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EFFECT OF PACKAGING CONDITIONS ON THE PHYSICALLY-CHEMICAL PARAMETERS OF PICKLED VENISON DURING STORAGE

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Abstract

Meat colour is one of the most important qualities influencing the consumer's decision to purchase. The colour of meat depends on many factors, such as the concentration of myoglobin, physical characteristics of the meat and pH. The aim of the current research was to determine changes in colour (using CIE L, a*, b* values), pH and moisture content of pickled venison during storage. Beef as a control was analysed for comparison of obtained results. The meat (2×3×2 cm) pieces were pickled in tomato sauce marinade (composition: tomato sauce, lemon, onion, parsley, sweet pepper, basil, black pepper, rosemary, salt) at 4±2 °C temperature for 48±1 h. Marinated meat was placed on the polypropylene trays, hermetically sealed with high barrier polymer film under modified atmosphere ($C0_2$ 40%+N_2 60%), as well as placing in packages iron based oxygen scavenger sachets (Mitsubishi Gas Chemical Europe Ageless®). As a control, meat packaged in air ambiance was used. During storage time, colour L*, b* values and pH of both investigated meat samples significantly ($p<0.05$) increased irrespective of packaging method. The moisture content in all packages and colour a* value of the meat samples packed under modified atmosphere significantly ($p<0.05$) decreased during storage.*

Key words: *venison, colour, pH, moisture, modified atmospheres, oxygen scavengers*

1. INTRODUCTION

Recent statistical updates indicate the significantly enhanced consumer interest in the venison meat, because of its high level of proteins, vitamins, mineral salts and lower, compared to meat of domestic slaughter animals, content of fat and cholesterol, as well as its lower level energetic value (Zochowska-Kujawska et al., 2009).

The cherry red colour in meat is one of the most important qualities influencing the consumer's decision to purchase. The colour of meat depends on many factors, such as the concentration and chemical state of heme pigments, particularly myoglobin, the physical characteristics of the meat and the pH (Franco et al., 2012). With prolonged storage oxymyoglobin oxidises to metmyoglobin and gives meat an unattractive brown colour (Djenane et al., 2002).

Venison is a highly perishable food with a short shelf life. The main aims of marinating have been considered to be tenderizing, flavoring and enhancing safety and shelf life of meat products due to inhibition of microbial growth (Bjorkroth, 2005). Traditionally, meat has been marinated by soaking in acid solution (Yusop et al., 2010); however marinades are nowadays complex sauces which have a great effect on product appearance and taste. They are typically water-oil emulsions containing salt, sugar and acids (acetic, citric), rheology-improving additives (such as xanthan and guar gum), antimicrobial agents (such as sorbate and benzoate) spices and aroma enhancers. Basic flavour is often obtained using pepper, onion and tomato base together with other added spices (Bjorkroth, 2005). Beneficial effects of marination on meat texture include a juicier texture and reduction of water loss during cooking (Zochowska-Kujawska et al., 2012).

It is well known that packaging makes food more convenient and gives the food greater safety assurance from microorganisms, biological and chemical changes so that the packaged foods may have a longer shelf life. In modified atmosphere packaging (MAP), an initial atmosphere is generated by either permitting air to be enclosed or by injecting a desired initial gas mixture (Skandamis and Nychas, 2002). Typically for meat packaging under modified atmosphere use gas composition O_2 80%+CO_2 20% (Franco et al., 2012), however for venison preservation gas composition $C0_2$ 40%+N_2 60% is the most appropriate (Vergara et al., 2003). Modified atmospheres technologies not always completely remove oxygen and oxygen penetrates through the packaging film. Using of oxygen scavengers can reduce oxygen level in a package. Oxygen scavengers are made from easily oxidisable substances, usually contained in sachets made of air permeable materials. Almost all oxygen scavenger sachets used commercially are based on the principle of iron oxidation. The sachets are made up of finely divided powdered iron, ferrous compounds and various catalysts, which under appropriate humidity conditions initiate the reaction, using up any residual oxygen to form non-toxic iron oxide (Brandon, 2009).

The aim of the current research was to determine changes in colour (using CIE L*, a*, b* values), pH and moisture content of pickled venison during storage.

2. MATERIALS AND METHODS

The experiments were carried out at the Department of Food Technology, Latvia University of Agriculture, in 2012. The meat of farmed red deer (*Cervus elaphus*) was obtained from a local farm 'Saulstari 1', located in Sigulda region, Latvia; the beef of farmed cattle *(Colloquially cows)* from Ltd. 'Margret' located in Jekabpils region, Latvia, was used for control.

Tomato sauce marinade (composition: tomato sauce, lemon, onion, parsley, sweet pepper, basil, black pepper, rosemary, salt) was used for venison and beef pickling.

Marinating process of the samples included the following steps:

1) *Longissimus dorsi* muscle from venison and beef saddle cuts were manually divided by knife in 0.250±0.020 kg pieces;

2) 0.250±0.020 kg pieces of *Longissimus dorsi* muscle were divided into smaller pieces of the size of 2×3×2 cm, and tomato sauce marinade was added;

3) prepared samples were marinated at 4±2 ℃ temperature in the refrigerator for 48±1 h.

Marinated meat samples were placed on the polypropylene (PP) trays (210×148×35 mm) and hermetically sealed with high barrier polymer film Multibarrier 60 (composition: APA/TIE/PA/EVOH/PA/TIE/PE/PE; thickness 60±2 μm) under modified atmosphere ($C0_2$ 40%+N_2 60%) without and with iron-based oxygen scavenger sachets (Mitsubishi Gas Chemical Europe Ageless®), as a control packaging in air ambiance packed pickled venison and beef was used. Venison samples were analysed after 0, 4, 7, 11 and 14 days of storage under modified atmosphere (MA) packaging without/with oxygen scavenger and after 0, 4 and 7 days of storage in air ambiance. Beef samples were analysed after 0, 4, 7, 11 and 14 days of storage under MA packaging with oxygen scavenger and after 0, 4, 7 and 11 days of storage in air ambiance and under MA packaging without oxygen scavenger. Samples were stored at 4±2 °C. For pH and moisture content analyses, meats were homogenised using a household blender according to ISO 17604:2003 standard procedure. Experiments were finished on 7th day, on 11th day and on 14th day of storage because the microbiological parameters of meat exceeded 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).

The pH was measured using JENWAY 3520 (Barloworld Scientific Ltd., ESSEX, UK) pH-meter. The pH electrode was dipped into a mixture of homogenized sample and distilled water (1:10), according to LVS ISO 5542:2010.

The content of moisture was determined according to ISO 1442:1997.

The data was processed by analysis of variance (ANOVA) in order to determine the effect of packaging condition and storage time on each variable. Tukey's test was carried out to determine differences between groups. The level of statistical significance was evaluated at $p<0.05$. Statistical analyses were performed using SPSS 15.0. software packages.

3. RESULTS AND DISCUSSION

3.1. Colour

The changes of colour parameters L*, a* and b* values of venison in tomato sauce marinade during storage are shown in Table 1.

Table 1. Effects of packaging conditions and storage time on the colour values (L*, a*, b*) of venison in tomato sauce marinade[1]

Parameter	Storage days	Packaging[2]		
		A	B	C
L*	0	$33.76^{a} \pm 2.14$	$33.76^{a} \pm 2.14$	$33.76^{a} \pm 2.14$
	4	$33.86^{ax} \pm 2.18$	$33.94^{ay} \pm 2.01$	$33.95^{ay} \pm 3.14$
	7	$34.01^{ax} \pm 1.51$	$34.02^{ay} \pm 1.30$	$34.59^{ay} \pm 2.42$
	11	-	$34.74^{by} \pm 1.74$	$34.81^{by} \pm 1.09$
	14	-	$35.17^{by} \pm 1.46$	$35.22^{by} \pm 1.37$
a*	0	$8.12^{a} \pm 2.92$	$8.12^{a} \pm 2.92$	$8.12^{a} \pm 2.92$
	4	$8.60^{ax} \pm 2.68$	$8.02^{ay} \pm 6.52$	$8.00^{ay} \pm 1.01$
	7	$8.98^{ax} \pm 1.18$	$7.01^{aby} \pm 1.60$	$7.05^{aby} \pm 1.79$
	11	-	$6.56^{by} \pm 1.37$	$6.31^{by} \pm 1.90$
	14	-	$6.24^{by} \pm 3.14$	$6.21^{by} \pm 1.32$
b*	0	$12.56^{a} \pm 10.89$	$12.56^{a} \pm 10.89$	$12.56^{a} \pm 10.89$
	4	$13.44^{ac} \pm 7.51$	$12.58^{ac} \pm 13.25$	$13.43^{ac} \pm 4.29$
	7	$14.99^{bcd} \pm 2.64$	$13.98^{bcd} \pm 4.36$	$13.80^{bcd} \pm 5.05$
	11	-	$13.73^{ad} \pm 2.03$	$13.93^{ad} \pm 2.95$
	14	-	$14.26^{bd} \pm 6.29$	$14.43^{bd} \pm 2.39$

-, not analysed.

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

Significant differences ($p < 0.05$) were found in colour values L* and a* among in air ambiance packaged and under MA without/with oxygen scavenger packed venison. During storage of samples, colour values L* and b* significantly ($p < 0.05$) increased in all packages. The colour of meat samples after storage was lighter (higher L* values) and this indicate the well-known tendency for the colour of venison on display to deteriorate (Purchas et al., 2010). Colour parameter b* increment may be associated with transformation of the meat pigment and the formation of metmyoglobin, which is faster at a relatively low oxygen concentration (Vergara et al., 2003). Parameter a* value increased significantly ($p < 0.05$) in samples packaged in air ambiance. High oxygen concentrations enhance bright-red colour to fresh meat, but low concentrations accelerate the oxidation of myoglobin to metmyoglobin, which turns the colour to brown (Gokoglu et al., 2011).

The changes of colour parameters L*, a* and b* values of beef in tomato sauce marinade during storage are shown in Table 2.

Table 2. Effects of packaging conditions and storage time on the colour values (L*, a*, b*) of beef in tomato sauce marinade[1]

Parameter	Storage days	Packaging[2]		
		A	B	C
L*	0	$37.85^{a} \pm 2.80$	$37.85^{a} \pm 2.80$	$37.85^{a} \pm 2.80$
	4	$37.90^{a} \pm 1.34$	$37.86^{a} \pm 1.47$	$37.89^{a} \pm 1.84$
	7	$38.27^{b} \pm 1.67$	$38.32^{b} \pm 1.75$	$38.47^{b} \pm 1.18$
	11	$38.32^{b} \pm 2.02$	$38.78^{b} \pm 1.42$	$38.84^{b} \pm 1.11$
	14	-	-	$39.59^{b} \pm 1.44$
a*	0	$6.20^{a} \pm 3.51$	$6.20^{a} \pm 3.51$	$6.20^{a} \pm 3.51$
	4	$6.41^{abx} \pm 1.40$	$5.86^{aby} \pm 6.33$	$5.72^{aby} \pm 4.23$
	7	$6.57^{bx} \pm 1.74$	$5.48^{by} \pm 2.13$	$5.60^{by} \pm 1.83$
	11	$6.82^{bx} \pm 1.23$	$5.36^{by} \pm 1.43$	$5.51^{by} \pm 1.44$
	14	-	-	$5.43^{b} \pm 1.62$
b*	0	$20.13^{a} \pm 8.22$	$20.13^{a} \pm 8.22$	$20.13^{a} \pm 8.22$
	4	$20.67^{b} \pm 5.03$	$20.75^{b} \pm 9.64$	$20.77^{b} \pm 7.89$
	7	$21.46^{c} \pm 3.04$	$21.77^{c} \pm 4.94$	$21.91^{c} \pm 3.82$
	11	$21.78^{c} \pm 3.36$	$21.88^{c} \pm 3.34$	$22.01^{c} \pm 3.27$
	14	-	-	$22.19^{c} \pm 3.28$

-, not analysed.

[1]All values reflect mean ± standard deviation. Values in the same column with the different letters ([a, b, c]) are significantly different ($p < 0.05$). Values in the same row with the 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 relevant differences ($p > 0.05$) were not found in L* and b* values among the in air ambiance packaged and under MA with/without oxygen scavenger packed beef. Parameter a* values of beef packaged in air ambiance and under MA without/with oxygen scavenger significantly different ($p < 0.05$). During storage, all colour parameters change significantly ($p < 0.05$) irrespective of the packaging method. Change in trend remains the same as in the experiments with pickled venison.

3.2. pH

The present experiment did not indicate significant differences ($p>0.05$) in pH values among the in air packed and under MA packed meat with/without oxygen scavenger. It could be explained by the fact that meat offers a relatively strong buffering system and that the vast majority of "added" CO_2 is present in meat in dissolved form (Sørheim et al., 2004; Daszkiewicz et al., 2011). pH values tended to significantly increase ($p<0.05$) with increasing storage period in all packages. Results are similar to the finding of Pollard et al. (2002), Vergara et al. (2003) and Franco et al. (2012). Moore and Gill (1987) suggested that tissue breakdown may be responsible for this increase. pH changes in venison and beef pickled in tomato sauce marinade during storage are shown in Figure 1.

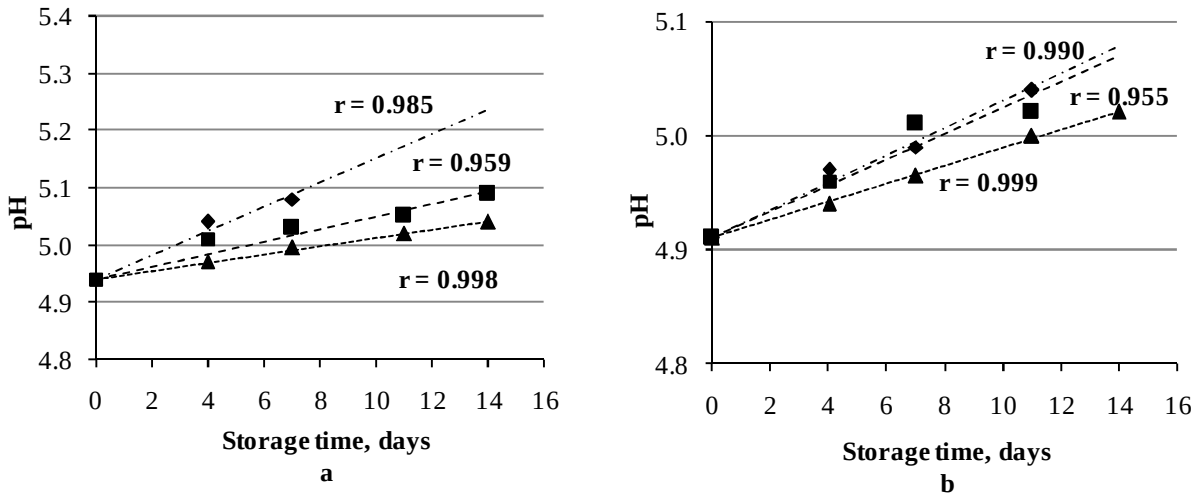

Fig. 1. Changes in pH values of venison (a) and beef (b) pickled in tomato sauce marinade during storage:

♦- air ambiance; ■- CO_2 40%+N_2 60% (without oxygen scavenger); ▲- CO_2 40%+N_2 60% (with oxygen scavenger).

The correlation coefficients showed close interconnection between pH values and storage time (Figure 1).

3.2. Moisture

No significant differences ($p>0.05$) were found among the moisture content under modified atmosphere without/with oxygen scavenger and the in air ambiance packaged pickled venison. Moisture content of pickled beef packaged in air ambiance and modified atmosphere with oxygen scavenger was significantly different ($p<0.05$). Initial moisture content of pickled venison was 75.40% (beef – 67.81%). During storage moisture content significantly decreased ($p<0.05$) of both investigated meat samples in all packages. Slow decline moisture content of pickled venison and beef packed under modified atmosphere with oxygen scavenger was observed. After 14 days of storage moisture content of pickled venison packed under modified atmosphere with oxygen scavenger was 74.55% (beef – 65.08%). Moisture loss could be explained with water vapour permeation through the packaging materials. Moisture content of pickled venison and beef samples during storage are shown in Figure 2.

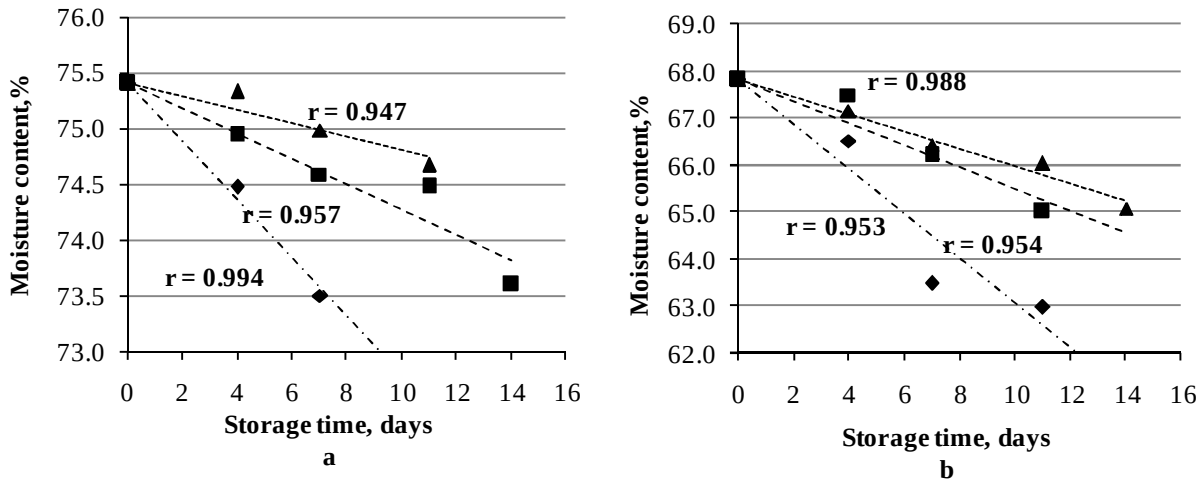

Fig. 2. Changes in moisture content of venison (a) and beef (b) pickled in tomato sauce marinade during storage:

♦- air ambiance; ■- CO_2 40%+N_2 60% (without oxygen scavenger); ▲- CO_2 40%+N_2 60% (with oxygen scavenger).

A close correlation was observed between storage time and moisture content for venison and beef in all packages (see Figure 2).

4. CONCLUSIONS

Significant changes ($p<0.05$) in L* and a* colour values were determined among the venison samples packaged in air ambiance and under modified atmosphere without/with oxygen scavenger.

The results of this study did not indicate a significant ($p>0.05$) influence of the applied packaging type on changes in pH values and colour parameters L*, b* values of pickled beef.

During storage, all determined parameters (colour, pH and moisture) significantly changed ($p<0.05$) irrespective of the packaging method.

The used packaging conditions do not fully protect pickled meat from the colour changes. Evaluating all packaging types, packaging under modified atmosphere with oxygen scavenger could be suggested for pickled meat storage.

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