in muscle protein structure and water retention caused by bromelain activity. This distinction is particularly important when interpreting the present results. The increase from 27.5 in the control to 35.3 at 5% pineapple extract suggests that the lowest concentration may have modified the meat structure in a way that favored water retention under the measurement conditions used. In another relevant investigation, the effects of bromelain

treatment on pork loin were examined by Kim et al. [23]. Their results showed that bromelain-based treatment altered WHC and other physicochemical properties. Under the conditions of this experiment, 5% pineapple extract was the most promising treatment for improving the observed water-holding capacity of fresh meat from old camels. Research on pineapple-derived proteolytic treatments has similarly examined changes in water-holding capacity, cooking yield, and muscle structure, demonstrating the importance of evaluating these parameters alongside pH [21]. Similarly, Al-Sanger et al. [24], in their investigation of bromelain treatment in aged camel meat, reported significant differences in WHC and other physical characteristics among treatment groups. Their study supports the relevance of bromelain treatment for modifying the physical properties of meat from older camels. Matsumoto et al. [25] observed higher total loss and lower WHC in bromelain-treated beef compared with the control. The authors discussed the possibility that enzymatic degradation of connective tissue and disruption of muscle structure could contribute to water loss. The finding in this study agreed with the finding by Matsumoto et al. [25] in the WHC observed when pineapple extract concentration increased from 5% to 15% in the present study, while also highlighting that enzyme-mediated tenderization may be involved in the relation between tenderness of the meat and water retention.

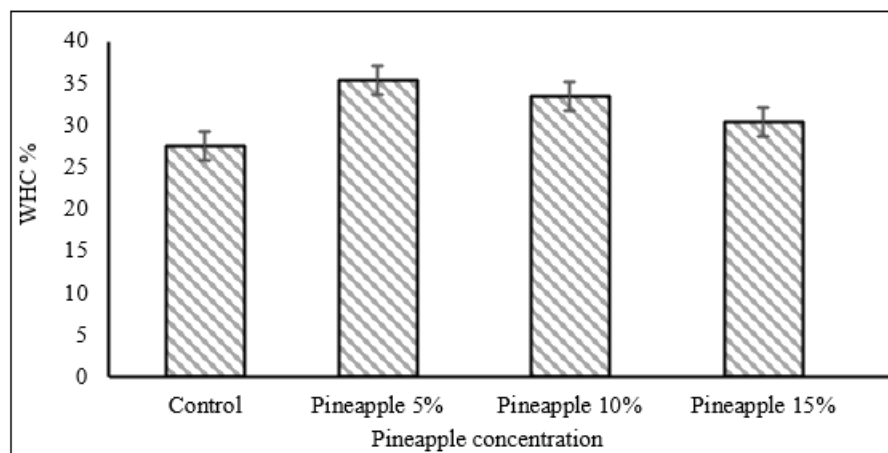


Figure 2: WHC of old camel meat treated with pineapple extract at different concentrations

3.3 Proximate composition analysis

The results demonstrate that increasing the concentration of pineapple extract produced clear changes in the proximate composition of old camel meat. The control treatment contained 77.55% moisture, 18.87% crude protein, 2.10% crude fat, 0.95% ash, and 0.53% carbohydrate. Addition of pineapple extract at 5% increased moisture to 79.20%, whereas 10% pineapple extract resulted in 76.76%, followed by a marked increase to 81.48% at 15%. According to the table, these moisture values carry different superscript letters, indicating significant differences among treatments at $p \leq 0.05$. The particularly high moisture content at 15% pineapple extract suggests that the highest treatment was associated with greater retention or incorporation of water in the meat matrix. However, because WHC was not measured in this table, this increase in

moisture should not be described directly as an increase in WHC. Recent work emphasizes that WHC is a specific functional property that requires an appropriate direct or standardized analytical measurement rather than being inferred simply from moisture percentage references [26,27]. The study by Santos et al. [28] on pineapple by-products enriched in bromelain demonstrated that enzyme concentration and treatment duration influence the resulting properties of the meat. The moisture response was therefore non-linear rather than concentration dependent. The 5% treatment increased moisture by approximately 1.65 percentage points relative to the control, whereas 10% decreased it by about 0.79 percentage points, before the 15% treatment increased it by approximately 3.93 percentage points. Crude protein as pineapple-extract concentration increased. Protein decreased from 18.87% in control to 15.07% at 5%, 12.73% at 10%, and 11.27% at 15%.

Thus, compared with the control, the 15% treatment represented a reduction of approximately 40% in the reported crude-protein percentage. The differences are marked with different superscript letters, indicating significant treatment effects ($p \leq 0.05$). This trend is consistent with the known proteolytic action of bromelain. Bromelain is a cysteine protease capable of hydrolyzing muscle and connective-tissue proteins, producing smaller peptides and soluble protein fragments [16]. Saengsuk et al. [17] similarly demonstrated extensive protein degradation in bromelain-treated pork, with increased soluble proteins, peptides, and collagen fractions as enzyme treatment increased. Yiale et al. [18] likewise reported that bromelain extracted from

pineapple waste could digest beef proteins, with greater protein digestion at higher bromelain concentrations. The crude-fat content increased substantially following pineapple treatment, from 2.10% in control to 3.85%, 4.60%, and 4.63% at 5%, 10%, and 15%, respectively. The ash content showed a clear increasing pattern, from 0.95% in the control to 1.10%, 1.35%, and 1.40% at 5%, 10%, and 15%, respectively. The treated samples are indicated as significantly different from the control, while the three pineapple treatments appear not to differ significantly from one another. An increase in ash is reasonable when a fruit extract is incorporated because pineapple-derived material contains mineral constituents [16].

Table 1: Proximate composition of old camel meat treated with pineapple extract at different concentrations

Sample	Moisture%	Crude Protein%	Crude fat%	Ash content%	Carbohydrate %
Control	77.55 $\pm$ 0.45 ^c	18.87 $\pm$ 0.21 ^a	2.10 $\pm$ 0.11 ^c	0.95 $\pm$ 0.03 ^c	0.53 $\pm$ 0.02 ^c
Pineapple 5%	79.20 $\pm$ 0.62 ^b	15.07 $\pm$ 0.34 ^b	3.85 $\pm$ 0.15 ^b	1.10 $\pm$ 0.05 ^b	0.78 $\pm$ 0.04 ^a
Pineapple 10%	76.76 $\pm$ 0.58 ^d	12.73 $\pm$ 0.28 ^c	4.60 $\pm$ 0.12 ^a	1.35 $\pm$ 0.04 ^a	0.66 $\pm$ 0.03 ^a
Pineapple 15%	81.48 $\pm$ 0.71 ^a	11.27 $\pm$ 0.42 ^d	4.63 $\pm$ 0.18 ^a	1.40 $\pm$ 0.06 ^a	0.22 $\pm$ 0.01 ^d
^{a,b,c,d} Values with lowercase subscript letters within the column are significantly different $p \leq 0.05$. The values are the average readings of three replicates					

4. Conclusion

Pineapple extract treatment caused an improvement in some physicochemical of old camel fresh meat, including pH, water holding capacity and proximate composition of the meat compared with the control. This investigation suggested that pineapple extract has a concentration-dependent effect on the proximate composition of old camel meat. The results suggest that pineapple extract has potential as an acidifying ingredient in the processing of old camel meat. The highest pineapple concentration applied to meat; the lowest pH value is observed. In contrast, the higher the pineapple's concentration is used the higher the water-holding capacity (WHC) is obtained. With 15% extract producing the highest moisture content (81.48%), the lowest crude protein content (11.27%), and relatively high fat and ash contents. Further studies on optimization of the best pineapple concentration on texture and sensory evaluation properties of camel meat are highly recommended.

Declaration

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Data availability: Data are available and can be requested from the corresponding author for confidentiality requirements.

Author contributions: Ibrahim Alsallum: Conducted the study, collect the data and analyzed them.

M. Abd Elgadir: Prepared the manuscript according to the IJSR guide.

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