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AGING OF BEEF RUMPSTEAK ON SENSORY QUALITY, COLOR APPEREANCE AND TEXTURE PROPERTIES

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ABSTRACT

The aim of the work was to optimize the time of aging of beef – rumpsteak for culinary processing in relation to color, texture and sensory changes.The 8 weeks of dry-aging had an influence on color change by 18% and there was darkening of samples, darker meat linearly, without any variations. During dry-aging decreased softness and increased strength steaks. There was no significant effect of maturation and softness, it has only been affected by less than 5% (p <0.05). The best evaluation was obtained after 7 weeks of aging in descriptors. The main point was in intensity and pleasantness of flavor and intensity and pleasantness and taste. On the other hand, juiciness and texture to bite was evaluated after 4 weeks of aging the best. As the softest sample in descriptor texture in bites it was four-week aging; as the hardest sample was observed in 8 week of dry-aging. Dry-aging affected (p <0.05) the L* value, the trend during dry-aging period had decreasing tendencies. On the other hand, in the course of decreasing lightness fluctuations was observed in lightness value L*. Chromaticity value a* displayed a negative significant (p <0.05) correlation to weeks of dry-aging. Dry aging had a significant negative effect (p <0.05) on the chromatic value b*. The length of the dry-aging had significant statistical impact on the ligthness and both chromatic coordinates. The length of dry-aging had paramount influence on the textural properties of rump steaks evaluated by instrument.

Keywords: beef meat dry-aging; sensory evaluation; CIELAB; consistency; color

INTRODUCTION

Consumers commonly use product appearance and color to select or refuse food processed products; muscle food products must also create and keep the desired color attributes. In fresh meat, color is the most important attribute that consumers use as purchase criterion **(Mancini and Hunt 2005; Tapp et al., 2011; AMSA, 2012; Aroeira et al., 2017)**. Appearance and color depend on the content of heme pigments and muscle structure **(Aroeira et al., 2017)**.

The color of muscle food is mainly influenced by myoglobin, the primary red pigment in meat. Nevertheless, ultimate perceived color is affected by many factors such as species, animal genetics, and nutritional background, postmortem changes in muscle (especially the dynamics of pH and meat temperature decline), inter- and intramuscular effects, postmortem storage temperatures and time, and a whole host of processing (including antimicrobial interventions), packaging, and display and lighting variables **(AMSA, 2012)**.

Aging conditions influence the cellular mechanisms governing myoglobin redox chemistry and thus can affect color stability when aged beef is subsequently displayed in retail **(Suman et al., 2014; Aroeira et al., 2017)**. Color evaluation is an essential part of meat research, product development, and troubleshooting of processing problems. When done properly, both visual and instrumental appraisals of color are powerful and useful research tools for meat scientists **(AMSA, 2012)**.

During post-mortem aging, substantial improvements in meat palatability attributes such as tenderness, flavor, and/or juiciness occur likely due to a structural breakdown of muscle by endogenous proteases **(Kristensen and Purslow, 2001; Huff-Lonergan and Lonergan, 2005; Kemp et al., 2010; Kim et al., 2014)**. In general, aging can be progressed through either dry-aging (where beef carcasses or primal/sub-primal cuts are stored in a refrigerated temperature without protective packaging materials), or wet-aging (mostly wholesale primal/sub-primal cuts under vacuum packaging). Dry-aging is typically the aging of premium meat under critically controlled ambient conditions of temperature, relative humidity and airflow **(Colle et al., 2016)**. These parameters need to be carefully balanced and monitored to inhibit microbial growth and minimise weight loss, while producing excellent eating quality resulting from

Table 1 Legend of rump steak analyses.

Samples	Date of slaughtery	Start of aging	Aging (weeks)	Age of animal (months)
0	2016-07-01	2016-07-04	0	19
2	2016-06-24	2016-06-27	2	21
3	2016-06-13	2016-06-16	3	22
4	2016-06-02	2016-06-06	4	29
5	2016-06-02	2016-06-03	5	29
6	2016-05-26	2016-05-31	6	22
7	2016-05-13	2016-05-17	7	32
8	2016-05-09	2016-05-11	8	22

tenderisation and enhanced flavor **(Savell, 2008; Kim et al., 2016)**.

It has been established that several factors affect the instrumental color readings of meat samples **(Tapp et al., 2011)**. Meat color changes affect physical properties of light, chemical composition of muscle, and aging process. Color of muscle food is evaluated by sensory assessors who can be affected of other incidental effects and final color is complex of several sensations **(Sýkora et al., 2016)**. Nevertheless, assessors can better evaluated general color and other properties of muscle food effectively than instrumental equipment. Certain parameters are investigated in the instrumental measurement with specific background and all measured parameters are standardized. Sensory evaluation is good tool of simultaneously instrument measurement because some of parameters are better to evaluated by assessor e.g. general appearance and by instrument e.g. changes during dry-aging.

Dry-aging is a traditional process to store whole carcasses or unpackaged primals or sub-primals under a controlled environment (e.g. temperature, humidity, and air flow) for a certain period of time **(Savell, 2008; Kim et al., 2016; Kim et al., 2017)**.

The aim of the work was to optimize the time of aging of beef – rumpsteak for culinary processing in relation to color, texture and sensory changes.

MATERIAL AND METHODOLOGY

Material

For all analyses there were used samples of round of beef from the middle part of rump (rumpsteak) (Table 1). For experiment samples were storaged in condition of dry-aging in period of 8 weeks at the temperature 1 ±0.5 °C and relative humidity 80 – 85%. Samples were sampling together, analyzed and evaluated in one day.

Methods

Color

Color of the rumps steaks samples were determined as reflectance values based on the L*a*b* system of CIE; using a spectrophotometer CM-3500d (Konica Minolta, Osaka, Japan) containing an integrated spectral component, at D65 illuminator, 10° observer, and SCE. Samples were measured in foil at least three scans were taken per steak. CIE L*a*b* values were recorded, which represent lightness, redness, yellowness, respectively. The recorded results from am Color Data Software SpectraMagic NX were calculated in statistical evaluation.

Texture properties

The texture properties of raw rumpsteak were measured by TIRATEST 27025 (TIRA Maschinenbau GmbH, Germany) – universal testing machine measuring of various materials for tensile, pressure, and bending resistance. Two methods with a 200 N compression load cell with a crosshead speed of 100 mm.min-1 were used. The tenderness of the raw rumpsteak was determined through the application of the Meullenet–Owens razor shear (MORS) test **(Cavitt et al., 2005; Meullenet et al., 2004)** during which Razor Blade Shear Force (N) were recorded. The second method was the penetration with ball-end probe with diameter 10 mm to the depth 1 cm.

Sensory evaluation

Samples were prepared by chef specialist by rapid browning on all sides of the steak, subsequently baking at 180 °C in 5 minutes and 5 minutes “rest” before final filleting and served. There were not used any seasonings in samples preparation. Steaks were assessed by 12 assessors and were present randomly and without the time sequence of the aging. Results were recorded in the form without unstructured graphical segments, with endpoints word description (100 mm). There were evaluated following descriptors: flavor – pleasantness, flavor – intensity, texture on bite, juiciness, taste – pleasantness, taste – intensity.

Statistical evaluation

Panel data were collected by MS Excel and tested with one-way analysis of variance (ANOVA, Statistica 12.0) by means of Duncan’s test (p <0.05) for multiple comparisons.

RESULTS AND DISCUSSION

Dry-aging affected (p <0.05) the L* value, the trend during dry-aging period had decreasing tendencies (Table 2). Dynamic changes during steaks dry-aging could lead to a series of alterations that may affect meat quality, especially its color. It is likely that the large concentration of solutes, especially heme pigments, in the intracellular medium cause by aging contributed to a greater absorption of light, and is thus responsible for the reduced lightness **(Aroeira et al., 2017)**.

During dry-aging there were observed changes in L* value. The initial L* 40.52 ±0.61 increased in the second week of aging to 44.82 ±1.07 and this variability in L* were observed in next four weeks. In the fourth week L* 43.96 ±0.76 slightly decreased to minimal L* value

Table 2 Statistical correlation matrix of color properties with advance dry-aging.

Trait	Samples	Aging	L*(D65)	a*(D65)	b*(D65)	C*(D65)	h(D65)
Samples	1	0.989109	-0.435479	-0.649752	-0.653163	-0.66534	-0.36338
Aging		1	-0.396307	-0.644802	-0.639801	-0.657044	-0.340479
L*(D65)			1	0.588632	0.741479	0.665762	0.679673
a*(D65)				1	0.913198	0.985287	0.386172
b*(D65)					1	0.969383	0.725655
C*(D65)						1	0.53662
h(D65)							1

Table 3 Texture properties of raw rumpsteak (mean ±SD).

Samples	Razor Blade Shear Force (N)	Penetration Force (N)
0	5.91 ±2.51[c]	2.47 ±0.93[a]
2	2.22 ±0.90[a]	1.82 ±0.69[a]
3	2.95 ±1.68[ab]	1.80 ±0.47[a]
4	5.94 ±2.58[c]	2.58 ±0.94[a]
5	3.82 ±1.62[ab]	2.42 ±1.15[a]
6	3.02 ±1.63[ab]	1.54 ±0.46[a]
7	4.61 ±2.12[bc]	3.86 ±2.15[b]
8	2.07 ±0.45[a]	1.92 ±0.55[a]

[a, b, c] – means with different uppercase letters in column indicate a statistically significant difference (p <0.05).

35.87 ±1.03 in seventh week of aging. And at the end of dry-aging in the eighth week L* value increased to 40.26 ±2.32. At the beginning and at the end of dry-aging there were investigated significant statistical correlation (p <0.05) between samples and it correspondent their L* values 40.52 ±0.61, 40.26 ±2.32, respectively. The carried out results were confirmed by **Zakrys-Valiwander et al. (2011)**, who observed paramount statistical changes (p <0.05) in value L* during fourteen days of aging of sirloin muscle beef steaks. On the other hand, **Colle et al. (2015)** observed no statistical differences across meat aging during 63 days in muscle beef *gluteus medius* and *longissimus lumborum*. During aging time, variably of lightness value L* increased and decreased; its changes may cause reallocated in the intracellular medium and the effects of the pigments concentration **(Farouk and Wieliczko, 2003; Aroeira et al., 2017)**. Chromaticity value a* (indicating redness) displayed a negative significant (p <0.05) correlation to weeks of dry-aging. There were observed three groups of redness value, significant (p <0.05) statistical correlation were observed at samples at the beginning to fourth week of aging, except third week which was in between first and second group of distribution of redness value a*. To the second group belonged next samples from fifth, sixth, and eighth week of ripening. In seventh week of dry-aging were determinated different values. There were lowest L* and different values a* and b* (p <0.05) too. Both a* and b* values showed negative significant (p <0.05) correlation in time of dry-aging (Table 2). The decreasing trends were observed in a* and b* from beginning of dry-aging till the third week and from the fourth till the seventh week (p = 0.0000, r^2 = 0.4222 and p = 0.0000, r^2 = 0.4266, respectively). The changing in values a* and b* corresponded to study of **Zakrys-Waliwander et al. (2011)** and **Colle et al. (2015)** what it contrary with result obtained by **Aroeira et al. (2017)** where a* and b* increased with time of aging.

The texture properties of dry-aging steaks measured by two methods are shown in Table 3. The Razor Blade Shear Force of rumpsteak ranged from 5.91 N (0 week of aging) to 2.07 N (8 week of aging). The penetration by ball-end probe ranged from 2.47 (0 week of aging) to 1.92 N (8 week of aging).

From the results of sensory analysis we can conclude, that the time of dry-aging had statistically significant

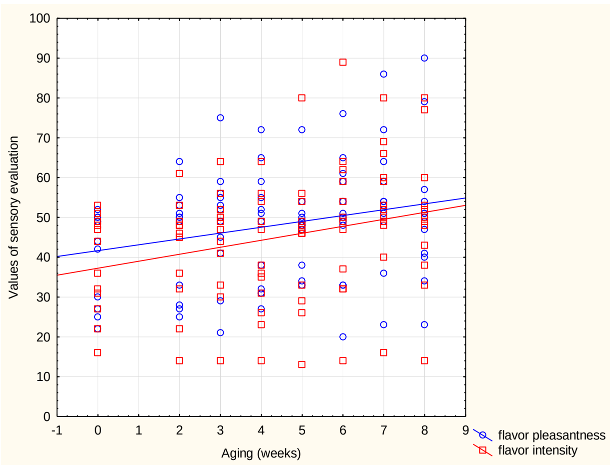

Figure 1 Linear regression plot of flavor pleasantness and flavor intensity.

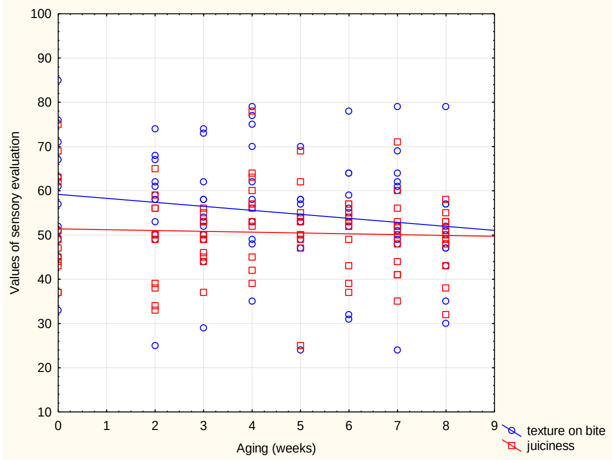

Figure 2 Linear regresion plot of texture on bite and juiciness.

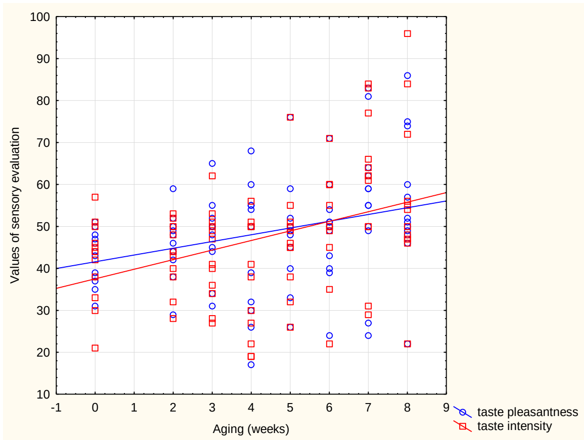

Figure 3 Linear regresion plot of taste pleasantness and taste intensity.

effect (p ≤0.05) for each monitored descriptors, except for the descriptor "texture in bite" (Table 4).

In the evaluation of flavor pleasantness it was created large homogenous group of six samples out of eight. A statistically significant difference was between the sample 0 and sample 7 (Tab. 2). From the results of linear regression (p = 0.0133; r^2 = 0.0634), we can conclude that the time of aging influence on pleasantness of flavor but on minimal range (6%). The assessors evaluated sample 7 as the best. Samples 0 and 2 were the worst.

The highest flavor intensity had sample no 7, after 7 weeks of dry-aging. The lowest intensity was registered at sample 0 and sample 4. Statistically significant differences were only between samples of ripening: samples 0 and 7 (Figure 1). There is dependence of the dry-aging on the intensity of the flavor for 7 weeks with (p = 0.0063; r^2 = 0.0768).

As the softest sample in descriptor texture in bite it was four-week aging and as the hardest sample number 8. From linear regression is noticeable the effect the length of the ripening on texture in bite with descending process. It means, with the length of maturation is the steak tougher (the significance p = 0.0842; r^2 = 0.0314 is very low).

From the evaluation of juiciness there were no found statistically significant differences (p ≤0.05). From the results of statistical evaluation we can detect zero impact on the length of the ripening on descriptor juiciness (p = 0.6534; r^2 = 0.0022). The highest juiciness was after 4 weeks of ripening (sample 4) and the lowest was after 8

Table 4 Determined values of the descriptors in the sensory evaluation and statistical evaluation (mean ±SD).

Samples	Flavor pleasantness	Flavor intensity	Texture on bite	Juiciness	Taste pleasantness	Taste intensity
0	40.8 ±10.9^{a}	38.0 ±11.8^{a}	59.2 ±13.8^{a}	51.8 ±12.0^{a}	42.4 ±6.1^{b}	41.8 ±9.5^{a,b}
2	44.5 ±12.2^{a,b}	41.6 ±12.8^{a,b}	57.0 ±11.9^{a}	48.3 ±9.8^{a}	45.9 ±7.2^{a,b}	43.5 ±7.5^{a,b}
3	48.7 ± 13.4^{a,b}	44.2 ±12.7^{a,b}	54.7 ±11.6^{a}	48.9 ±5.1^{a}	47.8 ±8.6^{a,b}	43.2 ±10.2^{a,b}
4	46.8 ±14.2^{a,b}	39.4 ±14.3^{a,b}	59.6 ±12.9^{a}	55.5 ±10.2^{a}	44.7 ±14.9^{a,b}	37.8 ±13.2^{a}
5	47.8 ±9.8^{a,b}	43.9 ±16.4^{a,b}	51.9 ±10.3^{a}	51.4 ±9.9^{a}	48.1 ±11.9^{a,b}	46.9 ±11.9^{a,b,c}
6	49.9 ±14.7^{a,b}	49.1 ±18.4^{a,b}	54.1 ±12.3^{a}	50.3 ±6.6^{a}	48.5 ±11.1^{a,b}	50.6 ±12.2^{b,c,d}
7	55.0 ±15.3^{b}	53.5 ±15.3^{b}	55.8 ±13.1^{a}	50.3 ±9.2^{a}	55.7 ±16.9^{a,b}	59.9 ±17.0^{d}
8	51.4 ±17.5^{a,b}	49.8 ±17.1^{a,b}	49.7 ±11.7^{a}	48.2 ±7.0^{a}	55.8 ±15.9^{a}	56.4 ±18.6^{c,d}

Note: $^{a, b, c, e}$ – means with different uppercase letters in column indicate a statistically significant difference (p <0.05).

weeks of ripening (sample 8) (Figure 2).

The pleasantness of taste increased linearly with the time of aging (p = 0.0021; r^2 = 0.0964). There was also found a statistically significant difference between samples 0 and 8. The time of dry-aging affected pleasantness of taste of 10%. The best evaluated were samples 7 and 8 (the end of aging).

Another evaluated descriptors, which were influenced by the time of aging, was intensity of flavor. From the results of linear regression we can see a distinct increase in the intensity of taste with time of aging (p = 0.00006; r^2 = 0.1582) about 16%. The highest value was 7 weeks of aging (Figure 3).

Based on results of sensory analysis we can conclude, that as regards descriptors of aroma and taste, the sample 7 (7 weeks of aging) was the best and in terms of juiciness and texture the best one was evaluated the sample no 4 (4 weeks of aging).

Warren and Kastner (1992) found more intensified flavor characteristics such as beefier and more brown/roasted flavor by dry-aged beef samples compared to wet-aged or unaged beef. However, several other studies found no significant dry-aging impacts on palatability components of beef **(Laster et al., 2008; Smith et al., 2008; Dikeman et al., 2013)**. There have been reports of the improvement of meat quality during long-term wet or dry aging. **Campbell et al. (2001)** reported that the tenderness, flavor intensity, and juiciness of lean beef stored for 16 or 21 days by dry aging were higher than those of beef stored for a few days. The softness of lean beef has been improved by wet aging for 28 days **(Dixon et al., 2012)**. **Nishimura et al. (1988)** reported that the intramuscular connective tissue content decreases progressively by 28 days after slaughter. Furthermore, **Yanagihara et al. (1995)** showed in meat from Holsteins that qualities such as taste and tenderness improved during postmortem aging for 32 to 56 days; the taste worsened with further aging. Despite these studies, there are still few reports on quality improvement of highly marbled beef during aging. It is well known that beef should be generally stored for about 2 to 3 weeks at 2 to 4 °C to improve its tenderness and flavor after the post-slaughter rigor mortis has subsided **(Nishimura et al., 1988; Shimada et al., 1992; Campbell et al., 2001; Dixon et al., 2012)**. However, highly marbled beef is sometimes stored longer, under specific regulated conditions, than conventional beef. For example, one brand of marbled beef, Tajima beef, is conditioned for several weeks at about 1 °C and 80% humidity, with an air stream over meat surface. Such regulated conditioning improves the quality of this highly marbled beef.

CONCLUSION

The best evaluation had the samples after 4 weeks of ripening when consumer prefere better textural properties instead significant taste atributes. The similar evaluation had the samples after 7 weeks of dry-aginng. Significant changes in the values of L*a*b* were observed in seven week dry aging. After this time there are significant color appereance, flavor, and taste properties instead worse texture evaluation.

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