THE pH TRENDS OF BEEF MEAT DURING TWO AGING PROCESSES

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Abstract. The aim of this study was to assess the pH trend during the dry and wet aging processes, of two anatomical cuts (ribeye and sirloin), from two different beef breeds: Black Angus (BA) and Romanian Spotted (RS). Thus, acidity during the aging period was measured and the correlations between pH values and the qualitative attributes of meat were assessed and compared between two beef cattle breeds. The results showed that after 14 days of wet aging, the pH value decreased below 5.29 for all samples, with the lowest pH recorded for the Black Angus Ribeye (BAR) sample. In contrast, after 21 days of dry aging, the pH of the samples dropped below 5.33, with the lowest value (5.14) measured for the Black Angus Ribeye (BAR) sample. Thus, the BA breed exhibited a greater decrease in pH compared to RS, which could indicate an advanced proteolysis of proteins.

Keywords: pH, meat, meat aging, Romanian Spotted, Black Angus

INTRODUCTION

Beef is a source of various bioactive compounds, including conjugated linoleic acid, taurine, creatine, betaine, and carnitine (da Silva Bernardo et al., 2021). These compounds contribute to the nutritional and functional properties of beef, offering potential health benefits such as improved metabolic function, enhanced muscle performance, and antioxidant activity (da Silva Bernardo et al., 2021; Salzano et al., 2021).

Beef is among the most extensively consumed red meats globally (Farmer & Farrell, 2018; Pogorzelski et al., 2022; Polkinghorne & Thompson, 2010) thus, consumers demand high-quality beef and are willing to pay a higher price for a higher quality (Pogorzelski et al., 2022).

Aging of meat is a prevalent practice within the meat industry, because it enhances tenderness and facilitates flavor development (Dikeman et al., 2013; Sitz et al., 2006). Meat aging is a dynamic process where enzymatic reactions break down proteins and fats, moisture evaporates, and microorganisms interact with the meat, influencing its flavor, tenderness, and texture, over time (da Silva Bernardo et al., 2021; Kim et al., 2016). One of the aging methods, through storage, is dry aging, where the meat is exposed directly to the environmental conditions of the aging chamber (DeGeer et al., 2009). While wet aging implies vacuum-packaging of meat and subsequent storage in a controlled environment chamber, at refrigerated temperature, for a specific number of weeks (Dikeman et al., 2013; Smith et al., 2008). Dry aging of beef conveys a distinctive aroma and unique quality to the meat (DeGeer et al., 2009; Li et al., 2013).

The Aberdeen Angus breed originates from the counties of Aberdeen and Angus in North East Scotland and was developed through the crossbreeding of local bulls with other breeds like Galloway, Ayrshire, Guernsey, and Shorthorn. It was first introduced as a breed in Romania in 1999 (Ivancia Mihaela et al., 2019). Significant importation of the Angus breed into Romania occurred at the beginning of the 2000s, particularly near Sibiu (Ivancia Mihaela et al., 2019). Since then, the Aberdeen Angus breed was intensively bred, due to the remarkable adaptability to the Romania pedoclimatic conditions (Ivancia Mihaela et al., 2019).

The Romanian Spotted breed originated from crossbreeding between Simmental bulls and the Romanian grey breeds from Transylvania and Bucovina regions. The crossbreeding process began in the latter half of the previous century with the initial imports of Simmental cattle from Austria, Hungary, and former Czechoslovakia. Following this, particularly after the Second World War, imports were primarily sourced from Switzerland, but also from other countries (Han & Bobiş, 2018; Velea & Mureşan, 2012). After its homologation and recognition as a distinct breed, the Romanian Spotted breed has underwent improvements through selection methods, establishment of breeding lines and families, as well as infusion with Deutsches Fleckvieh, Alpenfleckvieh, Simmental, and more recently, Red Holstein genetics. The Romanian Spotted breed currently accounts for approximately 36% of the total cattle population in Romania, distributed across regions such as Banat, Crișana, and several counties in Transylvania (Han & Bobiş, 2018). This breed exhibits a combination of dual-purpose characteristics for both milk and meat production, although it is worth noting the existence of sub-populations specialized in meat or dairy production (Onaciu, 2013).

One of the primary characteristics of meat quality and freshness is its acidity (Silva et al., 1999). The pH of meat is directly related to its color attributes, tenderness, shelf life, taste, and aroma. Under normal conditions of humidity and temperature, the pH of meat decreases within the first few hours post-slaughter, dropping from initial values of 6.7-7 to about 5 (Gh & MOREA, 2013). Animals that experience stress before slaughter exhibit pH values around 6 (Gh & MOREA, 2013), resulting in meats with an unpleasant aroma and reduced shelf life (Obanor, 2002).

Few researchers have documented the direct correlation between tenderness and pH in beef, by a linear relationship (Silva et al., 1999; Wu et al., 2014). Contrarily, other studies have observed that both low pH ultimate and high pH ultimate beef exhibit greater tenderness compared to beef samples with intermediate pH ultimate levels (Jeleníková et al., 2008; Pulford et al., 2008; Wu et al., 2014).

Thus, the aim of the current study was to present the pH trend occurring during the dry and wet aging of two anatomical cuts (ribeye and sirloin) obtained from two different beef breeds: Black Angus (BA) and Romanian Spotted (RS). Given the known correlation between pH values and the qualitative attributes of meat, there was a strong incentive to measure acidity during the aging period and observe the similarity of trends among the two selected breeds.

MATERIALS AND METHODS

Raw material preparation

Four calves from two different cattle breeds: Black Angus (BA) and Romanian Spotted (RS), were selected for this study. These calves were raised on a farm, near Cluj and were fed identical diets to further develop meat characteristics suitable for aging.

At the age of 22-24 months, with a live weight of approximately 600 kg, the cattle were slaughtered and butchered to obtain anatomical parts suitable for the meat aging process. Slaughtering and butchering were conducted in sanitary-veterinary authorized facilities, meeting all hygiene and food safety standards.

The meat cuts obtained from both breeds included in the study were sectioned into anatomical parts (ribeye and sirloin) and sampled for two types of aging: dry aging - without packaging, respectively, wet aging - in special vacuum bags. Afterwards, the samples were transferred to a refrigerated aging showcase for further processing under controlled cooling conditions.

Aging methods and time

For the dry-aging treatment, samples were processed without any packaging, and directly exposed to the aging environment, maintained at 2–4±0.5℃ and under 85% relative humidity for 21 days (Álvarez et al., 2021). The beef cuts assigned to wet-aging were individually vacuum-packaged in sealed bags. Wet aging was conducted under controlled conditions in the same dry aging showcase, with samples placed on stainless steel gratings for 14 days (Ahnström et al., 2006; Álvarez et al., 2021).

pH measurement

The pH of each loin section was assessed by employing a calibrated probe (Testo, 206-PH2), which was directly inserted into the meat in three distinct points, both before and after the aging process. During the pH measurement procedure, sample temperatures were 2 ± 0.5°C. Each determination was conducted in triplicate. The data were collected and analyzed on Microsoft Office Excel, 2010.

RESULTS AND DISCUSSIONS

After 14 days of wet aging, the pH value decreased below 5.29 for all samples, with the lowest pH recorded in the Black Angus Ribeye (BAR) sample (fig. 1). Comparing each breed, in both anatomical parts, it was observed that in the case of RS, the ribeye showed a more accelerated decrease in pH until the middle of the aging period and maintained its pH until the end of aging period. The sirloin samples record a decrease gradual pH value throughout the wet aging period. In contrast, BA recorded an accelerated decrease in pH in the sirloin cut and a gradual decrease in the case of ribeye.

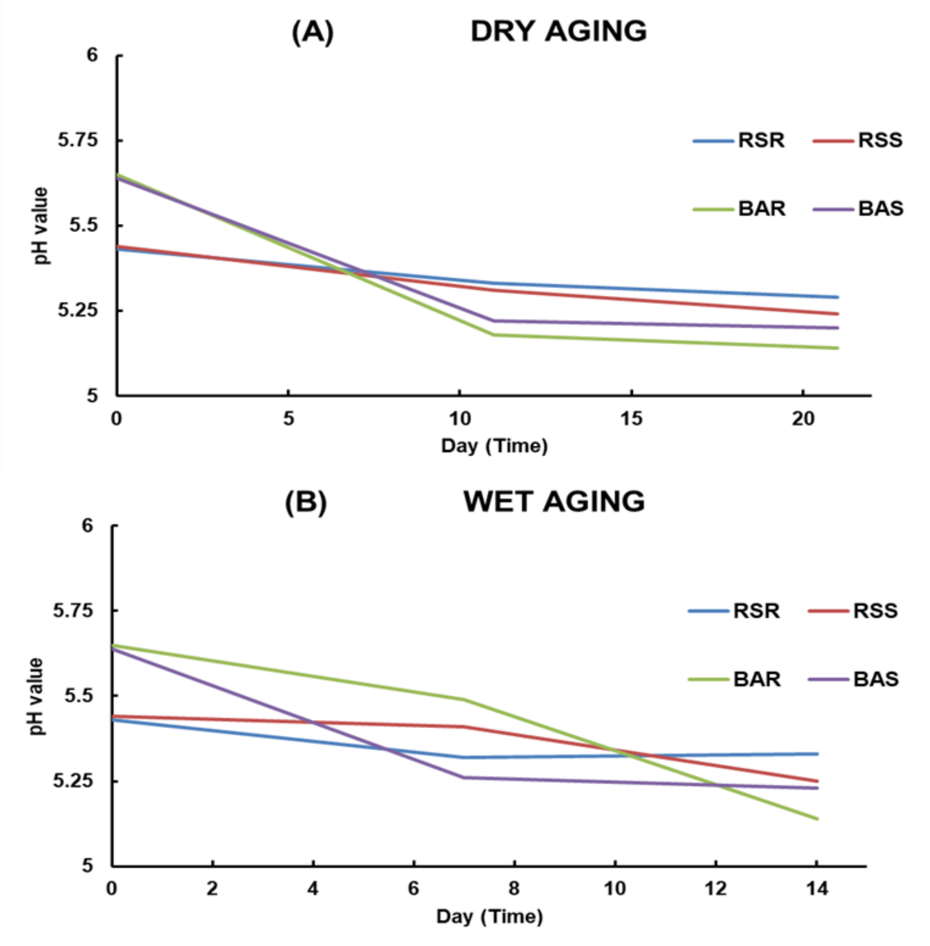

Fig 1. pH fluctuations in defined anatomical areas of Black Angus and Romanian Spotted Beef following dry-aging (21 days) (a) and wet-aging (14 days) (b): RSR- Romanian Spotted Ribeye steak, RSS- Romanian Spotted sirloin steak, BAR- Black Angus Ribeye steak, BAS- Black Angus sirloin steak

In contrast, after 21 days of dry aging, the pH of the samples dropped below 5.33, with the lowest value achieved again by the Black Angus Ribeye (BAR) sample at 5.14. From an overview, in Figure 1 there are highlighted both anatomical parts of the RS breed which maintained a linear decrease in pH throughout the entire period of dry aging, while the anatomical parts of the BA showed a slightly more accelerated decrease in the pH value up to half of the period. As the process of converting muscle into meat progressed, the muscle pH dropped due to the accumulation of hydrogen ions. This decrease in pH led to a reduction in the net charge of muscle proteins as they approach the isoelectric point. Thus, the number of positive and negative charges became balanced, diminishing repulsion forces between proteins. Consequently, proteins can pack more tightly together, reducing the available space within the myofibril and the capacity to retain water (Ribeiro et al., 2021).

Lactic acid bacteria are recognized for their capacity to generate lactic and acetic acids within meat, potentially resulting in a decline in pH levels (Meloni et al., 2023). In a study conducted by Leisner et al. (1995), meat subjected to experimental inoculation with *Lactobacillus sake* exhibited a reduction in pH to 5.31 following 10 weeks of storage under vacuum conditions(Leisner et al., 1995). The highest pH value recorded in fresh meat (day 0) was observed in ribeye for both cattle species, specifically 5.65. Consequently, a lower glycolysis capacity could lead to the elevated pH of ribeye, potentially impacting proteolysis (Feng et al., 2020).

Gramatina et al. (2019), revealed notable variations in pH levels during the aging period of beef and lamb meats. Specifically, the lowest pH was observed in beef, with initial pH levels recorded at 5.39, which gradually decreased to 5.23 throughout aging. Conversely, current literature reported that lamb exhibited the highest initial pH value of 5.77, which decreased during the aging process, eventually reaching 5.72 (Gramatina et al., 2019). These findings also align with the reports of Hwang et al. (2022), who observed similar trends in pH changes during the aging process of beef products. Specifically, they reported initial pH values of 5.52 for raw beef, 5.60 for wet-aged beef, and 5.59 for dry-aged beef. Throughout the cold storage, the pH of these beef products gradually decreased, reaching 5.04 for raw beef, 5.23 for wet aging beef, and 5.33 for dry aging beef (Hwang et al., 2022).

CONCLUSIONS

This study highlighted the fluctuations of pH during the aging process, for two of the most commonly used aging methods. The results showed a similar trend of the pH during the aging period regardless of beef cut, breed and aging method. Even though these results are promising, additional research in this area is still needed, as it can improve the understanding of the meat aging mechanism which could in turns benefit meat aging practices as a whole in the future.

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