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EFFECTS OF HIGH HYDROSTATIC PRESSURE ON QUALITY PROPERTIES OF WILD RED DEER MEAT

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ABSTRACT

Wild red deer meat might be considered a viable alternative to red meat for human consumption. Meat sourced from animals raised under natural environment has increased consumers interest in recent years. This study aimed to assess the effect of high hydrostatic pressure (HHP) applied on the quality parameters: drip loss, dry matter and water holding capacity of the wild red deer meat (*Cervus elaphus)*. Quality parameters were measured on day 1, 7, and 14. Pressures ranged from 150 to 600 MPa were applied to the muscle of red deer. The results suggest that high hydrostatic pressure was effective on drip loss, WHC, dry matter with potential positive effects during storage time on meat quality. Future studies should further explore more quality parameters like textural analysis, sensorial evaluation, and microbiological count.
Keywords: *Deer meat; Game meat; HHP; WHC; Drop loss; Dry matter*

INTRODUCTION

There has been a growing consumer preference for meat from animals living in nature. Among these, the wild red deer (*Cervus elaphus*) stands out as one of the popular deer species globally *(Hoffman & Wiklund*, 2006). From a nutritional point of view, meat serves as an important source of amino acids, proteins, and minerals (*Lorenzo et al*., 2014). Red deer meat has gained popularity as a favorable food product, attributed to its low cholesterol content and intramuscular fat (IMF), alongside its high iron content. Additionally, red deer meat exhibits a high content of unsaturated fatty acids and serves as a good source of long-chain n-3 polyunsaturated fatty acids (PUFA) *(Dannenberger et* *al*., 2013). These nutritional benefits have led to an increase in the consumption of red deer meat in, with claims that it offers a healthier alternative to other types of red meat.

In recent times, meat consumers have developed an increased awareness of the interplay between health, nutrition, and taste. Consequently, the concept of meat quality has expanded to encompass taste, technological quality, nutritional value, and safety. Wood et al. have highlighted the impact of meat's IMF content on its fatty acid (FA) profile. Furthermore, the cholesterol level, fat content, and composition of meat have garnered attention concerning consumer health, as they have been linked to obesity, hypercholesterolemia, and cancer. These health concerns have seen a significant surge in prevalence, emerging as leading causes of mortality in industrialized nations. Several countries have launched public health and regulatory campaigns to educate the populace about the perils of unhealthy diets, with health organizations advocating for reduced SFA consumption and increased PUFA intake (*Kudrnáčová et al*., 2018).

The modern consumer now demands food that is safe and nutritious, free from additives, pleasing taste, and, for certain products, has a longer shelf life. High hydrostatic pressure (HHP) processing is one of technologies that can potentially meet both consumer demands and scientific requirements. HHP, classified as a non-thermal technology, the packaged food is placed in the pressure vessel and submitted to water pressures ranging from 100 to 900 MPa. The primary objective of using HHP in the treatment of meat and meat products is to enhance microbial safety. Within the meat industry, HHP treatment is also an attractive method that can be used to inactivate various microorganisms without compromising the essential characteristics and attributes of at least some of the meat products *(Garriga et al., 2004; Garriga & Aymerich, 2009; Jofré et al., 2009; Tassou et al*., 2007).

Despite these previous studies, there is no research on the use of HHP treatment on wild red deer meat. This study aims to fill this gap by investigating the effect of different ranges of HHP treatment on the quality parameters like drip loss, water holding capacity, and dry matter of red deer meat.

MATERIALS AND METHODS

1.Pressure treatment

Fresh samples of wild red deer meat were from a local processing plant and transported to the laboratory in the polyethylene bags under chilled condition at 4 ± 1°C. The samples were cut into similar sizes. The samples were vacuum-packed in polyethylene bags. After vacuum-packing samples were treated with HHP processing. Samples were pressurized at 150, 200, 250, 300, 350, 400, 450, 500, 550, and 600 MPa for 5 min at 22°C. In total 11 samples including non-treated control sample. After the treatment all samples were stored in cold storage at a temperature of 4 ± 1°C for a period of 14 days. The evaluation of quality parameters was conducted on days 1, 7, and 14 of the storage periods.

2.Drip loss measurement

Drip losses were determined by weight difference before and after aging in vacuum-packing. The weight of each meat sample was measured before treatment. After ageing, the samples were taken from the vacuum bags, blotted dry and weighed. Drip loss was calculated as:

$$Drip\ loss = \frac{Initial\ weight - Drip\ weight}{Initial\ weight} \times 100$$

3. Water holding capacity determination

The water holding capacity of the red deer meat samples was determined using the filter paper press method (*Honikel*, 1998). Briefly, a 200 mg meat sample was measured in analytical scale and placed in filter paper between two glass plates, and a 0,5 kg weight was applied for 5 min. Then the filter papers dried. After cutting the appeared spot from meat juice from filter paper, the remaining paper was measured on the analytical scale. And the water holding capacity was calculated as a percentage of the initial weight of the meat sample. Three replicates were analyzed from each sample.

4.Determination of dry matter content

To determine the dry matter content of red deer meat, the weight of the petri dishes was measured first. Subsequently, 1-2 g of the sample was measured using an analytical scale and placed into the pre-weighed petri dishes. Three replicates were analyzed from each pressure range. The samples were then transferred to a drying cabinet, and their weights were re-measured after 8-9 hours. The dry matter content was then calculated based on the measurements obtained.

5.Statistical analysis

To evaluate the impact of HHP processing on the quality of wild red deer meat samples, a statistical analysis was performed using IBM SPSS27 (Armonk, NY 2020) as a tool for statistical evaluation. Analysis of variance (ANOVA) and Tukey's HSD post hoc test were conducted, and differences were considered significant at a $P < 0.05$.

RESULTS AND DISCUSSION

1.Drip loss

Table 1 shows the impact of HHP processing at various pressure levels on drip loss in red deer meat samples. The control and certain pressures (150, 350, 400 MPa) consistently exhibit lower drip loss values compared to other pressures across all observation days. This suggests that these specific pressure levels contribute to minimizing drip loss and, by extension, preserving meat quality. The progressive increase in drip loss with higher pressures, especially at 600 MPa, highlights the pressure-dependent nature of this phenomenon. These findings underscore the significance of selecting appropriate HHP conditions to achieve optimal outcomes in terms of meat quality and moisture retention.

Table 1.: Effects of HHP processing on drip loss values of deer meat samples during retail display at 4 ± 1 °C.

	Drip loss		
	Day 1	Day 7	Day 14
Control	1.56±0.11^{a}	3.97±0.29^{a}	6.19±0.23^{a}
150 MPa	1.92±0.09^{a}	3.64±0.35^{a}	6.73±0.34^{a}
200 MPa	2.61±0.18^{ab}	5.92±0.26^{b}	8.01±0.57^{ab}
250 MPa	5.08±0.86^{c}	5.01±0.42^{ab}	7.93±0.78^{a}
300 MPa	3.98±0.51^{b}	8.65±0.23^{bc}	5.84±0.45^{a}
350 MPa	2.31±0.19^{a}	4.82±0.52^{a}	5.23±0.23^{a}
400 MPa	2.56±0.31^{a}	3.84±0.23^{a}	5.03±0.41^{a}
450 MPa	3.18±0.15^{b}	8.97±0.46^{bc}	6.66±0.22^{a}
500 MPa	5.47±0.47^{c}	6.04±0.17^{b}	10.26±0.87^{b}
550 MPa	5.75±0.39^{c}	10.06±0.89^{c}	12.85±0.11^{b}
600 MPa	5.84±0.67^{c}	10.31±0.96^{c}	18.67±1.11^{c}

^{abc}Different letters are for significantly different groups (Tukey, $p < 0.05$).
Data are recorded as Mean ± Standard Error.

2.Water holding capacity

Figure 1 illustrates the impact of HHP treatment on the water holding capacity (WHC) of red deer meat samples. On Day 1, 450 MPa and 500 MPa demonstrate the highest WHC, emphasizing the effectiveness of these pressures in preserving moisture. Conversely, 300 MPa exhibits the lowest WHC on the same day. Day 7 reveals 350 MPa with the highest WHC, while 150 MPa exhibits the lowest. By Day 14, 350 MPa maintains the highest WHC, contrasting with the control sample displaying the lowest.

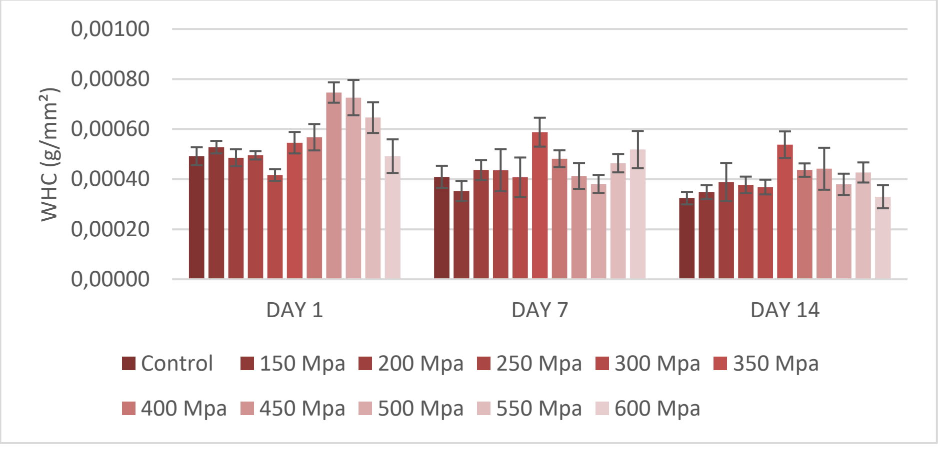

Figure 1.: of HHP processing on WHC of deer meat samples during retail display at 4 ± 1 °C.

Crucially, a temporal trend emerges as Day 1 results significantly surpass those of Day 14, indicating potential alterations in WHC during the storage period. These findings underscore the importance of selecting optimal pressure conditions, such as 450 MPa, 500 MPa, and 350 MPa, to enhance the water retention capacity of red deer meat throughout processing, storage, and cooking.

3.Dry matter

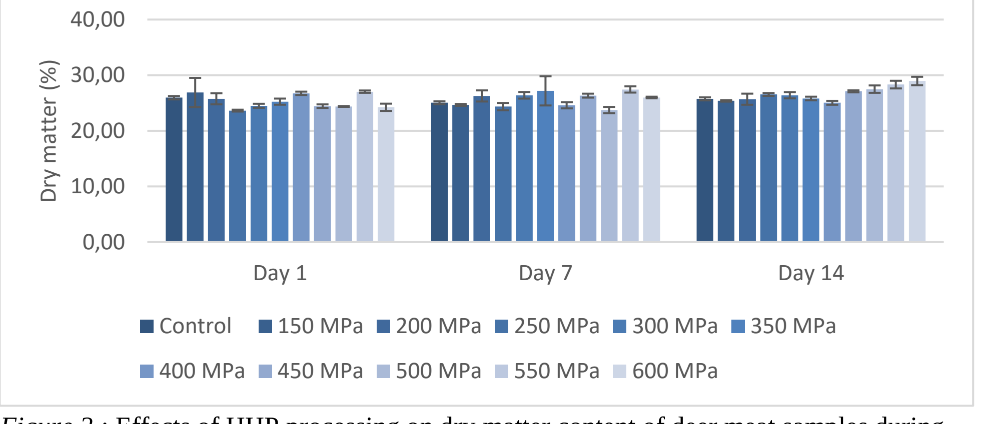

Figure 2.: Effects of HHP processing on dry matter content of deer meat samples during retail display at 4 ± 1 °C.

The dry matter analysis of red deer meat under HHP processing results were illustrated on *Figure 2.* Elevated dry matter content at 150, 400, and 550 MPa on Day 1 indicates positive effects on solid component preservation, contrasting with the lowest content at 250 MPa. Day 7 sustains the positive influence, exemplified by peak content at 550 MPa, while variability at 450 MPa indicates pressure-dependent nuances. Notably, Day 14 shows a cumulative effect with increased content at 550 MPa and 600 MPa, but the lowest at 400 MPa suggests pressure-specific deviations. These findings underscore the dynamic relationship between HHP treatment and dry matter, emphasizing the need for tailored pressure selection in optimizing red deer meat composition.

CONCLUSION

In conclusion, the comprehensive analysis of drip loss, water holding capacity, and dry matter content in red deer meat subjected to HHP treatment offers valuable insights into the multifaceted effects of pressure on meat quality. The pressure-dependent variations observed in drip loss underscore the need for nuanced pressure selection to minimize meat moisture loss. Similarly, the dynamic changes in WHC, with notable peaks at specific pressures, emphasize the pressure-sensitive nature of water retention in meat. Concurrently, the examination of dry matter content reveals distinct patterns, highlighting the potential positive influence of certain pressures on solid component preservation. Collectively, these findings underscore the complexity of the relationship between pressure levels and meat quality parameters. This nuanced understanding is crucial for optimizing HHP processing conditions and enhancing the overall quality of red deer meat. Future studies should further explore more quality parameters like textural analysis, sensorial evaluation, and microbiological count.

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