EFFECT OF AGING TIME, METHOD AND TEMPERATURE ON BEEF QUALITY INDICATORS

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Abstract

The meat business must produce consistently high-quality meat in order to satisfy consumers and improve consumption frequency. Due mostly to its somewhat larger connective tissue composition, beef's sensory palatability features (e.g., increased muscle tissue hardness) have certain unfavorable traits (e.g., greater hardness). To reach the maximum degree of quality and consumer satisfaction, the meat business, and specifically the beef sector, has developed many procedures, including aging processes. The primary goal of this research was to examine the effects of varying the age procedure (wet vs dry), the duration of aging (1, 10, or 15 days), the aging temperature (2, 4°C), on cuts of beef. Beef carcasses or primal cuts are hung and matured for a certain period of time in a room controlled between 0 and 4 degrees Celsius and 75 and 80% relative humidity for dry aging. For wet aging, beef is vacuum-sealed in special bags designed to preserve its internal humidity. The pH of beef samples increased significantly ($p < 0.001$) during the period of storage, with wet aging causing more significant results than dry aging. Dry aging and a higher temperature (4 °C) both contributed to a significant increase in refrigeration losses over time ($p < 0.01$). Regarding the color parameters, L*, a*, and b* values decreased over time in dry-aged beef ($p < 0.001$), whereas in wet-aged beef, the lightness increased in the first 10 days and a* values diminished. The three variation factors had a substantial effect ($p < 0.001$) on the approximate composition (method, time, and temperature). In the case of dry aging, the water content decreased at a more pronounced rate over time, whereas the fat content increased with the loss of water content.

Key words: wet-aging, dry-aging, beef, storage conditions, color, pH.

The demand for high-quality meat, especially red meat, is increasing, due to the growing importance of quality nutrition, which is the most important factor in consumers' meat choices. Meat quality can be defined as a set of properties that together identify what is valued in meat when it is purchased by consumers, when it is consumed, or when it is selected for use as a raw material for meat products. (Purslow P.P., 2017). Flavor, juiciness, and tenderness are the three main attributes that influence the sensory palatability of meat (Bhat Z.F. *et al*, 2018). In addition to the palatability attributes that influence the purchase decision, the first sensory attribute that stands out and determines the consumer's first reaction, or the consumer's interest, is the color of the meat. Color significantly influences meat purchasing decisions, as consumers use discoloration as an indicator of spoilage and precarious safety (Mancini R., 2013).

Aging technologies have been used to improve meat quality for a very long time (Kim H. *et al*, 2017). It is well established that storing carcasses for several days or weeks after slaughter improves the meat's texture and flavor. Also referred as "aging" or "conditioning," the procedure includes storing carcasses, half-carcasses, or meat cuts under regulated refrigerated settings for a specific amount of time to prevent the formation of contaminating microorganisms (Bhat Z.F. *et al*, 2018). Meat aging begins immediately after the completion of muscle rigidity, approximately 24-48 hours after slaughter (the time interval differs depending on the species), and is characterized by parameters of speed and intensity (Banu C. *et al*, 2003; Boișteanu P.C. *et al*, 2015).

In addition to improving tenderness, chewiness, and juiciness, maturing beef gives it a specific salty, roasted, or buttery flavor compared to unmatured beef. Aging can also lead to some undesirable changes. Drip loss increases with longer aging periods and higher temperatures, but cooking losses tend to decrease with increasing aging time (Bekhit A. *et al*, 2014)

Aging, an approach used to improve the tenderness, flavor, and juiciness (water-holding capacity) of raw beef, has recently been applied to low-marbling products (Lee H.J. *et al*, 2017). The

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meat aging process is divided into two types: wet and dry aging (Kim et al, 2019). Wet aging (anaerobic aging) involves vacuum-packing beef to retain moisture, followed by refrigeration temperature storage (below 5 °C) during the aging period, whereas traditional dry aging (TD) involves exposing beef to a controlled temperature, relative humidity (RH), and airflow (Smith R. *et al*, 2008; Lee H.J. *et al*, 2017; Zhang R. *et al*, 2022). In general, wet aging results in a more sour and stronger blood/serum flavor to the meat compared to dry aging (Kim H. *et al*, 2019).

Considering the customer desire for aged meat and the significance of the first visual appearance dictated by the color of a cut of meat, the goal is to accomplish the desirable benefits of aging (tenderness, juiciness, and flavor) with minimum changes in color and low weight loss. The purpose of the study was to determine the influence of aging technique (wet and dry), aging period (1, 10, and 15 days), and aging temperature on the qualitative attributes of beef rib samples by monitoring changes in color, pH, chilling losses, and proximate composition.

MATERIAL AND METHOD

The samples taken in the study were pieces of beef tripe purchased at the food market. The samples were divided into uniform batches and then prepared for aging. For the wet samples, the pieces were vacuum-packed in special vacuum bags, and for the dry samples, they were tied with string, spread out evenly on the racks, and put in a controlled open-air environment. Samples were coded for easy identification, as shown in table 1.

Table 1

Structure and coding of sample batches

Aging time (days)	Aging method	Aging temperature (°C)	Sample code
1	Dry	2	L1US2
		4	L1US4
	Wet	2	L1UM2
		4	L1UM4
10	Dry	2	L2US2
		4	L2US4
	Wet	2	L2UM2
		4	L2UM4
15	Dry	2	L3US2
		4	L3US4
	Wet	2	L3UM2
		4	L3UM4

Post-aging losses were calculated as refrigeration losses, which represent the amount of moisture lost by exudation or drip during the refrigeration period due to changes in muscle fibre volume. Losses were calculated by the percentage ratio of the initial weight to the weight of the sample after aging.

The pH value was determined using a HANNA HI 99163 Meat pH meter by direct insertion into the meat sample. The instrument was previously calibrated in buffer solutions of known pH (acidic solution: pH = 4.01; neutral solution: pH = 7.01). After calibration and between readings, the electrode of the instrument was cleaned with distilled water in order not to influence the results obtained.

The color determination of the beef samples was carried out on the surface with a Konica Minolta Chroma Meter CR-410 spectrophotometer, using an illuminant D50, a standard 2° observers, and the CIE L*, a*, and b* color scales. The instrument was calibrated on the surface of a white calibration plate.

The determination of the proximate chemical composition was carried out using the Food Check, an automatic analyzer that determines the water composition, protein, collagen, and lipids using an infrared spectrophotometer. The Food Check analyzer works with a spectral range of 730–1100 nm. Determination involves processing the sample by grinding it, placing it on a glass plate and placing it in a holder in the drawer of the instrument. The results will be displayed on the screen at the end of the analysis cycle, with a measurement time of approximately 50-60 seconds.

The results of the determinations were analyzed using the two-way ANOVA test, a function of the XLSTAT program in Microsoft Excel. Significant differences between samples were considered at p-values < 0.05, and a comparison of means was performed using the Tukey test.

RESULTS AND DISCUSSIONS

The pH range of the samples was 5.38 to 5.79 (*table 2*). Temperature and the aging period had independent effects on the pH ($p < 0.0001$). 10 and 15-day-old samples kept at 4 °C had a lower pH than those stored at 2 °C. Also, the pH value of

samples aged by traditional dry aging was substantially different from those aged in vacuum ($p < 0.05$); the pH of samples aged by traditional dry aging for 15 days was greater than that of those aged by wet aging.

The weight losses of fresh beef (*table 2*) were influenced by the aging technique and duration ($p < 0.001$). After 10 and 15 days, the aging loss of traditionally aged meat was greater than that of vacuum-aged beef. In addition, although temperature had no significant effect on aging losses, samples aged at 4°C exhibited greater losses than those aged at 2°C.

Table 2

pH and ageing loss in beef longissimus thoracis (LT) after ageing by traditional dry ageing or wet (vacuum) ageing for 1, 10 or 15 days, at 2°C and 4°C

Trait	Aging time	Aging method				p-value		
		Wet		Dry		Time	Temperature	Method
		2	4	2	4			
pH	1	5.43±0.053	5.41±0.073	5.43±0.077	5.38±0.052	**<0.0001*****	**<0.0001*****	**0.018***
	10	5.75±0.212	5.45±0.040	5.59±0.081	5.51±0.077			
	15	5.79±0.076	5.45±0.080	5.6±0.067	5.42±0.023			
Ageing loss (%)	1	0.002	0.085	0.012	0.018	**0.005****	0.539 ns	**0.003****
	10	0.25	1.3	7.4	6.04			
	15	0.46	1.96	14.85	15.06			

Significance codes: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ns $p > 0.05$.

Time and method of aging exhibited a statistically significant ($p < 0.001$) influence on each of the color parameters (L*, a*, and b*, *table 3*). The L*, a*, and b* values of dry-aged samples decreased as aging time increased. In contrast, the wet-aged samples exhibited a reduction in color characteristics during the first ten days, followed by an increase until the fifteenth day. L* and b* color values were not significantly affected by aging temperature ($p > 0.05$); however, a* values were significantly affected by temperature ($p < 0.001$).

Table 3

Color of beef longissimus thoracis after ageing by traditional dry ageing or wet (vacuum) ageing for 1, 10 or 15 days, at 2°C and 4°C

Trait	Aging time	Aging method				p-value		
		Wet		Dry		Time	Temperature	Method
		2	4	2	4			
L*	1	36.06±1.28	39.08±3.42	36.06±1.08	35.99±1.11	**0.001****	0.237 ns	**<0.0001** ***
	10	41.24±7.36	40.06±5.39	32.29±2.01	33.75±1.04			
	15	34.57±2.71	38.99±2.96	30.28±2.89	28.99±2.52			
a*	1	20.45±1.31	20.29±2.46	19.62±3.13	19.9±0.64	**<0.0001** ***	**<0.0001*****	**<0.0001** ***
	10	16.95±2.75	18.73±1.32	8.26±0.86	18.64±2.63			
	15	18.48±1.56	19.48±1.71	7.83±0.95	11.62±1.69			
b*	1	10.43±1.21	11.55±1.54	10.3±2.11	9.88±0.46	**0.001****	0.419 ns	**<0.0001** ***
	10	11.46±2.94	11.13±2.17	7.59±1.42	8.15±4.27			
	15	8.48±1.74	11.11±0.92	6.6±2.21	5.69±0.73			

L * = Lightness, a * = redness, b * = yellowness; Significance codes: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ns $p > 0.05$.

As demonstrated in table 4, the chemical composition of beef samples changed according to aging method, duration, and temperature. Independent effects of time, temperature, and method of aging were seen on the proximate composition ($p > 0.0001$). Dry aging significantly decreased the moisture content of all beef samples compared to wet-aged cuts, which is consistent with the findings of Kim M. *et al* (2019), who reported no differences in the water content of wet and non-aged beef cuts. Dry-aged samples had the greatest fat content, whereas wet-aged samples had the lowest. After wet and dry aging, a negative association was found between beef's fat and moisture content. The wet-aged beef had a lower protein content than the dry-aged beef, and there were significant differences between all groups ($p > 0.001$). The collagen content was inversely proportional to the protein amount, with wet-aged beef containing less collagen.

Table 4

Proximate composition of beef longissimus thoracis after ageing by traditional dry ageing or wet (vacuum) ageing for 1, 10 or 15 days, at 2°C and 4°C

Trait	Aging time	Ageing method				p-value		
		Wet		Dry		Time	Temperature	Method
		2	4	2	4			
Water (%)	1	74.9±0.17	74.7±0.26	73.9±0.53	72.7±0.57	**<0.0001****	**0.0001*****	**<0.0001*****
	10	72.6±0.72	74.0±0.46	70.7±0.42	73.5±0.61			
	15	72.6±0.12	74.3±0.25	69.0±0.32	70.8±0.87			
Fat (%)	1	3.17±0.21	3.43±0.32	4.37±0.64	5.80±0.62	**<0.0001****	**<0.0001**	**<0.0001*****
	10	6.60±0.10	4.30±0.52	9.37±0.40	4.87±0.72			
	15	5.97±0.12	3.90±0.36	8.30±0.46	8.20±1.14			
Protein (%)	1	21.60±0.00	21.50±0.10	21.30±0.10	20.97±0.15	**<0.0001****	**0.0001*****	**<0.0001*****
	10	20.93±0.32	21.37±0.12	19.93±0.06	21.23±0.21			
	15	20.93±0.06	21.43±0.06	20.33±0.12	20.43±0.32			
Collagen (%)	1	19.90±0.10	19.80±0.20	19.50±0.26	19.23±0.12	**0.0001*****	**0.002****	**<0.0001*****
	10	19.27±0.46	19.67±0.12	18.17±0.15	19.57±0.25			
	15	19.33±0.15	19.77±0.06	18.67±0.06	18.67±0.29			

Significance codes: *** p < 0.001; ** p < 0.01; * p < 0.05; ns p > 0.05.

CONCLUSIONS

All three variation variables utilized in our investigation (method, time, and temperature) had an effect on the aged beef quality parameters. The aging method (wet or dry) had a significant effect on chilling losses, as the dehydration of the samples was much more pronounced in the case of dry aging. The temperature had a significant effect only in the case of wet aging, where an increase in temperature from 2 to 4 °C nearly quadrupled chilling losses. In terms of the lightness of the samples, the beef samples that matured for 1 and 10 days had greater values. In addition, wet aging led to greater lightness, which may be explained by the fact that the surface of the vacuum-packed samples was less oxidized. The levels of lipids, proteins, and collagen, on the other hand, were not significantly affected by ageing parameters (temperature, time, and technique), and the differences were due to the raw material properties of the meat.

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