COMPARATIVE STUDY ON PHYSICO-CHEMICAL CHANGES DURING DRY AGING OF BLACK ANGUS AND ROMANIAN SPOTTED BEEF

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Abstract. The Black Angus (BA) beef is considered worldwide as the ideal choice for a wholesome, tasty and at the same time healthy steak. The Romanian spotted (RS) is known as a mixed breed, it is exploited in Romania almost exclusively for milk and rarely for meat. **The aim of this study** was to compare the physical-chemical changes in BA *versus* RS after a 21-day dry aging period. The parameters studied were content of fat (%), content of protein (%), content of collagen (%), content of water (%) and collagen-protein ratio. For all the studied compounds, the aged samples present significant changes compared to the initial day. The Pearson correlation highlighted a positive correlation between protein and humidity content and a negative correlation between fat and protein ($p<0.05$).

Keywords: beef, dry aging, chemical composition, Romanian Spotted, Black Angus

INTRODUCTION

Beef has specific nutritional qualities relative to other meats (Bourre, 2011), being well-known as a complex nutritious food, a highly source of protein, minerals and essentials amino acids (Akter et al., 2009). All of these components are essential due to their roles in vital metabolic pathways and the antioxidative enzymatic system. Regarding the lipid content in meat, fat offers vital dietary energy and essential nutrients, including a variety of fatty acids and fat-soluble vitamins. The lipid content significantly influences the cooking characteristics, palatability, and overall organoleptic properties of the meat (Wood et al., 2008). Beef provides additional nutritional benefits, particularly a high content of B vitamins, including B12, B2, niacin, and B6. These nutrients found in red meat are significant for muscle development, immune function, and overall health (Bourre, 2011; Scollan et al., 2014). The lipid profile of beef is largely dependent on the cut of the meat. It is also influenced by the fatty acid profile of the feed, as well as the breed and age of the animal (Bourre, 2011).

Dry aging is recognized for its ability to improve the sensory characteristics of meat, particularly by developing a distinctive dry aged flavor. Few studies reported that this process results in specific descriptive attributes such as brown-roasted, beefybrothy, buttery, nutty, roasted nut and sweet (Campbell et al., 2001; Terjung et al., 2021; WARREN & KASTNER, 1992).

Dry-aged beef is produced through a controlled aging process in which unpackaged beef is stored under specific conditions of temperature (2 ± 1 °C), relative humidity (75 ± 5%), and air speed circulation (0.5–2 m/s) (Bulgaru et al., 2022; Kahraman & Gürbüz, 2018; Stenstrom et al., 2014). The controlled environment ensures the optimal enzymatic and microbial activity necessary for the breakdown of muscle fibers, resulting in a more tender texture and intensified flavor (da Silva Bernardo et al., 2020; Savell, 2008; Smith et al., 2008).

However, dry aging is a costly process due to several factors (da Silva Bernardo et al., 2020; Degeer et al., 2009). Firstly, it requires a strictly controlled conditions including precise regulation of temperature, relative humidity, and air circulation within aging chambers (Smith et al., 2014). Additionally, these chambers must be spacious enough to accommodate the proper air flow around each piece of beef, often requiring larger facilities compared to those used for wet aging. Furthermore, dry aging results in higher weight loss (9.92-11.37%) due to evaporation and trimming of desiccated surfaces, which adds to the overall expense (Dikeman et al., 2013; Obuz et al., 2014). Consequently, these requirements make dry aging a more resource-intensive and expensive method than wet aging (da Silva Bernardo et al., 2020).

Additionally, dry-aged beef is typically produced using high-quality beef sourced from British cattle breeds known for their superior marbling and thick subcutaneous fat. The high marbling, which refers to the intramuscular fat, contributes to the tenderness and rich flavor of the beef, while the thick subcutaneous fat layer protects the meat during the aging process, preventing excessive drying and enhancing the overall quality of the final product (da Silva Bernardo et al., 2020).

The Black Angus (BA) cattle breed is widely distributed within the temperate regions of meat-producing countries and is the primary breed used for beef production in Argentina. This breed is favored for its adaptability to temperate climates and their superior meat quality, characterized by excellent marbling and tenderness (Mazzucco et al., 2016). In recent years, the Aberdeen Angus breed has seen significant growth in Romania, attributed to its specific traits related to both production and breeding conditions. Concurrently, associations of breeders have been established for this breed. These associations are responsible for the official control of meat production and the maintenance of the genealogical register for the registered livestock herds, ensuring the integrity and quality of the breed (Terezia et al., 2022).

The Romanian Spotted (RS) breed, is another notable cattle breed in Romania. This breed is highly valued for its dual-purpose capabilities, providing both high-quality milk and meat (Han & Bobiş, 2018). The Romanian Spotted breed is well adapted to local environmental conditions, making it a popular choice among Romanian farmers for its productivity and resilience (Han & Bobiş, 2018). Regarding the suitability of the RS breed for various breeding and exploitation systems, numerous researchers have highlighted its potential abilities for meat production. To further evaluate and enhance its combined capacity, a series of crossbreeding experiments have been initiated (Cârcu et al., 2010; FEŞTILĂ et al., 2011; Han & Bobiş, 2018).

Therefore, this study is a preliminary study to assess comparatively the physico-chemical changes occurred during dry aging, for 21 days, of BA *vs* RS meats.

MATERIALS AND METHODS

Sampling. Twelve sirloins beef cuts (n=6 from each breed) used in this research were bought from a local butchery in Cluj, Romania. Three cuts from each breed (BA and RS) were sampled on day 0 and preserved at -18°C until further analysis. The other 3 cuts of RS and BA sirloin were dry aged in a chamber at 1-2°C and < 90% relative humidity for 21 days. The beef cuts were exposed directly to the controlled environment and supervised for all the aging periods (fig. 1).

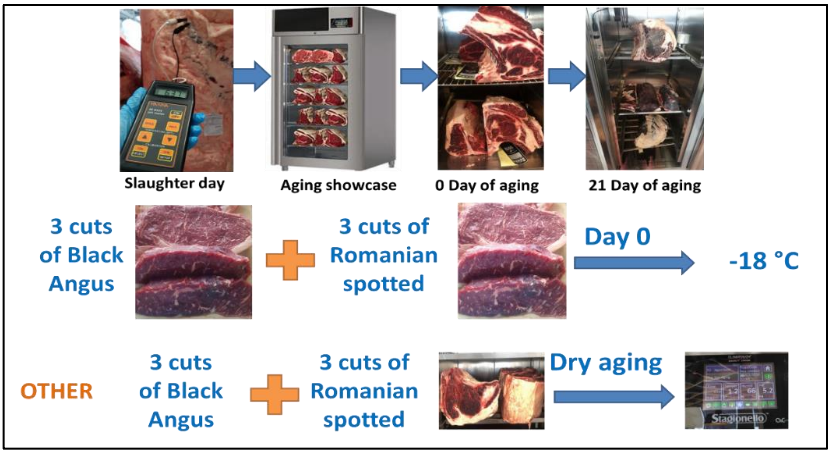


Fig. 1. Samples processing methodology

Methods. At the end of the aging period, each sample was minced and analyzed by Food Scan Lab (fig. 2). The measured parameters were content of fat (%), protein (%), collagen (%), water (%) and the collagen-protein ratio was calculated in each case. Different observations (n=6-12) were made for each parameter. The results were expressed as the means of 3 measurements ± standard deviation.

The data were collected in Microsoft Office Excel matrices and statistically analyzed by ANOVA analysis of variance using the XLSTAT software (version 2023.1.2). The analysis of variance and Fisher LSD were employed to assess the significance of differences between variables (physico-chemical parameters) and different samples were determined, while Principal Component Analysis (PCA) was performed on the data formatted in observations/variables table to show correlation among the samples.

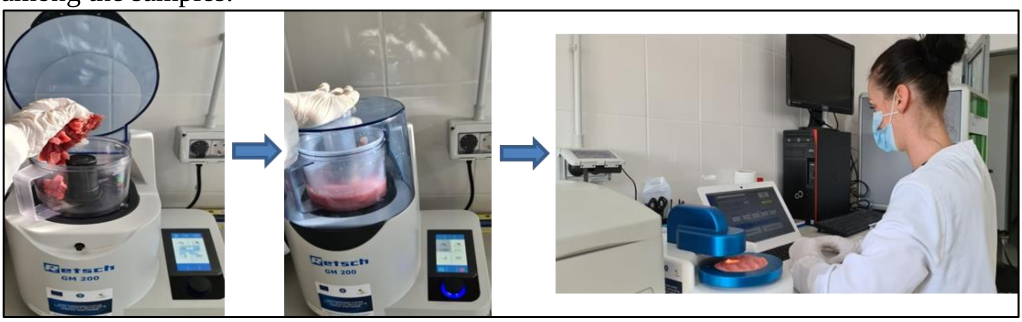


Fig. 2. Samples analysis by Food Scan Lab methodology

RESULTS AND DISCUSSIONS

As evidenced, dry aging directly influences the physico-chemicals profile of beef meat. Table 1 includes the mean values and standard deviations (mean ± SD) for each group of samples (BA and RS) and parameters (protein, fat, humidity, collagen and collagen-protein ratio). During the dry aging period, the content of protein, fat, humidity and collagen-protein ratio presented significantly changes ($p<0.05$), which means that the changes that occur on the 21st day of aging were significantly different from the 0 day of aging.

In the case of RS, the percentage in protein content increased from initial day of 14.60 ± 0.51 up to 17.56 ± 0.50 in 21st day of aging. Similarly, the humidity content increased from 52.47 ±1.17 in initial day up to 56.05 ± 1.64, in 21st day of aging. In a similar study, Bulgaru et al. (2022) subjected the Simmental beef to dry aging for 21 days to investigate its impact on the physicochemical profile. They reported a similar decrease value for the indicators, respectively: protein percents of 24.64 ± 0.07 up to 23.59 ± 0.45 and humidity content of 59.55 ± 0.45 up to 55.80 ± 0.37 (Bulgaru et al., 2022). In opposite, in our study the fat content and collagen significantly decreased from 30.35 ± 1.98, respectively 3.56 ± 0.29 to 22.44 ± 0.91, respectively 3.33 ± 0.28. Contrasting to our results, in the study conducted by Bulgaru et al. (2022), the value of fat and collagen percentage increased during the aging period from 6.40 ± 0.20, respectively 0.41 ± 0.010 up to9.02 ± 0.18, respectively 0.48 ± 0.005 (Bulgaru et al., 2022).

The BA sirloin shown the same trend as RS sirloin, recorded an increased percentage in case of protein content from 16.10 ± 0.51 up to 17.45 ± 0.50 in 21st day of aging. Accordingly, the humidity content increased from 54.82 ± 1.26 up to 56.68 ± 0.33 and decreased the fat content from 31.08 ± 1.05 up to 27.23 ± 0.89. In a similar study, Kim et al. (2019) subjected the Hanwoo beef to dry aging for 28 days to investigate its impact on the physicochemical profile. They reported insignificant changes for protein content, an significant increased content of fat (9.90 ± 0.484, respectively 12.82 ± 0.982) and also, a decrease trend value for the indicators: humidity content of 67.13 ± 0.393 up to 63.81 ± 0.917, collagen content of 1.79 ± 0.051 up to 1.65 ± 0.116 (Kim et al., 2019).

Comparing the physico-chemical variation between breeds (BA and RS), it observed that in the initial day, the BA sirloin shown a superior protein (16.10±0.50), humidity (54.82±1.26) and collagen (3.69±0.15) content than the RS sirloin, where recorded were protein (14.60±0.51), humidity (52.47±1.17), collagen (3.56±0.29). Simultaneously, on day 21 of dry aging, these parameters did not record significant differences between breeds. Despite the differences shown in the cases of protein, humidity and collagen content, the fat content indicated a similarity content in day 0. In the opposite direction, this parameter differed significantly at the end of aging, respectively the RS sirloin (22.44±0.91) recorded a lower fat content compared to BA fat sirloin (31.08±1.05). As an overview point, no significant differences were noticed between the individual values of the three cuts, either in BA or in RS group. Slight increases were observed for protein and humidity percentages while decreases of fat content, also non-significant. Collagen and its ratio to protein did not show variances.

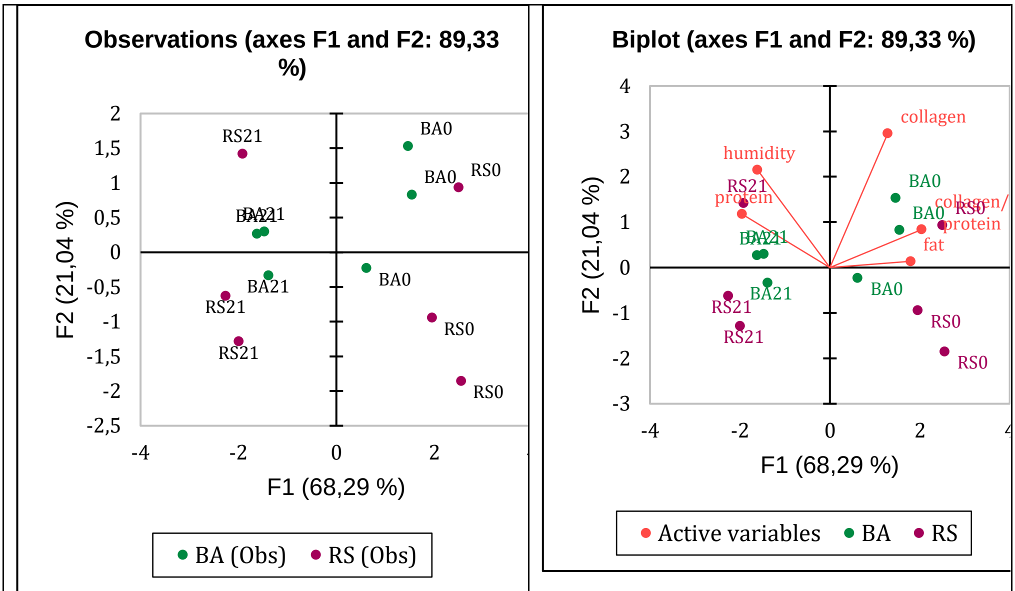
Table 1.

Physico-chemical changes of the three cuts during aging period (21 days), expressed in percentages (%)

Breed	Day	protein	fat	humidity	collagen	collagen/protein
BA	0	16.10±0.50^{b}	31.08±1.05^{a}	54.82±1.26^{b}	3.69±0.15^{a}	0.23±0.01^{b}
BA	21	17.45±0.50^{a}	27.23±0.89^{b}	56.68±0.33^{a}	3.34±0.06^{b}	0.19±0.00^{c}
RS	0	14.60±0.51^{c}	30.35±1.98^{a}	52.47±1.17^{c}	3.56±0.29^{b}	0.24±0.01^{a}
RS	21	17.56±0.50^{a}	22.44±0.91^{c}	56.05±1.64^{ab}	3.33±0.28^{ab}	0.19±0.01^{c}

Note: Values with different letters (a, b, c) in the same column indicate significant differences among the samples (Fisher (LSD), $p < 0.05$); where BA – "Black Angus"; RS– "Romanian Spotted".

The Principal Component Analysis (PCA) plots represent graphically the discrimination between the variables (physical-chemical parameters) and also between the two groups at different times (0 and 21 days). The plot had different co-variances, depending on the 5 components (F1 *versus* F2-F5), in order of their contribution to the discrimination. The highest discrimination was found between the components F1 vs F2, as shown in Figure 3.



a. b.

Fig. 3. PCA biplots representing the discrimination between groups and parameters in both axes which represent components F1 vs F2, having the highest covariance of 89.33%, where BA0 – "Black Angus Day 0"; BA21 - "Black Angus Day 21"; RS0 – "Romanian Spotted Day 0"; RS21 - "Romanian Spotted Day 21".

Figure 3a a includes the plot which shows the discrimination between groups BA and RS, (considering all observations for each parameter and group). The covariance of 89.33% indicate a very good discrimination in all four quadrans: between the groups BA (green points) and RS (red points) at time 0 (at right) and also at day 21 (at left) and also inside each group, from time 0 to 21 e.g. BA0 vs BA21 and RS0 vs RS21, respectively. A more complex image is shown in Figure 3b, when also the parameters were superposed in a biplot. In this case also the highest discriminations were observed between components F1 and F2, showing the contribution of each parameter to the discrimination. In the upper positive region (F1 and F2) one can consider the correlations between collagen, fat, collagen/protein ratio against protein and humidity. For example, collagen and fat are reversely correlated with protein and humidity while collagen and fat in-between are positively correlated. These differences are meanwhile correlated with the times of evaluation, and the breed which are superposed in this figure. After aging (time 0 vs 21) especially one can see the reverse correlation between these parameters. No significant differences for these parameters were found between the two breeds BA and RS.

CONCLUSIONS

During the dry aging period, significant changes ($p<0.05$) were observed in the content of protein, fat, humidity, and the collagen-protein ratio. These results indicate that the changes occurring on the 21st day of aging were significantly different from those at the beginning of the aging process.

In the case of RS, the protein content increased from the initial day to the 21st day of aging. Similarly, the humidity content also rose during this period. Conversely, both the fat content and collagen levels decreased from the initial day to the 21st day of aging.

The BA sirloin exhibited the same trend as the RS sirloin, with an increase in protein content from the initial day to the 21st day of aging. Similarly, the humidity content also rose during this period. Conversely, the fat content decreased over the same timeframe.

As an overview for both breeds, changes in physico-chemical parameters during aging period have a similar trend: decreasing for fat content and collagen-protein ratio and increasing for protein and water content. Moreover, collagen and fat show an inverse correlation with protein and humidity, while being positively correlated with each other. These correlations are influenced by the evaluation times and the breed. Notably, after aging (from time 0 to 21), the inverse correlation between these parameters becomes more pronounced, which means that changes in the elements analyzed are not influenced by the breed of meat origin.

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