LWT - Food Science and Technology 64 (2015) 1217–1224

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Production process and quality of two different dry-cured sheep hams from Western Balkan countries

Sandra Stojković [a], Vladana Grabež [b], Milena Bjelanović [b], Snježana Mandić [a], Goran Vučić [a], Aleksandra Martinović [c], Torunn Thauland Håseth [d], Ana Velemir [a], Bjørg Egelandsdal [b, *]

[a] University of Banja Luka, Faculty of Technology, Department of Food Technology and Biotechnology, Vojvode Stepe Stepanovića 73, 78 000 Banja Luka, Bosnia and Herzegovina
[b] Norwegian University of Life Sciences, Department of Chemistry, Biotechnology and Food Science, P.O. Box 5003, N-1432 Aas, Norway
[c] University of Donja Gorica, Faculty of Food Technology, Food Safety and Ecology, Donja Gorica bb, 81000 Podgorica, Montenegro
[d] Animalia, Lørenveien 38, P.O. Box 396 Økern, N-0513 Oslo, Norway

ARTICLE INFO

Article history:
Received 14 January 2015
Received in revised form
26 June 2015
Accepted 10 July 2015
Available online 13 July 2015

Keywords:
Stelja
Sheep ham
Volatile compounds
Sensory properties

ABSTRACT

Differences in the production process, the composition of volatile compounds (VOCs), physicochemical parameters and sensory properties were studied in *Stelja* sheep ham, produced in Bosnia and Herzegovina (B&H) and Montenegro (MN) using different technologies. Gas Chromatography–Mass Spectrometry was used for the analysis of volatile compounds. MN sheep hams were featured with more intense smoke flavour, relatively higher salt content (6.4% w/w) and a one week salting period. The most prominent smoke compounds identified in MN hams were furans and phenols. Furthermore, lipid degradation compounds (butanal, hexanal, heptanal, 2,3-pentanedione, and 1-hydroxy-2-propanone) differed among the two ham productions, being more abundant in MN hams, yet the products were not evaluated as rancid. B&H hams were less salty (4% w/w after 3 weeks of salting), with a distinct garlic and metallic flavour and a more acidic taste compared to MN hams. Metabolites of the B&H hams implied that, due to the longer salting step, fermentation by microorganisms could have occurred. Differences in process technology significantly influenced the composition of volatile compounds and sensorial properties of these products produced in neighboring geographical areas.

1. Introduction

Dry-cured sheep meat traditionally produced in the Western Balkan countries is often made using sheep aged between 1 and 6 years. The name *Pastrma* refers to salted, smoked and dried sheep carcasses (Stamenković & Dević, 2006). Užice sheep *Pastrma* (Serbia) consists of the whole carcass after cutting along sternum and pelvic and removing head, organs and spinal cord from the inside of the carcass. Kidneys with fat are kept on the carcass. Leg muscles are removed for ham production. Salted and dried sheep meat without bones is called *Stelja*. In Zlatibor (Serbia) mountain region, sheep ham and *Stelja* were produced by using nitrite and nitrate during a 28–42 days period (Troeger, Vesković-Moračanin, Turubatović, Ristić, & Dederer, 2009). In B&H *Stelja*, ham and shoulder are typical sheep products (Ganić, Čaušević, Karahmet, Stojković, & Ratković, 2013; Operta, Smajić, Tahmaz, & Ganić, 2010). In B&H garlic and pepper are added in some regions with salt to achieve characteristic aroma to the product (Ganić et al., 2013). The eastern part of B&H uses dry spruce branches during the first few days of smoking to obtain gold-yellow colour and specific aroma (Ganić, 2012). The former Yugoslav Republic of Macedonia has its own *Pastrma* produced from deboned sheep carcass using characteristic processing steps like wrapping of the product in sheep skin or sprinkling it with corn flour (Džinleski, 1969). *Kastradina* (Croatia) is produced during 43 and 73 days from sheep haunch, shoulder, and "kora" (remaining part of carcass) using salting (sea salt, with or without spices), washing, drying-smoking, and ripening (Krvavica, Friganović, Đugum, & Kegalj, 2009; Krvavica et al., 2011).

Mediterranean countries consider dry-salted and dried sheep meat as a regional, traditional product (Villalobos-Delgado et al.,

* Corresponding author.
E-mail address: bjorg.egelandsdal@nmbu.no (B. Egelandsdal).

http://dx.doi.org/10.1016/j.lwt.2015.07.022
0023-6438/

2014). However, North–Europe has also traditionally produced dried sheep and lamb in the Faeroe Islands, Iceland and Norway (Håseth, Thorkelsson, Puolanne, & Sidhu, 2014). The Faeroe Islands have a unique air-dried and unsalted lamb meat product named *Skerpikjøt*. Norway has a protected product from dry-cured lamb or sheep leg called *Fenalår*. The production varies in salt content, the use of nitrite, smoke, and flavour additives, and the entire processing takes 90 days (Håseth et al., 2014).

The number of publications related to Western Balkan lamb and sheep dry-cured ham is small (Ganić, 2012; Ganić et al., 2013; Krvavica et al., 2009, 2011; Operta et al., 2010; Stamenković & Dević, 2006; Troeger et al., 2009) as for other parts of Europe (Håseth et al., 2014; Villalobos-Delgado et al., 2014). Chemical characterization of sheep hams is useful for understanding and comparing sensory properties of specific regional products, but is largely missing in the literature.

The present study focuses on *Stelja* production from two regions of Western Balkan, *i.e.* from B&H and Montenegro. From B&H the dry-cured product studied was typical for the Vlašić region while Montenegro has only one production process. Both products are produced by the local sheep Pramenka. The dry-cured sheep meat in B&H and MN is mostly produced in local butchers' during the winter and spring season (Stamenković & Dević, 2006) in small quantities. Nevertheless, larger scale production has been established during the last decade mimicking the old traditional production processes.

This study was designed to describe the differences in salt content, development of volatile compounds, organic acid profiles and sensory attributes of traditional, dry cured sheep ham produced in different regions of Western Balkan (B&H and MN).

2. Materials and methods

Fifteen sheep of the Vlašićka Pramenka from mountain Vlašić (B&H) and 15 sheep of Pivska Pramenka from Pljevlja area (MN) were obtained. The animals were approximately 5 years old, taken from the same herd and production system.

2.1. Raw materials and processing

After slaughtering (at 10 °C), the carcasses were chilled at +4 °C for 24 h. Carcasses were deboned, but shin bones (*Os tibia et Os fibula*) were kept for hanging the carcass in a smoke house. The pH was measured 24 h *post mortem* in *M. semimembranosus* using pH meters: HANNA 99161 (Cluj-Napoca, Romania) for B&H animals and Knick Portamess 913 (Berlin, Germany) for MN animals.

2.1.1. Bosnia and Herzegovina

The weight of sheep carcasses used in B&H ham production was 25.0 ± 3.1 kg with EU fat scores in a range 8–12 (scale 1–15 points). Average $pH_{24\ h}$ of the thigh was 5.87. The ham was cut by a butcher. Salting was done by rubbing coarse salt (no nitrite) on the surface (35 g NaCl/kg) with peppercorn (0.3% w/w) and crushed garlic (~0.3% w/w). Salted carcasses were placed horizontally in plastic containers, pressed with 100 kg during the first week, up to 200 kg during the second week, and to 300 kg during the third week to facilitate removal of blood and brine. Carcasses were left in their own brined juice for 21 days (at 4–10 °C, RH 85–90%). Drying and cold smoking with beech wood and sometimes sawdust was conducted in a traditional smoke house (12–18 °C, RH 70–80%), approximately 2 h per day for 14 days. The distance between stokehole and meat was about 2–3 m. Ripening in an aerated room without smoke (7–10 °C, RH 70–80%) lasted 7 days. The *Stelja* production process lasted for 42 days. The weight loss was 14.73%.

2.1.2. Montenegro

Sheep carcasses for MN ham production were 27.3 ± 3.6 kg with EU fat score in the range 6–11 (scale 1–15 points). Average $pH_{24\ h}$ was 5.58. The production took place in an industrial facility, following the same steps that are used in the traditional production. Carcasses were covered by salt (35–40 g NaCl/kg) and kept in plastic containers for 7 days (4–8 °C, RH 85–90%). Surplus salt was removed by quick immersion into water, followed by drying for 8 h (13–15 °C, RH 70%). The cold smoking process, regulated with airflow, was conducted 4 h/day for 7 days with controlled parameters: 15–18 °C, RH 75–80%. Smoke was generated by glowing beech wood in a smoke generator. The ripening phase continued in a chamber with controlled conditions (10 °C, RH 65–70%) for additional 15 days. Industrial production of *Stelja* lasted 29 days and the weight loss was 28%.

2.2. Chemical and sensory analysis of the products

Sheep ham was removed from dry-cured carcass called *Stelja* and sample of *M. Semimembranosus* was vacuum-packed in plastic bags and stored (+4 °C, in the dark, up to 2 months). The samples were than subjected to sensory analysis while the samples for volatile and chemical analysis were manually cut (2 × 2 × 2 mm^3 pieces) and frozen at −80 °C until analysis.

Chloride content was determined using the methodology suggested by Håseth, Egelandsdal, Bjerke, and Sørheim (2007). The obtained results are presented as % w/w NaCl.

Samples for HPLC quantitative analysis of organic acids were prepared and analysed by the method described by Narvhus, Østeraas, Mutukumira, and Abrahamsen (1998).

Volatile compounds were analysed using Gas Chromatography–Mass Spectrometry (GC–MS) using 2 g of the sample, in three replicates. The samples were analysed by a dynamic headspace collector (Teledyne Tekmar HT3, Ohio, USA) coupled with gas chromatograph 6890 and mass spectrometer 5975 (Agilent technologies Santa Clara, CA, USA). Volatiles were separated using a DB-water fused silica capillary column (J&W Scientific; 30 m; 0.25 mm i.d., film thickness 0.50 μm). Helium flow was 1 mL/min. The temperature program was as follows: 30 °C for 10 min, ramped 1 °C/min to 40 °C than 3 °C/min to 70 °C, and 6.5 °C/min to 230 °C, holding 5 min at 230 °C. GC/MS interface was set on 250 °C. Mass spectrum was obtained by electronic impact at 70 eV with recorded mass range 30–550 *m/z*. The volatiles were identified comparing the obtained mass spectrum with the mass spectrum in the NIST 05 (Mass Spectral Library, Agilent technologies Santa Clara, CA, USA). If the probability of correct identification of each volatile was below 60%, the component was discarded.

To exclude contamination from GC data set, GC–MS analysis were performed with samples of plastic bags in laboratory air under the same conditions as volatile analysis. Semi-quantitative amounts of volatiles were calculated using pentanal run routinely as an external standard at low and high concentrations. Other chemical groups were also run as external standards but pentanal had, in retrospective, the most suitable dynamic range.

The slices (1.5 mm thick) of *M. Semimembranosus* were sensory evaluated by 8 trained panellists in a room equipped with fluorescent lighting (at 25 °C). The evaluators were provided with 50 mL of water and 20 g of unsalted bread to rinse their palate. The panel was trained on different sensory attributes of *Stelja*, such as, appearance (fat yellowness, redness, marbling), texture (fat firmness, hardness, dryness, juiciness), flavour (smoke, garlic, saltiness, bitterness, acidity, mature, cured, metallic, rancid, and soapy), and aroma intensity. The sensory evaluation of sheep ham was carried out by a 9 point structured scale, using quantitative-descriptive analysis (Hootman, 1992).