DRIED VENISON PHYSICAL AND MICROBIOLOGICAL PARAMETERS CHANGES DURING STORAGE

Ilze Gramatina, Laima Silina, Liga Skudra, Tatjana Rakcejeva

Department of Food Technology, Faculty of Food Technology, Latvia University of Agriculture, Liela Street 2, Jelgava, Latvia, e-mail: ilzegramatina@inbox.lv

Abstract

Venison due to the lower fat content in muscles has gained increased popularity in recent years comparing to pork or beef. The aim of the current research was to determine changes in physical and microbiological parameters of dried venison during storage. For the experiments the meat (0.02×4.00×7.00 cm) pieces were marinated in "teriyaki sauce" marinade (composition: teriyaki sauce, sweet and sour sauce, taco sauce, soy sauce, American BBQ sauce hickory, sesame oil, garlic, garlic salt, tabasco red pepper sauce) at 4±2 °C temperature for 48±1h. To improve the meat textural properties sodium monophosphate (E339) was added in part of marinade too. After marinating meat samples were dried in microwave-vacuum drier MUSSON–1, packaged in vacuum pouches made from polymer film (PA/PE) with barrier properties and storage for 4 months at +18±1 °C temperature in dark place. The following physical and microbiological parameters of dried meat were evaluated after 35, 91 and 112 storage days using standard methods: pH (AACC 02-52), colour by Colour Tec PCM/PSM (CIE L*a*b* system), texture by TA. XT. plus Texture Analyser, the total count of mesophilic aerobic and facultative anaerobic microorganisms (Ref. Nr. 01–140), lactic acid bacteria (Ref. Nr. 01–135). Experimentally it was ascertained, that the shelf-life of dried venison with sodium monophosphate additive is 91 day and without sodium monophosphate additive – 112 days. Significant differences were detected in meat color and texture changes. However, dried meat color stability and texture is possible to provide during storage by adding of sodium monophosphate at marinade.

Keywords: venison, drying, microwave-vacuum drier.

Introduction

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

Colour, tenderness and juiciness are the most important parameters for consumers in meat (Vergara et al., 2003). Currently, marination is widely used by consumers and producers to improve meat tenderness and juiciness (Ergezer, Gocke, 2011).

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 (Kargiotou et al., 2011; Pathania et al., 2010). 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 (Burke, Monahan, 2003).

Drying is a method of food preservation that works by removing water from the food, which inhibits the growth of bacteria and has been practiced worldwide since ancient times to preserve food. A solar or electric food dehydrator can greatly speed the drying process and ensure more consistent results. Water is usually removed by evaporation (air drying, sun drying, smoking or wind drying). Bacteria, yeasts and moulds need the water in the food to grow, and drying effectively prevents them from surviving in the food (Bowser et al., 2009).

Hot-air drying has been to date the most common drying method employed for food materials. However, this method has many disadvantages, including poor quality of dried products, low energy efficiency and a long drying time. Microwave-vacuum drying is a novel alternative method of drying, allowing to obtain products of acceptable quality. It permits a shorter drying time and a substantial improvement in the quality of dried materials, in relation to those dried with hot air and microwaves drying method (Bondaruk et al., 2007).

Microwaves and radiofrequency waves are electromagnetic waves that are given in concrete frequency bands and both are enclosed into the dielectric heating (Knoerzer et al., 2006). Microwave energy is adequately combined with vacuum technology; it enables to keep temperatures within a low range (Yongsawatdigul, Gunasekaran, 1996). If a suitable control system is used, microwaves provide high quality products with less nutrient loss, more flavour retention, less colour change, a natural appearance (Drouzas, Schubert, 1996; Erle, Shubert, 2001).

The aim of the current research was to determine changes in physical and microbiological parameters of dried venison during storage.

Materials and Methods

The experiments were carried out at the Department of Food Technology, Latvia University of Agriculture, in Year 2013.

The object of the research

The meat of farmed red deer (*Cervus elaphus*) was obtained from a local farm Saulstari 1, located in Sigulda region, Latvia.

Components of marinade

Teriyaki sauce marinade (composition: teriyaki sauce, sweet and sour sauce, taco sauce, soy sauce, American BBQ sauce hickory, sesame oil, garlic, garlic salt, tabasco red pepper sauce) was used for venison marinating.

Meat marinating

Marinating process of the meat included the following steps:

- *Musculus longissimus lumborum* muscle from venison was manually divided into smaller pieces of the size 0.02×4.00×7.00 cm, and teriyaki sauce marinade was added. To improve the meat textural properties sodium monophosphate was added in 1.2% from total amount of marinade according to Ergezer and Gocke (2011).
- Prepared samples were marinated at 4±2 °C temperature for 48±1 h.

Meat drying and packaging

After marinating, the microwave-vacuum drier Musson-1 (OOO Ingriedient, Russia) (Vacuum microwave drier MUSSON-1, 2007) was used for venison drying.

Dry meat samples were packaged in the vacuum pouches made from polymer film (PA/PE) with barrier properties.

Dried meat storage conditions

Packaged dry meat samples were stored at dark place at 18±1 °C temperature for 112 days. Quality parameters of dry venison samples were analysed after 0, 35, 91 and 112 days of storage.

Standard methods for samples quality analysis

Microbiological parameters were analysed:

- the total plate count (TPC) of mesophilic aerobic and facultative anaerobic microorganisms according to the standard method LVS EN ISO 4833:2003
(Ref. Nr. 01–140);
- lactic acid bacteria according to the standard method ISO 9332:2003 (Ref. Nr. 01–135).

The *pH* was measured using Jenway 3520 pH Meter (Jenway, AK). The pH electrode was dipped into a mixture of homogenized sample and distilled water (1:10), according to AACC02-52. For pH analyses, meats samples were homogenised using a household blender according to ISO 17604:2003 standard procedure.

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 Analyser (Stabel Micro Systems, UK) equipped with a Warner-Bratzler blande.

Mathematical data processing

Microsoft Excel software was used for the calculation of mean arithmetical values and standard deviations. SPSS 20.0 software was used to determine the significance of research results and ANOVA analyses to explore the impact of factors and their interaction, the significance effect (p-value).

Results and Discussion

Technological parameters

During experiments optimal technological parameters for marinated meat (2.5±0.1 kg) drying in microwave-vacuum drier were developed: temperature – +36±2 °C and drying time – 80 min, one working cycle, pressure 7.5/9.3 kPa, container rotation speed – 6 rpm, the total energy input 2856 kJ kg^{-1} initial load.

Meat was dry until content of moisture in samples without and with sodium monophosphate accordingly achieved 25.08±0.66% and 34.78±0.60% corresponding to Yang et al. (2009).

Microbiological parameters

The total plate count (TPC) of mesophilic aerobic and facultative anaerobic microorganisms (CFU g^{-1}) in dry meat not regulates with European Commission regulation No. 2073/2005. Therefore for obtained data interpretation Russian sanitary and epidemiological regulations Enactment date of sanitary and epidemiological rules and regulations "Hygienic Requirements for Safety and Nutrition Value of Food Products / Sanitary Rules and Regulations (SanPin) 2.3.2.1078–01" with permissible limit as 1×10^4 CFU g^{-1} (Санитарно–эпидемиологические правила..., 2002) was used. Experimentally was detected that before drying TPC CFU g^{-1} of marinated meat without sodium monophosphate was 2.32 log CFU g^{-1} and with sodium monophosphate – 2.46 log CFU g^{-1}, obtained results was not exceed permissible level.

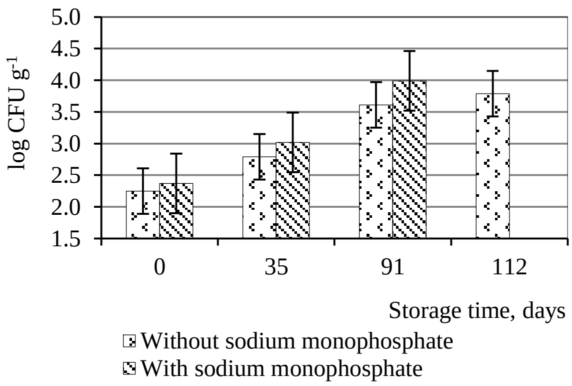

Figure 1. TPC dynamics of dried venison during storage

There are not found significant (p=0.117) changes of TPC of meat samples after drying.

Significant TPC changes of dry venison samples (Figure 1) with sodium monophosphate were indicated after 91 days storage, as a result the volume of TPC reach permissible level – 1×10^4 CFU g^{-1}, and it was 3.99 log CFU g^{-1}. Such changes could be explained by relatively higher moisture content in analysed meat samples. However in dry venison samples without sodium monophosphate TPC CFU g^{-1} reach permissible level after 112 storage days and it was – 3.79 log CFU g^{-1}. Therefore the recommendable dry venison with sodium monophosphate shelf-life could be 91 days, but of venison without sodium monophosphate – 112 days.

The count of lactic bacteria (Fig. 2) in marinated venison without sodium monophosphate was 1.99 log CFU g^{-1}, however in samples with sodium monophosphate – 1.90 log CFU g^{-1}. After drying a count of lactic acid bacteria increases as follow in meat samples without sodium monophosphate until 2.00 log CFU g^{-1}, with sodium mono phosphate – 1.98 log CFU g^{-1} ($p>0.05$).

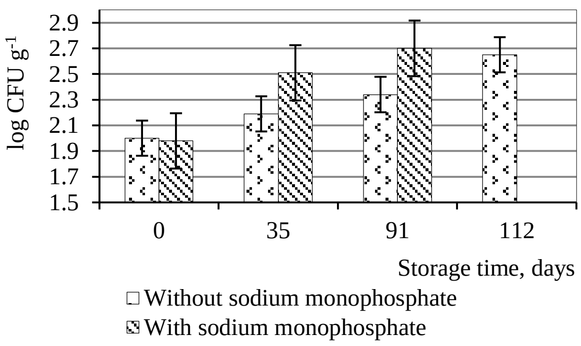

Figure 2. Lactic acid bacteria dynamics in dried venison during storage

There are not found significant differences in count of lactic acid bacteria between analysed dry venison samples during storage (p=0.166). From other side the higher count of lactic acid bacteria was established in dry meat with sodium monophosphate additive. Obtained results could be explained with higher moisture content in analysed dry meat samples with sodium monophosphate, that create favourable conditions for development of lactic acid bacteria. The changes of count of lactic acid bacteria very tightly connected with meat samples pH value as a result a pH value was less and the amount of lactic acid bacteria increases (Skandamis, Nychas, 2002).

Physical parameters

pH value of marinated venison without sodium monophosphate before drying was 5.14±0.06, but with sodium monophosphate – 5.32±0.04.

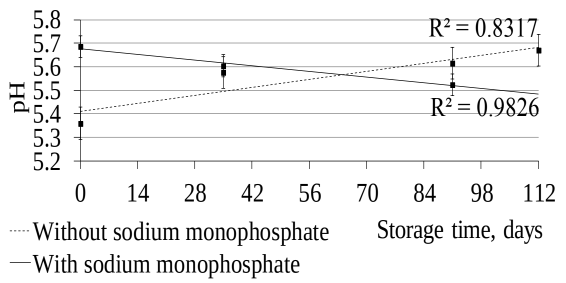

Figure. 3. Changes in pH values of dried venison during storage

In scientific literature is mentioned that in result of using of phosphate pH value of meat increase (Sheard, Tali, 2004; Murphy, Zerby, 2004).

pH changes of meat samples after drying was not significant ($p>0.05$). pH value of dry venison without sodium monophosphate was obtained as 5.36±0.01, with sodium monophosphate – 5.69±0.03. Significant differences between dry meat samples without/with sodium monophosphate in pH value was not established ($p>0.05$). An increase of count of lactic acid bacteria in meat during storage mainly depends on pH value decreasing in dry meat with sodium monophosphate.

Colour

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

Colour parameter L***** value of marinated meat with sodium monophosphate was higher comparing with marinated meat without sodium monophosphate; differences was not significant ($p>0.05$). L* value of marinated venison without sodium monophosphate was 30.66±1.60, but with sodium mono phosphate – 31.37±2.05. However, colour of meat stabilizes optimal pH value. Myoglobin is found in fresh meat, but after some hours of store at air ambiance or after of heat treatment process meat colour turn of brown or grey-brown, due to metmyoglobin formation. Meat colour stabilization is possible to prevent development of metmyoglobin.

Table 1

Effects of storage time on the colour values (L*, a*, b*) of dry venison

Parameter	Storage days	Dry venison meat	
		A	B
L*	0	31.05±2.71	30.42±5.17
	35	35.11±2.82	34.42±2.83
	91	36.89±2.81	34.85±3.84
	112	–	35.26±4.39
a*	0	8.45±9.68	7.99±1.51
	35	7.02±8.76	6.36±4.93
	91	6.16±7.65	5.78±8.46
	112	–	5.55±8.94
b*	0	5.03±4.64	6.19±7.30
	35	4.03±5.57	5.97±7.48
	91	3.98±1.19	5.26 ±4.40
	112	–	4.52±5.50

A – with sodium monophosphate; B – without sodium monophosphate.

After drying colour parameter L* value of meat decrease and meat samples turns darker, but obtained changes was not significant ($p>0.05$). The significant differences was established ($p<0.05$) in L* value between dry meat samples without/with sodium monophosphate in long period of storage time. Therefore, the experimental date indicates, that sodium monophosphate stabilizes colour of dry meat samples during storage.

Colour parameter a* value of marinated meat without sodium monophosphate (5.03±2.67) was lower comparing with marinated meat with sodium monophosphate (6.93±2.71), but detected differences was not significant ($p>0.05$).

Colour parameter a* values of meat samples without/with sodium monophosphate increased significantly (p=0.024; p=0.047) after drying, and it was 7.99±1.51 and 8.45±9.68 respectively. Such colour changes could be explained with moisture content decreases in meat samples after drying. As a result a colour of meat becomes more dark and red. Dry venison without sodium monophosphate color parameter a* value after 112 day of storage increase till 5.55±8.94 (significantly p=0.001), but of dry venison with sodium monophosphate a* colour parameter value after 91 day increase till 6.16±7.65, what is significant (p=0.0001). The O'Sullivan et al. (2002) indicated, that the colour parameter a* value usually was tightly connected with content of oxymyoglobin in meat. Therefore it is possible to conclude, that after heat treatment due to metmyoglobin formation colour parameter a* value decreases in meat. As a result meat colour turn of brown or grey-brown.

Colour parameter b* value of marinated venison without sodium monophosphate was obtained as 15.77±5.96, with sodium mono phosphate – 14.79±7.10 (p>0.05). After drying of marinated venison samples without/with sodium monophosphate colour parameter b* value decrease significantly (p=0.006; p=0.021) respectively, but differences between samples was not significant (p>0.05). b* colour parameter value of dry venison without sodium monophosphate was 6.19±7.30, with sodium monophosphate – 5.03±4.64. b* colour parameter value decrease significantly (p=0.0001) in dry venison samples without sodium monophosphate and in samples with sodium monophosphate (p=0.009) during storage (Table 1). After mathematical data processing significant differences was established between analysed samples without/with sodium monophosphate additive (p<0.05) during storage. It is necessary to indicate, according to the Franco et al., (2012) in scientific literature was not found explanation about b* colour parameter value changes in meat during storage.

Tenderness (shear force)

Experimentally it was detected that marinated meat with sodium monophosphate additive was softer then marinated meat without sodium monophosphate (p<0.05). Results indicated that marinated venison without sodium monophosphate tenderness was 23.42±6.72 N, but with sodium mono phosphate – 16.20±1.13 N or 1.45 times less.

Table 2

Effects of storage time on tenderness of dry venison

Parameter	Storage days	Dry venison meat A	Dry venison meat B
Shear force, N	0	95.33±9.46	120.77±7.71
	35	112.33±2.27	155.34±6.15
	91	151.61±4.54	292.63±9.65
	112	–	315.91±5.77

A – with sodium monophosphate; B – without sodium monophosphate.

After drying tenderness of meat samples increase significantly (p<0.05), because a content of moisture increase and finally structure mechanical properties of dried meat changed. Tenderness of dry venison without sodium monophosphate was 120.77±7.71 N, whereas with sodium monophosphate – 95.33±9.46 N (Table 2). During research it was proved that tenderness of meat samples with/without sodium monophosphate additive significantly increase (p<0.05) during storage. However dry meat samples with sodium monophosphate additive was softer (p>0.05), because it's higher pH value.

Conclusions

Experimentally it was ascertained, that the shelf-life of dried venison, packaged in vacuum pouches made from polymer film (PA/PE) with barrier properties and stored at a temperature +18±1 °C in the dark place, with sodium monophosphate additive could be 91 day and without sodium monophosphate additive – 112 days.

There are not found significant differences in pH values of analyses dried meat sample during storage comparing with the parameters of just dried meat.

Significant differences were detected in meat color and tenderness changes during meat storage. Dried meat color stability and structure mechanical properties possible provide by adding of sodium monophosphate at marinade.

Acknowledgment

The work of the doctoral student L. Silina is supported by the ESF project No.2009/0180/1DP/1.1.2.1.2./ 09/IPIA/VIAA/017.

This research and publication have been prepared also within the State Research Programme 'Sustainable use of local resources (earth, food, and transport) – new products and technologies (NatRes)' (2010.-2013.) Project No. 3. 'Sustainable use of local agricultural resources for development of high nutritive value food products (Food)'.

References

1. Bondaruk J., Markovski M., Błaszczak W. (2007) Effect of Drying Conditions on the Quality of Vacuum-Microwave Dried Potato Cubes. *Journal of Food Engineering*, Vol. 81, p. 306–312.
2. Bowser T.J., Frazier R.S., Weckler P.R., Kowalski S.J. (2009) Optimizing jerky drying time with minimal product impact. *The Open Food Science Journal*, Vol. 3, p. 79–83.
3. Burke R. M., Monahan F. J. (2003) The tenderisation of shin beef using a citrus juice marinade. *Meat Science*, No. 63, p. 161–168.
4. Drouzas A., Shubert H., (1996) Microwave application in vacuum drying of fruits. *Journal of Food Engineering*, Vol. 28, p. 203–209.
5. Ergezer H., Gocke R. (2011) Comparison of Marinating with Two Different Types of Marinade on Some Quality and Sensory Characteristics of Turkey Breast Meat. *Journal of Animal and Veterinary Advances*, Vol. 10, No. 1, p. 60–67.

6. Erle U., Shubert H. (2001) Combined osmotic and Microwave-Vacuum Dehydration of Apples and Strawberries. *Food Engineering*, Vol. 49, No.2, p. 193–199.
7. Franco D., Gonzalez L., Bispo E., Latorre A., Moreno T., Sineiro J., Sanchez M., Nunez M.J. (2012) Effects of calf diet, antioxidants, packaging type and storage time on beef steak storage. *Meat Science*, Vol. 90, p. 871–880.
8. Kargiotou C., Katsanidis E., Rhoades J., Kontominas M., Koutsoumanis K. (2011) Efficacies of soy sauce and wine base marinades for controlling spoilage of raw beef. *International Journal of Food Microbiology,* No. 28, p. 158–163.
9. Knoerzer K., Regier M., Schubert H. (2006) Microwave Heating: a New Approach of Simulation and Validation. *Chemical Engineering and Technology,* Vol. 9, No.7, p. 796–801.
10. Murphy M.A., Zerby H.N. (2004) Prerigor infusion of lamb with sodium chloride, phosphate, and dextrose solutions to improve tenderness. *Meat Science,* Vol. 66, p. 343–349.
11. O'Sullivan A., O'Sullivan K., Galvin K., Moloney A.P., Troy D.J., Kerry J.P. (2002) Grass silage versus maize silage effects on retail packaged beef quality. *Journal of Animal Science,* Vol. 80, p. 1556–1563.
12. Pathania A., McKee S. R., Bilgili S. F., Singh M. (2010) Antimicrobial activity of commercial marinades against multiple strains of *Salmonella* spp. *International Journal of Food Microbiology,* No. 139, p. 214–217.
13. Sheard P.R., Tali A. (2004) Injection of salt, tripolyphosphate and bicarbonate marinade solutions to improve the yield and tenderness of cooked pork loin. *Meat Science*, Vol. 68, p. 305–311.
14. Skandamis P.N., Nychas G.J.E. (2002) Preservation of fresh meat with active and modified atmosphere packaging conditions. *International Journal of Food Microbiology,* Vol. 79, p. 35−45.
15. Vacuum microwave drier MUSSON-1 (2007) Technical specification. Sankt-Petersburg, p.49 (in Russian).
16. Vergara H., Gallego L., García A., Landete-Casillejos T. (2003) Conservation of *Cervus elaphus* meat in modified atmospheres. *Meat Science*, No. 65, p. 779–783.
17. Yang H.S., Hwang Y.H., Joo S.T., Park G.B. (2009) The physicochemical and microbiological characteristics of pork jerky in comparison to beef jerky. *Meat Science,* Vol. 82, p. 289−294.
18. Yongsawatdigul J., Gunasekaran S., (1996) Microwave-vacuum drying of cranberries: Part 2. Quality evaluation. *Food Processing and Preservation,* Vol. 20, p. 145–156.
19. Санитарно–эпидемиологические правила и нормативы „Гигиенические требования к безопасности и пищевой ценности пищевых продуктов, СанПин 2.3.2.1078–01" (01.07.2002) / Enactment date of sanitary and epidemiological rules and regulations "Hygienic Requirements for Safety and Nutrition Value of Food Products. Sanitary Rules and Regulations (SanPin) 2.3.2.1078–01" (01.07.2002).