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The Effect of Papaya Vinegar *(Carica papaya L)* Marinating Time on the Physical Quality of Horse Meat *(Equus caballus).*

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ABSTRACT

Marination is a process used to soak meat, which functions to improve physical quality of meat. Horse meat has a high protein content of around 19.72% with a low fat content of 4.84%. To improve its quality, natural marination are needed, including papaya vinegar. Papaya can be used as a natural marination because it contains protease enzymes, namely papain enzymes. Papain enzymes function as catalysts in protein hydrolysis reactions that can improve meat quality. This research was conducted in January - April 2025 at the Animal Production Laboratory, Faculty of Agriculture, Universitas Sumatera Utara, and the Chemistry Department Testing Laboratory, Lhokseumawe State Polytechnic. The design used in this study was a Completely Randomized Design (CRD) with 4 treatments dan 5 replications. The treatment consisted of giving papaya vinegar as much as 25% in each treatment (P0 = control; P1 = 15 minutes; P2 = 30 minutes; P3 = 45 minutes of marination). The parameters observed were pH value, water holding capacity, cooking loss, and meat tenderness. The results showed that the duration of papaya vinegar marination on the physical quality of horse meat had a significant effect on water holding capacity and tenderness.

Keywords: Papaya vinegar, Horse meat, Papain enzyme, Physical quality of meat

1. Introduction

Meat is a livestock product widely used to meet human animal protein needs. One type of livestock that deserves attention and has potential for meat production is horses. Horse meat has a high protein content of around 19.72% with a low fat content of 4.84% [1]. [2] stated that horses can be an alternative meat supplier and have significant potential as a food source with a very high protein content.

People tend to prefer beef over horse meat. This is undoubtedly related to the quality of horse meat, which has a tough texture. The high toughness of horse meat is due to the presence of numerous muscle fibers, which is due to several factors besides age. Horses are generally also used for work [3].

Consumers pay close attention to meat quality, particularly its fine, tender, and easy-to-chew fibers. The relatively tough quality of the meat, due to its high connective tissue protein content and dark red or dark red color with a hint of brown [4], makes horse meat less desirable to consumers. One way to tenderize the meat is through marinating.

Marinating is the process of soaking meat in a marinade [5]. Marinades, for examples are seasoned or acidic solutions that enhance flavor, water-holding capacity, tenderness, juiciness, reduce cooking losses, and extend shelf life [6]. [7] mentioned that improving the physical quality of meat can be achieved by marinating

it with ingredients safe for meat products. [8] found that vinegar as a marinade solution has the potential to improve the physical and sensory quality of meat. One natural marinade ingredient that can be used is papaya vinegar.

Papaya fruit contains papain, a proteolytic enzyme. This papain enzyme can be used as a tenderizer for tough meat. According to [8] papain is a protease enzyme that plays a role in hydrolyzing protein, making it useful as a meat tenderizer. Papain has the ability to break down the endomysium that covers meat fibers and breaks down the connective tissue into amorphous fibers [9]. Papaya vinegar is produced through the fermentation process of papaya fruit. Vinegar contains the organic acid acetic acid [10].

Acetic acid can change the pH of meat so that a good level of water holding capacity, cooking loss and meat tenderness could be obtained [11]. Function of acetic acid some of which can help maintain and encourage stability of food products include color, taste, aroma and texture, thus quality food products can be achieved [12].

2. Method

This research was conducted from January to April 2025. The research locations were the Feed Science and Technology Laboratory, Faculty of Agriculture, Universitas Sumatera Utara, and the Animal Production Laboratory, Faculty of Agriculture, Universitas Sumatera Utara.

2.1. Materials

The materials used in this study were the main ingredient and supporting ingredients. The main ingredient was 600 grams of horse meat. Other ingredients included 1 kg of unripe papaya, 500 grams of brown sugar, 500 ml of water, and a 5-liter jar.

2.2. Tools

The tools used in this study were knives, blenders, analytical scales, thinwall, polyethylene plastic, pH meters, water baths, texture analyzers, measuring cylinders, Whatman No. 42 paper, graph paper, wood presses, water baths, thermometers, hotplates, and an oven**.**

2.3. Study design

The experimental design used in this study was a Completely Randomized Design (CRD) with 4 treatments and 5 replications, resulting in a total of 20 experimental units. Each experimental unit used horse meat (Equus caballus). The treatments were as follows:

P0 = control (without soaking in papaya vinegar)
P1 = horse meat + papaya vinegar with a marinating time of 15 minutes
P2 = horse meat + papaya vinegar with a marinating time of 30 minutes
P3 = horse meat + papaya vinegar with a marinating time of 45 minutes

2.3 Research Parameters

2.3.1 Potential of Hydrogen (pH)

The pH value can be measured using a pH meter. To measure the pH of meat, take 10 grams of horse meat and add 10 ml of distilled water.The pH is then measured using a calibrated pH meter.

Using buffer solutions with pH 4 and 7, the tip of the pH meter is inserted into the meat sample. Read and record the pH value displayed on the pH meter display [13].

2.3.2 Cooking lost

[14] stated that cooking loss in meat can be calculated using the CSIRO method, which is the ratio between the weight of the meat before (initial weight) and after cooking (final weight). Meat marinated in papaya vinegar is weighed at 25 grams before cooking. The marinated meat is placed in polyethylene plastic bags, tightly sealed, and vacuum sealed. The meat is boiled for 1 hour at 80°C, then drained. The boiled meat is weighed as the final weight.

2.3.3 Water Holding Capacity

[15] stated that measuring the water-holding capacity of meat can be done by preparing a 0.3-gram sample on Whatman paper No. 42, then pressing it using a wooden press for 5 minutes. The area covered by the sample and the wet area around the filter paper are marked and recorded on graph paper using a candling tool. The surface area of the sample is plotted, subtracting the wet area from the total area covered by the sample. Air content is measured by first weighing the dish. After weighing 2 grams of the sample, place it in an oven for

5 hours at 5°C.Then, cool the dish in a desiccator for 30 minutes.

2.3.4 Tenderness Test

Meat tenderness testing was carried out using the method of [16], with the following steps. A texture analyzer (LFRA Brook Field) was prepared. A 3x3x2 cm piece of meat was placed directly under the cylindrical probe. A needle was attached to the end of the sample with the grain horizontally. The measurement results were read, as indicated on the texture analyzer.

3. Result and discussion

3.1. Potential of Hydrogen (pH)

The acidity of a processed product is indicated by its pH value. A digital pH meter is used to measure the pH value [17]. Based on the results of a statistical analysis, the average pH value of horse meat marinated with papaya vinegar can be seen in Table 1.

Table 1. pH value of horse meat marinated using papaya vinegar

Treatment	Replication					Mean ± SD
	I	II	III	IV	V	
P0	6,26	5,72	5,4	5,44	5,44	$5,65^{b} \pm 0,36$
P1	5,46	5,63	5,25	5,28	5,3	$5,38^{ab} \pm 0,15$
P2	5,44	5,12	5,36	5,3	5,25	$5,29^{a} \pm 0,12$
P3	5,25	5,31	5,19	5,38	5,25	$5,27^{a} \pm 0,07$

Note: Different superscripts indicate a significantly different difference (P<0.05).

Based on the Table 1, the average pH value of horse meat marinated with papaya vinegar was 5.27–5.65. The highest pH value was found in P0 (control) at 5.65, and the lowest pH value was found in P3 (45 minutes) at 5.27. Based on the analysis of variance, it was found that marinating horse meat with papaya vinegar had a significant effect ($P < 0.05$) on the pH value of the marinated horse meat. The results showed that each treatment decreased the pH value of the horse meat, due to the acidic pH of the papaya vinegar solution, which is 3.07.

Next, a Duncan Multiple Range Test (DMRT) results at the 5% level for four horse meat treatments marinated with papaya vinegar showed significant differences (P<0.05) among the treatments. Treatment P0 was significantly different (P<0.05) from P2 and P3, but not significantly different (P>0.05) from P1. Based on these results, the longer the horse meat was marinated with papaya vinegar, the lower the pH value.

3.2. Cooking lost

Based on the statistical analysis results, the average cooking loss value of horse meat marinated in papaya vinegar can be seen in Table 2.

Table 2. Cooking loss value of horse meat marinated in papaya vinegar.

Treatment	Replication					Mean± SD
	I	II	III	IV	V	
P0	24,65	25,02	24,63	25,31	24,8	$24,88^{c} \pm 0,28$
P1	24,52	24,44	24,91	24,8	24,39	$24,61^{bc} \pm 0,23$
P2	24,3	24,41	24,5	24,25	24,61	$24,41^{ab} \pm 0,14$
P3	24,34	24,09	24,43	24,15	24,22	$24,25^{a} \pm 0,13$

Note: Different superscripts indicate highly significant differences (P<0.05).

Table 2 shows that the average cooking loss of horse meat soaked in papaya vinegar ranged from 24.25% to 24.88%. The highest average was found in treatment P0 (control), namely 24.88%, and the lowest cooking loss was found in treatment P3 (45 minutes), namely 24.25%. Analysis of variance showed that the duration of soaking horse meat in papaya vinegar significantly affected cooking loss (P<0.05). Table 2 shows that treatment P3, which soaked horse meat in papaya vinegar for 45 minutes, gave the best results, with the lowest cooking loss, namely 24.25%.

The results of the advanced Duncan's Multiple Range Test (DMRT) at the 5% level showed that P0 was significantly different (P<0.05) from treatments P2 and P3, but not significantly different from P1. Cooking loss was influenced by water holding capacity. The previous water holding capacity results showed a decrease in cooking loss for each treatment. P0 (control) showed a water holding capacity of 66.55% and a decrease in cooking loss of 24.88%. P1 (15 minutes) showed a water holding capacity of 67.80% with a cooking loss of 24.61%, and P2 (30 minutes) showed a water holding capacity of 68.42% with a cooking loss of 24.41%.

3.3 Water Holding Capacity

Water-holding capacity directly affects meat shrinkage, making it a critical factor in meat quality.Meat pH can influence its water retention capacity [18]. Based on statistical analysis, the average water-holding capacity of horse meat marinated in papaya vinegar is shown in Table 3.

Table 3 Water holding capacity of horse meat marinated in papaya vinegar

Treatment	Replication					Mean ± SD
	I	II	III	IV	V	
P0	65,07	67,26	68,94	65,43	66,05	$66,55^{ns}$ ± 1,57
P1	68,09	64,97	70,45	69,4	66,08	$67,80^{ns}$± 2,27
P2	67,44	65.71	67,77	73,16	68,01	$68,42^{ns}$± 2,79
P3	70,42	67,44	68,25	72,25	66,43	$58,96^{ns}$± 2,35

Note: ns : not significant ; the same superscript indicates no significant difference (P>0.05).

Based on Table 3, The average water holding capacity of horse meat marinated with papaya vinegar was 58.96%–68.42%. Analysis of variance showed that horse meat marinated with papaya vinegar had no significant effect (P>0.05) on the meat's water holding capacity. Table 3 shows that at P2 (30 minutes), the addition of papaya vinegar marination to horse meat was the best treatment, having the highest average water holding capacity of 68.42%.

3.4 Tenderness Test

[19] mentioned that society considers value tenderness, which is an important component in determining how much people like and accept meat or processed foods. The average tenderness of meat marinated using papaya vinegar can be seen in Table 4.

Table 4. Tenderness value of horse meat marinated in papaya vinegar (g/cm²)

Treatment	Replication					Mean ± SD
	I	II	III	IV	V	
P0	143	124	151	202	95	143^{ns} ± 39,40
P1	167	104	125	126	135	131^{ns} ± 22,92
P2	245	112,5	85,5	109	151	$140,6^{ns}$± 62,91
P3	159	84,5	134	132,5	102	$122,4^{ns}$ ± 29,27

Note: ns : not significant; the same superscript indicates no significant difference (P>0.05).

Based on Table 4, the average tenderness value for horse meat marinated with papaya vinegar ranged from 122.4 g/cm² to 143 g/cm². Analysis of variance results showed that horse meat marinated with papaya vinegar had no significant effect (P>0.05) on meat tenderness. However, Table 4 shows that the best tenderness value was found in P3, the horse meat marinated with papaya vinegar for 45 minutes, at 122.4 g/cm².

4. Conclusion

Soaking horse meat in papaya vinegar at 30 minutes had a significant effect on pH and cooking loss, but no significant effect on water holding capacity or tenderness.

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