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Colour and tenderness changes of marinated venison during storage

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Venison (deer meat) is popular as a healthy food. It is lower in calories, fat and cholesterol content comparing to lamb, pork or beef. Tenderness is one of the most important attributes of the eating quality of meat evaluated by consumers, but meat colour is typically used as the indicator of freshness and wholesomeness.

The objective of the present study was to determine changes in colour (using CIE L*, a*, b* values) and tenderness of venison in mayonnaise or vinegar marinade during storage. Marinated meat was placed on polypropylene trays, hermetically sealed with a high-barrier polymer film under a modified atmosphere (CO_2 40 % + N_2 60 %), as well as placing in packages iron-based oxygen scavenger sachets (Mitsubishi Gas Chemical Europe Ageless®). As a control venison, packaged in air ambiance was used.

The colour of marinated venison (L*, a* and b* values) differ in venison samples prepared using different marinade types. Shear force values tended to decrease ($p < 0.05$) with increasing the storage period in all packages irrespective of marinade type.

Key words: venison, colour, tenderness

Introduction

Venison, due to its lower fat content in muscles, has gained increased popularity in recent years. It is lower in calories, fat and cholesterol content as compares to lamb, pork or beef.

Colour, tenderness and juiciness are the most important parameters that consumers value in meat [1]. Currently, marination is widely used by consumers and producers to improve meat tenderness and juiciness [2]. Marination is the process of meat soaking or injecting a solution containing ingredients such as vinegar, lemon juice, wine, soy sauce, brine, essential oils, salts, tenderizers, herbs, spices and organic acids to flavour and tenderize meat products [3, 4]. The functionality of most marinades directly depends on their ingredients. The most common and important ingredients of acidic marinades are organic acid solutions (acetic acid, lactic acid, citric acid, etc.), vinegars, wine, or fruit juices [5]. Meat can be tenderized by the action of salt solutions or acids. Traditionally, meat is marinated in vinegar (acetic acid) or wine. The action of the acid is to break the muscle structure, possibly by encouraging the action of collagenases and cathepsins, which work best at a low pH. It also makes the myofibrils swell and hold water better, increasing tenderness and juiciness [6]. Aktas and Kaya [7] indicated that samples marinated with acids were brown in colour as compared with controls. The acid treatment appeared to enhance the conversion of myoglobin to metmyoglobin which has a lower colour intensity. Marinades are incorporated into meat by soaking texture and moisture retention to enrich the meat flavour, to tenderize the fibers of muscle foods, and to preserve the products over a longer time [8].

Venison, as well as beef or poultry, is a highly perishable product with a short shelf-life. The packaging technology that modifies the atmospheric conditions of the package is popularly applied to extend the shelf-life of meat [9]. The basic process for modified atmosphere packaging (MAP) is to remove the air from the package and to fill it with gas or a gas mixture instead, and then to seal hermetically [10]. The most appropriate gas composition for venison preservation is CO_2 40 % + N_2 60 % [1]. However, MAP technologies not always completely remove oxygen, and oxygen penetrates through the packaging film. Using oxygen scavengers can reduce the oxygen level in a package [11].

The objective of the present study was to determine changes in colour (using CIE L*, a*, b* values) and tenderness of venison in mayonnaise or vinegar marinade during storage.

Materials and methods

The experiments were carried out at the Department of Food Technology, Latvia University of Agriculture, in 2011. The meat of farmed red deer (*Cervus elaphus*) was obtained from the local farm "Saulstari 1" located in the Sigulda region, Latvia.

Mayonnaise marinade (composition: mayonnaise, onion, parsley, paprika, basil, black pepper, rosemary, and salt) and vinegar marinade (composition: tomato sauce, mayonnaise, vinegar, lemon, onion, parsley, paprika, basil, black pepper, rosemary, and salt) were used for venison marination.

Venison marination included the following steps:

1) *Longissimus dorsi* muscle from venison saddle cuts was manually divided into 0.250 ± 0.020 kg pieces with a knife;

2) pieces of *Longissimus dorsi* muscle were packaged in plastic bags and labelled;

3) the packaged meat samples were stored in a freezer at a temperature of –20 ± 2 °C for two weeks;

4) meat samples before marinating were defrosted at 4 ± 2 °C in the refrigerator for 24 ± 1 h;

5) after defrosting, venison was divided into pieces 2×3×2 cm in size, and marinades were added;

6) the prepared samples were marinated at 4 ± 2 °C in the refrigerator for 48 ± 1 h.

Marinated venison was placed on polypropylene (PP) trays (210×148×35 mm), hermetically sealed with the high barrier Multibarrier 60 polymer film (composition: APA/TIE/PA/EVOH/PA/TIE/PE/PE; thickness 60 ± 2 μm) under a modified atmosphere (CO_2 40 % + N_2 60 %) and then into iron-based oxygen scavenger sachets (Mitsubishi Gas Chemical Europe Ageless®). As a control, marinated venison packaged in air ambiance was used. Meat samples were analysed after 0, 4, 7, 11 and 14 days of storage. Samples were stored at 4 ± 2 °C. Experiments were finished on 11th day for venison in vinegar marinade and on 14th day for venison in mayonnaise marinade, because the microbiological parameters of meat exceeded the permissible limit.

Colour changes were determined with the *ColorTec PCM/PSM* colorimeter (Accuracy Microsensors Inc., USA) – CIE L* a* b* system. Colour values were recorded as L* (brightness), a* (–a, greenness, +a, redness) and b* (–b, blueness, +b, yellowness).

Meat tenderness was evaluated by shear force using a TA.-XT.Plus texture analyzer (Stable Micro Systems, UK) equipped with a Warner-Bratzler blade.

The data were analysed by the analysis of variance (ANOVA). Tukey's test was carried out to determine differences among the groups. The level of statistical significance was evaluated at $p < 0.05$. Statistical analyses were performed using SPSS 15.0. software package.

Results and discussion

The changes of colour parameters L*, a*, b* and shear force (SF) values of venison in mayonnaise marinade during storage are shown in Table 1. The mentioned parameters were not determined in samples packaged in air ambiance after 11 and 14 days of storage because their organoleptic properties, especially flavour, were not acceptable at this time due to the beginning of spoilage. Significant differences ($p < 0.05$) were found in colour values a* and b* between samples packaged under air ambiance and MAP with oxygen scavenger. During storage, a significant ($p < 0.05$) decrease of L* and b* values in all treatments were observed. The parameter a* value increased significantly ($p < 0.05$) in samples packaged under air ambiance during storage. High oxygen concentrations enhance the bright-red colour in fresh meat, but low concentrations accelerate the oxidation of myoglobin to metmyoglobin, which turns the colour to brown [10].

The SF values tended to decrease ($p < 0.05$) with increasing storage time in all treatments. Significant ($p < 0.05$) differences were observed between samples packaged under air ambiance and MAP with oxygen scavenger. While the presence of oxygen in a package maintained texture, in case of CO_2 it caused a decrease in hardness [10].

Table 1. Effect of packaging conditions and storage time on the colour values (L*, a*, b*) and tenderness (shear force) of venison in mayonnaise marinade[1]

Parameter	Storage days	Packaging[2]		
		A	B	C
L*	0	$63.18^{a} \pm 2.97$	$63.18^{a} \pm 2.97$	$63.18^{a} \pm 2.97$
	4	$59.53^{ac} \pm 2.04$	$59.86^{ac} \pm 1.87$	$60.77^{ac} \pm 2.45$
	7	$57.53^{bc} \pm 2.19$	$56.28^{bc} \pm 1.08$	$58.61^{bc} \pm 0.68$
	11	–	$54.78^{bc} \pm 0.76$	$58.36^{bc} \pm 2.25$
	14	–	$49.08^{b} \pm 2.14$	$55.65^{b} \pm 3.26$
a*	0	0.26 ± 0.88	0.26 ± 0.88	0.26 ± 0.88
	4	$0.30^{x} \pm 2.92$	$0.25^{y} \pm 1.00$	$0.22^{y} \pm 1.58$
	7	$0.38^{x} \pm 2.71$	$0.20^{y} \pm 1.47$	$0.18^{y} \pm 1.86$
	11	–	$0.19^{y} \pm 1.49$	$0.16^{y} \pm 0.97$
	14	–	$0.16^{y} \pm 1.39$	$0.14^{y} \pm 1.93$
b*	0	$24.65^{a} \pm 3.93$	$24.65^{a} \pm 3.93$	$24.65^{a} \pm 3.93$
	4	$23.45^{acx} \pm 7.16$	$23.35^{acx} \pm 3.75$	$20.03^{acy} \pm 3.61$
	7	$21.17^{bcx} \pm 2.30$	$22.41^{bcx} \pm 2.75$	$19.84^{bcy} \pm 4.46$
	11	–	$20.08^{bx} \pm 3.53$	$18.30^{by} \pm 3.35$
	14	–	$17.51^{bdx} \pm 2.46$	$15.67^{bdy} \pm 5.06$
Shear force, N	0	$64.48^{a} \pm 27.62$	$64.48^{a} \pm 27.62$	$64.48^{a} \pm 27.62$
	4	$63.65^{ax} \pm 14.70$	$64.11^{axy} \pm 4.72$	$60.60^{acy} \pm 28.06$
	7	$61.43^{acx} \pm 24.79$	$60.09^{acxy} \pm 9.94$	$59.72^{ay} \pm 14.62$
	11	–	$58.30^{bcxy} \pm 8.89$	$56.14^{bcy} \pm 20.78$
	14	–	$55.71^{bxy} \pm 31.77$	$50.85^{by} \pm 26.42$

–, not analysed.

[1]All values reflect the mean ± standard deviation. Values in the same column with different letters ($^{a, b, c, d}$) are significantly different ($p < 0.05$). Values in the same row with different letters ($^{x, y}$) are significantly different ($p < 0.05$).

[2]A = air ambiance; B = CO_2 40 % + N_2 60 % (without oxygen scavenger); C = CO_2 40 % + N_2 60 % (with oxygen scavenger).

The changes of colour parameters L*, a*, b* and shear force (SF) values of venison in vinegar marinade during storage are shown in Table 2. No relevant differences ($p > 0.05$) in L*, b* and SF values were found among all treatments. However, during storage the mentioned parameters changed significantly ($p < 0.05$). Significant differences ($p < 0.05$) were observed between the mean a* values of samples packaged under air ambiance and MAP with oxygen scavenger.

The proportion of different states of myoglobin at the meat surface changes with storage and the atmosphere around the meat. The decrease in redness may result from the gradual formation of metmyoglobin on the meat surface [10].

Table 2. Effect of packaging conditions and storage time on the colour values (L*, a*, b*) and tenderness (shear force) of venison in vinegar marinade[1]

Parameter	Storage days	Packaging[2]		
		A	B	C
L*	0	$62.47^{a} \pm 4.25$	$62.47^{a} \pm 4.25$	$62.47^{a} \pm 4.25$
	4	$61.71^{ac} \pm 2.97$	$61.97^{ac} \pm 1.85$	$61.85^{ac} \pm 2.21$
	7	$59.35^{bc} \pm 2.83$	$59.80^{bc} \pm 1.86$	$61.31^{bc} \pm 1.88$
	11	$57.89^{b} \pm 1.44$	$58.82^{b} \pm 1.50$	$60.63^{b} \pm 2.88$
a*	0	1.88 ± 1.32	1.88 ± 1.32	1.88 ± 1.32
	4	$2.01^{x} \pm 1.67$	$1.58^{xy} \pm 1.23$	$1.44^{y} \pm 0.76$
	7	$2.04^{x} \pm 2.75$	$1.19^{xy} \pm 1.13$	$1.07^{y} \pm 1.72$
	11	$2.87^{x} \pm 0.93$	$1.02^{xy} \pm 2.06$	$0.88^{y} \pm 1.93$
b*	0	$22.95^{a} \pm 3.30$	$22.95^{a} \pm 3.30$	$22.95^{a} \pm 3.30$
	4	$22.59^{ac} \pm 4.68$	$21.56^{ac} \pm 2.42$	$22.25^{ac} \pm 2.71$
	7	$22.05^{bc} \pm 6.21$	$20.78^{bc} \pm 4.49$	$21.14^{bc} \pm 5.48$
	11	$21.27^{b} \pm 3.40$	$20.36^{b} \pm 5.53$	$19.73^{b} \pm 5.19$
Shear force, N	0	$98.01^{a} \pm 17.18$	$98.01^{a} \pm 17.18$	$98.01^{a} \pm 17.18$
	4	$75.28^{b} \pm 23.47$	$70.60^{b} \pm 8.91$	$71.61^{b} \pm 17.66$
	7	$69.57^{b} \pm 16.57$	$65.26^{b} \pm 15.93$	$64.07^{b} \pm 10.12$
	11	$63.85^{bc} \pm 13.66$	$57.09^{bc} \pm 6.27$	$51.14^{bc} \pm 15.74$

[1]All values reflect mean ± standard deviation. Values in the same column with different letters ($^{a, b, c}$) are significantly different ($p < 0.05$). Values in the same row with different letters ($^{x, y}$) are significantly different ($p < 0.05$).

[2]A = air ambiance; B = CO_2 40 % + N_2 60 % (without oxygen scavenger); C = CO_2 40 % + N_2 60 % (with oxygen scavenger).

In the present research, significant differences ($p < 0.05$) were found in L*, a* and SF values between venison in mayonnaise and vinegar marinades. The venison in mayonnaise marinade was darker, less red (lower L*, a*) and more tender (lower SF value) than the venison in vinegar marinade. Such results can be explained by the different composition of marinades.

Conclusions

1. Significant changes ($p < 0.05$) were found in a*, b* and SF values between venison in mayonnaise marinade packaged in air ambiance and MAP with oxygen scavenger.
2. No significant differences ($p > 0.05$) in L*, b* and SF values were determined among venison samples in vinegar marinade when different types of packaging were used.
3. During marinated venison storage, a significant ($p < 0.05$) decrease of L*, b* and SF values was observed in all packages irrespective of marinade type.
4. Slower changes of L*, a*, b* and SF values were observed in samples packaged under MAP with oxygen scavenger. This may suggest MAP with the oxygen scavenger to be the most suitable method of storing marinated venison.

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MARINUOTOS ELNIENOS SPALVOS IR MINKŠTUMO POKYČIAI JĄ LAIKANT

S a n t r a u k a

Tirti majoneze ir acte marinuotos ir hermetiškai polipropileno indeliuose uždarytos elnienos spalvos ir minkštumo kitimo parametrai. Nustatyta, kad spalvos parametrai priklauso nuo marinato atmainos, o šlyties jėgos vertės elnieną laikant nuo marinato atmainos nepriklauso ir mažėja.