Effect of Storage Temperature on the Quality of Dry Fermented Sausage Poličan

Josef KAMENÍK[1], Alena SALÁKOVÁ[1], Gabriela BOŘILOVÁ[1], Zdeněk PAVLÍK[1], Eva STANDAROVÁ[2] and Ladislav STEINHAUSER[1]

[1]Department of Meat Hygiene and Technology and [2]Department of Milk Hygiene and Technology, Faculty of Veterinary Hygiene and Ecology, University of Veterinary and Pharmaceutical Sciences in Brno, Brno, Czech Republic

Abstract

Kameník J., Saláková A., Bořilová G., Pavlík Z., Standarová E., Steinhauser L. (2012): **Effect of storage temperature on the quality of dry fermented sausage Poličan**. Czech J. Food Sci., **30**: 293–301.

The influence of different storage temperatures (5°C and 15°C) on the quality of vacuum-packed dry fermented sausage Poličan was determined. The salami mixture, finished salamis (the maturing period of 30 days), and salamis stored for 30, 60, 90, and 120 days were analysed. The analyses performed (physical/chemical, sensory, microbiological) found no differences in sensory properties or basic physical/chemical and microbiological parameters in the products after storage under different temperature conditions for 120 days. When stored at 15°C, the total content of biogenic amines in samples was higher than that for samples stored at 5°C with statistical differences $P \leq 0.05$. If the principles of good manufacturing practice are observed at all phases of the technological process, the storage temperature of 15°C does not represent a risk as the consequent concentration of biogenic amines and polyamines remains extremely low.

Keywords: vacuum-packed products; oxidation changes; sensory evaluation; biogenic amine and polyamine content; chemical parameters

Dry fermented saausages are an important product group in the meat processing industry. Production has increased enormously in the Czech Republic since 1990, and now amounts to more than twenty thousand tons a year (Kameník 2011).

The production technology of these products includes a period of fermentation and ripening that is differently long, during which a number of biochemical processes take place. This period generally lasts between two and four weeks for traditional fermented products. From the aspect of production and economics this relatively long technological process may lead to operational complications, as a poor estimate of supply and demand frequently leads to a shortfall or surplus of fermented salamis at shipping warehouses. In practice, some companies try to avoid any shortfall by packing these products (usually by vacuum packing) once the final maturing has been attained and then storing them until there is a commercial demand for them.

Dry fermented salamis are products that need not be stored at refrigeration temperatures. Decree No. 326 of Ministry of Agricultures of the CR (Vyhláška MZe 326/2001 Sb.), with its latest amendments, lays down in its definition of dry fermented meat products a requirement for a minimum shelf life of 21 days at a temperature of 20°C. In practice, however, the shelf life of these products is much longer, especially after vacuum

Supported by the Ministry of Education, Youth and Sports of the Czech Republic, Project No. MSM 6215712402.

packing. Meat-processing plants regularly provide a period of minimum durability of as much as 90 days. These are extremely stable products in microbiological terms that spoil only after a number of months as a result of oxidation changes in the fatty constituent. The quality of the pork backfat used plays an important role here (Leistner 1985; Stiebing *et al*. 1993; Keim & Franke 2007).

The issue of the storage temperature of dry fermented salamis is often discussed in relation to the storage of vacuum-packed products. Is it appropriate to store these products at refrigeration temperatures, i.e. in practice at around 5°C, or can higher temperatures of as much as 15°C be permitted in warehouses? There is often a lack of refrigerated storage space in meat-processing plants, and cooling is an energy-intensive process. From this aspect it is preferable to store products at higher temperatures. On the other hand, these products contain active microorganisms with functional enzymes that can, along with endogenous enzymes, further catalyse biochemical reactions that may result in substances with a negative effect on taste and aroma at later stages of storage. Since the progression of enzymatic processes is related to the environmental temperature (Kameník 2011), in order to limit this activity it is appropriate to keep these products at refrigeration temperatures.

The aim of this paper was to assess the effect of storage temperatures of 5°C and 15°C on the properties of vacuum-packed dry fermented sausage Poličan.

MATERIAL AND METHODS

One batch (150 kg) of Poličan salami was prepared at a production plant according to the company recipe. This recipe was composed of 63% lean pork (saw) meat, 4% lean beef meat and 33% pork backfat. Dextrose (0.3%), a starter culture, spices and 2.4% nitrite salting mixture were added to this mixture. The mixture was filled into 55-mm diameter fibrous casings. Fermentation started at a temperature of 24°C. After a week the temperature was reduced to 16°C, and was maintained at this level until the end of the maturing process (3 weeks). The relative humidity of the air was set at 94%, before being reduced to < 80% after a week.

Following the prescribed maturing and the attainment of shipping maturity, the products were packed on a Webomatic APS ML 7100 vacuum-packing machine (Webomatic Maschinenfabrik GmbH, Bochum, Germany) with the use of the upper foil AV 80µ (PA/PE 20/60) and lower foil AV 230µ (PA/PE 80/150).

The products were kept at temperatures of 5°C and 15°C. Samples were taken at monthly intervals for basic physical and chemical analyses, microbiological and sensory studies, and for determination of the content of biogenic amines and polyamines. The samples were analysed in triplicate. The salami mixture (0 day), salami at the end of ripening (30 days) and salamis stored for a period of 30, 60, 90, and 120 days were analysed.

Chemical parameters. The sample parameters (pH, dry matter content, fat content and amount of malondialdehyde – TBARS) were established using standard methods. The salami samples (100 g) were homogenised. The following parameters were subsequently determined: amount of dry matter [ISO 6658:1997 – Meat and Meat Products: Determination of Moisture Content (Reference Method)], muscle protein (after elimination of non-protein N-compounds by hot tannin, protein content was measured on a KJELTEC from Tecator (Hillerød, Denmark). Nitrogen was converted to crude protein using a factor of 6.25 and fat was analysed on a Soxtec (FOSS Tecator AB, Höganäs, Sweden) with diethyl ether as the extraction agent (Application Sub Note 3127, 2001).

pH values were measured with a SenTix Sp needle probe on a 340i WTW pH-meter (WTW, Weilheim, Germany). The degree of lipid oxidation was measured by reaction with thiobarbituric acid after distillation – TBARS value (thiobarbituric acid reactive substances) similarly to Castellini *et al*. (2002). Malonaldehyde was distilled in duplicate from the sample and its absorbance was determined at 532 nm in a 1-cm glass cell.

Determination of biogenic amine (BA) and polyamine (PA) content. BA and PA content was examined in the samples taken on days 90 and 120 of storage. Biogenic amines (agmatine, tryptamine, 2-phenylethylamine, cadaverine, histamine, tyramine) and polyamines (putrescine, spermidine, spermine) were established by the method of Paulsen *et al*. (1997). Quantitative analysis was performed by the RP-HPLC method with gradient elution and fluorescence detection; histamine was determined on a PDA detector.

Particular biogenic amines and polyamines were identified by means of comparing their retention times with those of standards. Identification was

carried out using an external standard. Measurements were evaluated by the Empower fluorescence software (Waters, Illinois, USA). The method was validated using the EffiValidation software (Effichem, Lysice, Czech Republic).

Instrumental measurement of colour. Colour was measured by the CIE $L^*a^*b^*$ system using a Minolta CM 2600d (Konica Minolta, Osaka, Japan). A measuring area of 3 mm, illuminant D65 and 10° standard observer were used. The instrument was standardised using a standard white plate. CIE L^* – lightness, a^* – redness, b^* – yellowness, were calculated using the available software (Spectra Magic 3.61; Konica Minolta, Osaka, Japan).

Instrumental measurement of texture. Samples were tested by Texture Profile Analysis (TPA) using an Instron Universal Testing Machine (model 5544) (Instron Corporation, High Wycombe, UK). Parameters were obtained by the available computer software (Merlin; Merlin, Richardson, USA).

For TPA cylinder, samples (1 cm high, 1.25 cm diameter) were compressed twice to 50% of their original height with a compression platen of 36 mm in diameter. Force time curves were recorded at a crosshead speed of 50 mm/min. Hardness (N) – the peak force required for the first compression and cohesiveness – the ratio of the positive force area during the second compression to that in the first compression – were evaluated (Szczesniak 2002; Desmond & Kenny 2005).

Sensory evaluation. The salamis were evaluated by an untrained panel consisting of 12 judges selected from students and staff members of the department, taking into account their habits, acquaintance with the material to be analysed, sensitivity and ability to reproduce judgments. Evaluations were performed in individual booths, prepared as described in accordance with ISO 6658:2005. Unsalted crackers and water at room temperature were provided to clean the palate between samples. The test was carried out using non-structured 100-mm hedonic scales in which the panellists evaluated different attributes: cut surface appearance, matrix, odour, colour, consistency, texture, taste and rancidity (0 = extremely unpleasant and 100 = extremely pleasant).

Microbial analysis. The microbial status of the samples was evaluated by determining the total viable count (TVC) and lactic acid bacteria count (LAB).

Total viable counts were determined using Plate Count Agar (Merck, Darmstadt, Germany) after incubation at 30°C for 48 h according to the guidelines of ČSN EN ISO 4833:2003 (Microbiology of Food and Animal Feedstuffs – Horizontal Method for the Enumeration of Microorganisms – Colony Count Technique at 30°C). For microbial enumeration, 1 ml of serial dilutions of rinse fluid (1:100–100 000) was poured onto Petri dishes. The quantification of lactic acid bacteria (LAB) was performed on de Man, Rogosa, Sharpe agar (MRS Agar, CM0361; Oxoid, Basingstoke, UK) anaerobically at 30 ± 1°C for 72 ± 3 h, in accordance with the guidelines of ČSN ISO 13721:1998 (Meat and Meat Products – Enumeration of Lactic Acid Bacteria – Colony Count Technique at 30°C). All analyses were performed in duplicate. The number of formed colonies was counted and reported as $\log_{10}$ of CFU/g for each sample.

Data analysis. Statistical data analyses were conducted using the statistical program STATISTICA 7 CZ (StatSoft, Prague, Czech Republic). Student's *t*-test was applied for the determination of differences between storage temperatures. The 0.05, 0.01, and 0.001 levels of significance were used.

RESULTS AND DISCUSSION

The results of the physicochemical, microbiological and sensory analyses of vacuum-packed Poličan salami samples stored at 5°C and 15°C are shown in Tables 1–4 and Figure 1. The data are expressed as the means of the analysed values, including standard deviations.

Physicochemical parameters

Table 1 shows the results of the basic physical and chemical analyses; specifically pH values, content of dry matter, fat and TBARS value.

The pH of the salami fell from the initial value of 5.93 (day 0) to the value of 5.04 after 30 days of ripening. During storage, a slight increase of around 0.1 was recorded after 30 days, and this value remained practically unchanged during further storage. Samples stored at 15°C showed higher values of pH in comparison with those stored at 5°C. The differences amounting pH to 0.01–0.03 were statistically significant ($P \leq 0.001$).

Changes in the pH value during fermentation and maturing (ripening) are of great importance for dry fermented salamis made in the Czech Republic. The pH is controlled by the addition

Table 1. The physicochemical parameters of dry fermented sausages

		pH value (–)	Dry matter (%)	Fat (%)	TBARS (mg/kg)	Water/protein ratio
Sausages	0 day	5.93^{a} ± 0.03	50.81^{a} ± 0.78	33.00^{a} ± 2.13	1.33^{a} ± 0.32	3.83
	30 day	5.04^{b} ± 0.07	73.48^{b} ± 0.78	46.08^{b} ± 0.92	2.22^{b} ± 0.19	1.58
Storage period						
30 days	5°C	5.16^{a} ± 0.02	73.70^{a} ± 0.39	44.87^{a} ± 1.30	1.35^{a} ± 0.24	1.59
	15°C	5.18^{a} ± 0.03	73.96^{a} ± 0.30	45.23^{a} ± 1.20	1.34^{a} ± 0.32	1.59
60 days	5°C	5.06^{a} ± 0.02	73.88^{a} ± 0.49	44.88^{a} ± 1.56	2.72^{a} ± 0.46	1.58
	15°C	5.09^{b} ± 0.01	74.11^{a} ± 0.54	45.42^{a} ± 0.96	2.28^{a} ± 0.42	1.55
90 days	5°C	5.15^{a} ± 0.02	74.19^{a} ± 0.49	45.22^{a} ± 1.41	1.15^{a} ± 0.17	1.59
	15°C	5.16^{a} ± 0.01	74.86^{b} ± 0.29	45.42^{a} ± 1.33	1.25^{a} ± 0.18	1.50
120 days	5°C	5.11^{a} ± 0.02	75.18^{a} ± 0.51	45.94^{a} ± 0.85	1.78^{a} ± 0.16	1.46
	15°C	5.14^{b} ± 0.01	75.28^{a} ± 0.47	47.23^{b} ± 1.01	1.30^{b} ± 0.21	1.46

TBARS – thiobarbituric acid reactive substances; $^{a–b}$statistical differences $P \leq 0.05$ between 5°C and 15°C; $^{a–a}$no statistical differences between 5°C and 15°C

of saccharides (which determines the final pH value), by the application of starter cultures and by the temperature of the external environment which has a particular influence on the speed of fermentation (Stahnke & Tjener 2007). The final pH values attained by Poličan sausages, at which any fall in pH is halted, are generally 4.80–4.90 (Kameník 2011). These values are attained after 24–48 h and are dependent on the conditions mentioned above (type of starter culture, environmental temperature, type and amount of saccharide used). A gradual increase in the pH value can be expected towards the end of maturing as a result of ongoing proteolytic changes (Feiner 2006). The tests performed by Saláková *et al.* (2010) showed a rise in the pH value during the first month of storage of Poličan salami at 15°C from 4.80 to 5.00. With further storage, the pH continued to increase to as much as 5.25 after five months of storage.

In our study we saw a fall in the pH value after 30 days of maturing to 5.04 ± 0.07. During the first month of storage the pH increased again (to 5.16 at 5°C and 5.18 at 15°C) and subsequently remained at a comparable level for the duration of the study. Practically identical results were obtained for Poličan salami by Komprda *et al.* (2001). As the values of pH we found were higher from the first month of storage for samples stored at 15°C (statistically significant difference $P \leq 0.001$) we can deduce higher proteolytic activity in products stored in this way in comparison with those stored at 5°C.

The determination of thiobarbituric acid reactive substances is one of the commonest tests used to evaluate the advancement of oxidation process. Statistically significant differences ($P \leq 0.001$) between types of storage (5°C and 15°C) were determined after 120 days of storage. For samples stored at 5°C statistically significant differences were determined between the values after 30 days and 60 days of storage ($P \leq 0.001$), after 60 and 90 days of storage ($P \leq 0.001$) and after 90 and 120 days of storage ($P \leq 0.001$). For samples stored at 15°C statistically significant differences were observed between the values recorded after 30 and 60 days of storage ($P \leq 0.001$) and after 90 and 120 days of storage ($P \leq 0.001$).

The monitoring of oxidation changes in salamis is absolutely essential to the assessment of their quality and shelf life, as these products are characterised by high microbial stability, and when they go off, it is practically always a consequence of oxidation of the fats they contain. Determining the content of malondialdehyde is a suitable method for comparing samples of the same type at various phases of oxidation. The results obtained indicate that different temperatures in the course of storage did not have a significant effect on the progression of oxidation changes. When monitoring the exact course of oxidation during a long storage period, it is appropriate for this test to be supplemented by another kind of test in view of the fact that the malondialdehyde produced may later react with other constituents such as amino acids, sugars and nitrites, which

means that the values of TBARS may rise and fall repeatedly in the course of storage (Rubio *et al*. 2008). However, this method provides extremely precise results when samples of the same type are compared at various phases of oxidation or under various storage conditions.

On the basis of the results of this study, different temperature can be said not to have a significant influence on the course of oxidation changes during storage. This finding corresponds to those of other authors who have come to the conclusion that for example the method of packaging has a much more significant influence on meat products than the storage temperature (Zanardi *et al*. 2002).

Biogenic amine and polyamine contents

When stored at 15°C, the total content of biogenic amines in both months was higher than that for samples stored at 5°C with statistical differences $P \leq 0.05$ (Table 2). For particular biogenic amines and polyamines, statistical differences were recorded between the storage temperatures after 90 and 120 days of storage for 2-phenylethylamine, putrescine, cadaverine, histamine and tyramine ($P \leq 0.05$). For storage at 15°C no statistically significant differences were found between the values after 90 and 120 days of storage. For storage at 5°C the statistically signifiant differences were found between values after 90 and 120 days of storage only for putrescine ($P \leq 0.05$).

The fermentation of meat products creates appropriate conditions for the formation of biogenic amines (Vidal-Carou *et al*. 2007). They include microbial growth and proteolysis, during which the concentration of amino acids is increased. The greater availability of free amino acids as potential precursors to amines may increase the production of biogenic amines (Bover-Cid *et al*. 2006).

Although commercially used strains of starter cultures are tested for the ability to produce biogenic amines and only bacteria with negative decarboxylation activity are used, biogenic amines still appear in final fermented salamis. Their gross values generally fall within a range of tens to hundreds of mg/kg (Standara *et al*. 1994; Coïsson *et al*. 2004; Komprda *et al*. 2004). The hygienic quality of raw meat, selection of ingredients, checks on the period of storage and temperature are all important factors from the aspect of preventing the formation of biogenic amines in fermented meat products.

In the present study, the content of total BA and PA was 91 mg/kg for vacuum-packed Poličan stored for 90 days. The quantitatively most important BA were tyramine (47 mg/kg), 2-phenylethylamine (24 mg/kg), histamine (11 mg/kg), and putrescine (5 mg/kg). Similar results were already published previously. For unpacked fermented Poličan sausages, Komprda *et al*. (2001) found, at the end of the maturing period (42 days), 183 mg/kg of total BA, with the principal BA being tyramine (86 mg/kg) and putrescine (54 mg/kg). Similarly, Eerol *et al*. (1998) recorded 82 mg/kg of tyramine

Table 2. The content of biogenic amines and polyamines (mg/kg)

	After 90 days of storage		After 120 days of storage	
	5°C	15°C	5°C	15°C
Tryptamine	$2.36^{a} \pm 0.07$	$2.38^{a} \pm 0.07$	$2.31^{a} \pm 0.04$	$2.37^{a} \pm 0.05$
Agmatine	$0.33^{a} \pm 0.33$	$0.53^{a} \pm 0.59$	$0.02^{a} \pm 0.04$	$0.32^{b} \pm 0.11$
2-Phenylethylamine	$16.17^{a} \pm 1.99$	$23.99^{b} \pm 3.67$	$13.67^{a} \pm 1.15$	$23.79^{b} \pm 1.68$
Putrescine	$2.76^{a} \pm 1.48$	4.65 ± 3.29	$0.81^{a} \pm 0.78$	$4.10^{b} \pm 1.89$
Cadaverine	$0.13^{a} \pm 0.07$	$0.33^{b} \pm 0.26$	$0.07^{a} \pm 0.05$	$0.51^{b} \pm 0.27$
Histamine	$11.76^{a} \pm 0.86$	$11.15^{b} \pm 0.92$	$10.87^{a} \pm 0.20$	$11.14^{b} \pm 0.26$
Tyramine	$38.40^{a} \pm 8.76$	$47.04^{b} \pm 8.14$	$37.25^{a} \pm 6.04$	$45.17^{b} \pm 8.64$
Spermidine	$0.08^{a} \pm 0.11$	$0.07^{a} \pm 0.12$	$0.20^{a} \pm 0.11$	$0.09^{a} \pm 0.11$
Spermine	$1.23^{a} \pm 0.66$	$1.18^{a} \pm 0.39$	$2.24^{a} \pm 0.49$	$1.23^{b} \pm 0.57$
Total amines contents	73.23^{a}	91.31^{b}	67.44^{a}	88.73^{b}

$^{a–b}$statistical differences $P \leq 0.05$ between 5°C and 15°C; $^{a–a}$no statistical differences between 5°C and 15°C

in samples of Finnish fermented sausages from a commercial chain. Data relating to the content of BA in vacuum-packed sausages is, however, sporadic. Komprda *et al*. (2004) compared data on Paprikáš and Herkules sausages in relation to the formation of BA in unpacked and vacuum-packed sausages. However, no unambiguous conclusions could be drawn from their results. For Paprikáš sausage at the end of the storage period (13 weeks) the values of total BA for vacuum-packed sausages were lower than for unpacked sausages (115 and 88 mg/kg), while the opposite was true for Herkules sausage.

In both months, the total content of biogenic amines was higher in samples stored at 15°C than in sausages stored at 5°C. This can be explained again by increased proteolytic activity at higher temperatures. The increase in biogenic amine content at higher storage temperatures corresponds with the results of other studies (Komprda *et al*. 2001).

A fall in the total biogenic amine content was seen after 120 days of storage, both for samples stored at 5°C, for which certain differences were statistically significant, and for samples stored at a temperature of 15°C. A similar decline in BA formation at the end of the storage period was also discovered in Azetao cheese (Pinho *et al*. 2001). An increase in the content of biogenic amines during the first three to four months of storage can be expected with a view to previous works (Komprda *et al*. 2004).

Microbial parameters

The log CFU values for the total number of microorganisms and for lactic acid bacteria in 1 g of product are shown in Table 3. The population of lactic acid bacteria, and thereby the TVC, was influenced by the addition of starter cultures to the sausage mixture; the numbers of bacterial cells increased further after 30 days of maturing to approximately 8 log TVC/g in the case of lactic acid bacteria and log 9 CFU/g in the case of TVC. The populations of both bacterial groups remained at these values for the duration of the study.

Lactic acid bacteria in the mixture of dry fermented sausages play a fundamental part in the correct progress of the production process. Their population is influenced by the initial ingredients, and in particular the animal meat used (Talon *et al*. 2007). The addition of starter cultures that ensure a sufficient concentration of lactic acid bacteria for proper fermentation at the very beginning of production is commonplace today (Kameník 2011). The values for the number of lactic acid bacteria expressed as log CFU/g discovered are in accordance with the figures given in the literature (Drosinos *et al*. 2005; Silvestri *et al*. 2007) and demonstrate the correct progress of fermentation, which was also confirmed by the sensory analysis of the products.

Table 3. Total viable count (TVC) and lactic acid bacteria count (LAB) (log CFU/g)

		TVC	LAB
Beginning		$6.18^{a} \pm 0.18$	$6.02^{a} \pm 0.21$
End of ripening (30 day)		$8.99^{b} \pm 1.38$	$7.57^{b} \pm 0.51$
Storage period			
30 days	5°C	$7.35^{a} \pm 0.74$	$7.46^{a} \pm 0.56$
	15°C	$8.04^{b} \pm 1.25$	$7.65^{a} \pm 0.85$
60 days	5°C	$7.18^{a} \pm 0.51$	$6.89^{a} \pm 0.12$
	15°C	$7.97^{a} \pm 0.89$	$7.40^{a} \pm 0.69$
90 days	5°C	$7.00^{a} \pm 3.21$	$7.11^{a} \pm 1.03$
	15°C	$7.13^{a} \pm 0.60$	$6.97^{a} \pm 0.39$
120 days	5°C	$8.44^{a} \pm 1.60$	$7.18^{a} \pm 0.68$
	15°C	$8.51^{a} \pm 1.16$	$6.80^{a} \pm 0.54$

$^{a-b}$statistical differences $P \leq 0.05$ between 5°C and 15°C; $^{a-a}$no statistical differences between 5°C and 15°C

Colour, texture, and sensory evaluation

The colour of meat products is an important parameter by which a number of physical and chemical changes to the product can be assessed. It also has a significant influence on sensory assessment. Sausages stored at a temperature of 15°C had a higher proportion of red colour and a higher proportion of yellow colour in comparison with sausages stored at 5°C. These differences were not, however, statistically significant. Sausages darken in the course of the maturing process; a fall in L^* value occurred in the course of storage in comparison with the values seen at the end of maturing (Table 4). An instrumental assessment of texture was performed by means of a texture profile analysis (TPA). The parameters assessed were the maximum force required for the initial compression of the sample (hardness) and cohesiveness (Table 3). After 30 days of storage, the hardness was lower in comparison with the values obtained

Table 4. Colour and texture characteristics of dry fermented sausages

		L^*	a^*	b^*	Hardness (N)	Cohesiveness (–)
Beginning		$55.08^{a} \pm 3.56$	$14.89^{a} \pm 1.98$	$9.06^{a} \pm 1.23$	–	–
End of ripening (30 day)		$50.25^{b} \pm 1.78$	$16.66^{b} \pm 1.39$	$8.55^{a} \pm 0.96$	66.87 ± 8.71	1.35 ± 0.02
Storage period						
30 days	5°C	$48.76^{a} \pm 3.71$	$14.48^{a} \pm 2.47$	$7.25^{a} \pm 1.28$	$60.82^{a} \pm 1.89$	$1.37^{a} \pm 0.01$
	15°C	$46.05^{a} \pm 1.43$	$16.12^{a} \pm 0.86$	$8.12^{a} \pm 0.55$	$60.45^{a} \pm 2.31$	$1.39^{a} \pm 0.01$
60 days	5°C	$48.67^{a} \pm 0.97$	$15.67^{a} \pm 0.67$	$7.91^{a} \pm 0.67$	$62.05^{a} \pm 4.29$	$1.38^{a} \pm 0.01$
	15°C	$49.17^{a} \pm 1.69$	$15.79^{a} \pm 1.14$	$8.77^{b} \pm 0.90$	$66.45^{a} \pm 2.31$	$1.37^{a} \pm 0.02$
90 days	5°C	$49.14^{a} \pm 2.70$	$15.09^{a} \pm 1.71$	$8.16^{a} \pm 1.18$	$58.02^{a} \pm 5.79$	$1.41^{a} \pm 0.01$
	15°C	$48.39^{a} \pm 1.65$	$15.48^{a} \pm 1.14$	$8.70^{a} \pm 0.60$	$61.02^{a} \pm 4.38$	$1.42^{a} \pm 0.02$
120 days	5°C	$48.14^{a} \pm 2.17$	$14.76^{a} \pm 1.57$	$8.36^{a} \pm 0.81$	$63.82^{a} \pm 2.64$	$1.38^{a} \pm 0.01$
	15°C	$47.92^{a} \pm 2.29$	$15.45^{a} \pm 1.42$	$8.45^{a} \pm 0.66$	$71.76^{a} \pm 0.37$	$1.36^{a} \pm 0.02$

L^* – lightness; a^* – redness; b^* – yellowness; $^{a–b}$statistical differences $P \leq 0.05$ between 5°C and 15°C; $^{a–a}$no statistical differences between 5°C and 15°C

after maturing had been completed at both storage temperatures. From the 60th day of storage onwards, the salamis stored at a temperature of 15°C were harder than those stored at 5°C. In the assessment of cohesiveness, an increase in the values was seen during storage; the cohesiveness fell after 120 days of storage. A sensory evaluation was performed at the end of maturing and in the course of storage of the sausages. The parameters assessed were appearance when sliced, colour, formulation, aroma, consistency, texture; taste, and fat quality (rancidity) (Figure 1). After 30 days of storage the salamis stored at a temperature of 5°C received a better assessment in terms of all parameters with the exception of colour, which received a more favourable assessment for sausages stored at 15°C. After 60 days of storage, the assessors recorded differences in taste and matrix between the storage temperatures, with sausages stored at a temperature of 5°C receiving a better assessment. After 90 days of storage the sausages stored at a temperature of 15°C received a worse assessment in terms of all parameters with the exception of texture and fat quality (rancidity). After 120 days, differences were observed between the storage temperatures in terms of the quality of fat, and deviations in the aroma of the salamis were also detected. In the course of storage, the

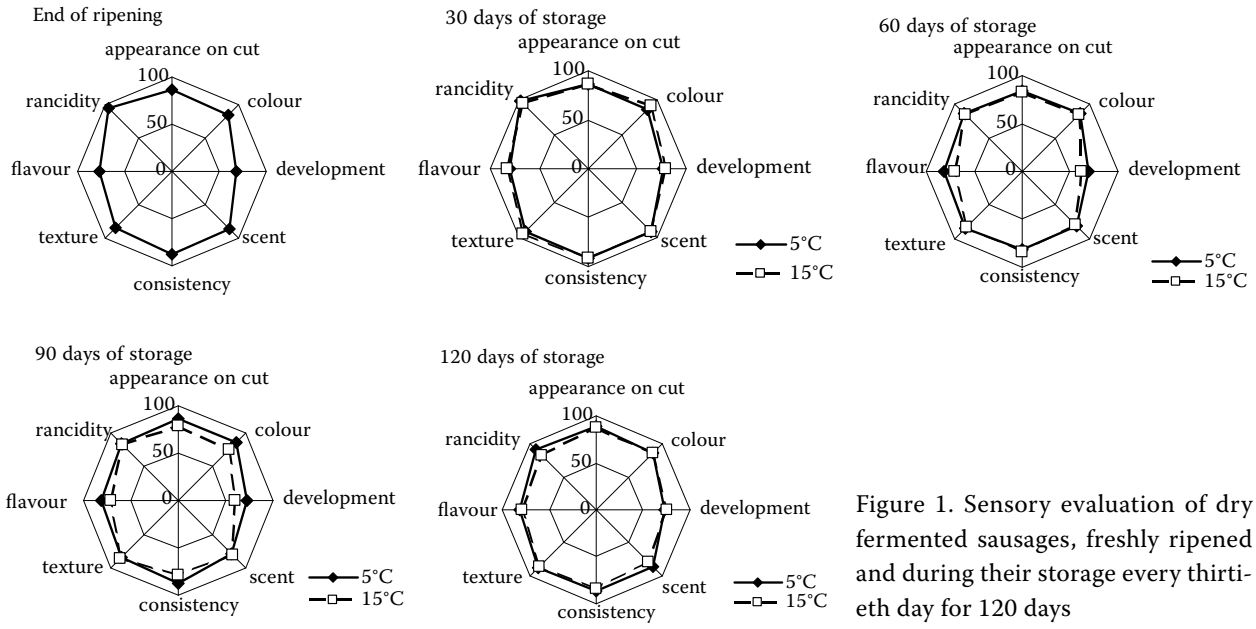

Figure 1. Sensory evaluation of dry fermented sausages, freshly ripened and during their storage every thirtieth day for 120 days

salamis received an extremely good assessment from the sensory assessors and the differences recorded were not statistically significant ($P \leq 0.05$).

Only minimal differences were found between the types of storage (5°C and 15°C), which confirms the results of sensory analysis and instrumental measurement of texture parameters. Meat colour is a critical factor for consumers, and is often the reason for the choice or rejection of products. Visual assessment of colour is closely linked to consumer assessment and sets a scale for instrumental comparison (Hunt *et al.* 1991). The sensory assessors did not record any significant differences when assessing colour. The lipid and colour stability of fermented meat products are two of the most important quality criteria during both processing and storage. Storage time affected the a^* value only. Sausages containing low fat had the lowest lightness and yellowness, but the highest redness, indicating a darker product. The high variability in lightness is a result of the high concentration of fat in the sausage formulation. However, no significant differences in lightness and yellowness were observed during the storage period. According to Soyer and Ertas (2007) only redness values were affected by storage time. Parameter a^* is influenced by the fat content (Andrés *et al.* 2006). If the fat content increases, the lightness of the meat product also increases (Ordóñez *et al.* 2001). In our study we did not find the kind of differences in fat content that would have an effect on the instrumental measurement of lightness (L^*) or the proportion of red colour (a^*).

CONCLUSION

The aim of this study was to determine the influence of different storage temperatures (5°C and 15°C) on the quality of vacuum-packed dry fermented sausage Poličan. The analyses performed (physical/chemical, sensory, microbiological) found no differences in sensory properties or basic physical/chemical and microbiological parameters in the products after storage under various temperature conditions for a period of 120 days. More significant differences were recorded in the concentration of selected biogenic amines, with the sausages stored at 15°C showing a statistically more significant content of these compounds. This finding was in agreement with data previously published in the literature and allows a recommendation of storage temperatures for dry fermented sausages up to 10°C. However, if the principles of good manufacturing practice are observed at all phases of the technological process, from the selection and treatment of the raw material and ingredients to final maturing and packing, the storage temperature of 15°C does not represent a risk for either the maker or the consumer, as the consequent concentration of biogenic amines and polyamines remains extremely low.

Acknowledgements. The team of authors would like to thank the staff of the company KMOTR-Masna Kroměříž a.s., and in particular the production director DVM František Mikeš, for their assistance in the organisation of the study and for the provision of samples.

References

Andrés S., Zaritzky N., Califano A. (2006): The effect of whey protein concentrates and hydrocolloids on the texture and colour characteristics of chicken salami. International Journal of Food Science and Technology. **41**: 954–961.

Application Sub Note 3127 (2001): Extraction of Fat in Meat and Meat Products. Foss Tecator AB Sweden.

Bover-Cid S., Miguelez-Arrizado M.J., Latorre Moratalla L.L., Vidal Carou M.C. (2006): Freezing of meat raw materials affects tyramine and diamine accumulation in spontaneously fermented salamis. Meat Science, **72**: 62–68.

Castellini C., Mugnai C., Dal Bosco A. (2002): Effect of organic production system on broiler carcass and meat quality. Meat Science, **60**: 219–225.

Coïsson J.D., Cerutti C., Travaglia F., Arlorio M. (2004): Production of biogenic amines in "Salamini italiani alla cacciatora PDO". Meat Science, **67**: 343–349.

Desmond E.M., Kenny T.A. (2005): Effect of pelvic suspension and cooking method on the processing and sensory properties of hams prepared from two pork muscles. Meat Science, **69**: 425–431.

Drosinos E.H., Mataragas M., Xiraphi N., Moschonas G., Gaitis F., Metaxopoulos J. (2005): Characterization of the microbial flora from a traditional Greek fermented salami. Meat Science, **69**: 307–317.

Eerol H.S., Roig Sagués A.X., Hirvi T.K. (1998): Biogenic amines in Finnish dry salamis. Journal of Food Safety, **18**: 127–138.

Feiner G. (2006): Meat Products Handbook. Practical Science and Technology. Woodhead Publishing Limited and CRC Press LLC, Abington.

Hunt M.C., Acton J.C., Benedict R.C., Calkins C.R., Cornforth D.P., Jeremiah L.E., Olson D.G., Salm C.P., Savell J.W., Shivas D.S. (1991): Guidelines for Meat Color Evaluation. AMSA, Champaign.

ISO 6658 (2009): Sensory Analysis – Methodology – General Guide. Czech office for Standards, Metrology and Testing: 1–23.

Kameník J. (2011): Trvanlivé masné výrobky. VFU, Brno.

Keim H., Franke R. (2007): Fachwissen Fleischtechnologie. Deutscher Fachverlag, Frankfurt am Mein.

Komprda T., Neznalova J., Standara S., Bover-Cid S. (2001): Effect of starter culture and storage temperature on the content of biogenic amines in dry fermented salami Poličan. Meat Science, **59**: 267–276.

Komprda T., Smělá D., Pechová P., Kalhotka L., Štencl J., Klejdus B. (2004): Effect of starter culture, spice mix and storage time on biogenic amine content of dry fermented salamis. Meat Science, **67**: 607–616.

Leistner L. (1985): Allgemeines über Rohwurst und Rohschinken. In: Leistner L. (ed.): Mikrobiologie und Qualität von Rohwurst und Rohschinken. Bundesanstalt für Fleischforschung, Kulmbach: 1–29.

Murphy S.C., Gilroy D., Kerry J.F., Buckley D.J., Kerry J.P. (2004): Evaluation of surimi, fat and water content in low/no added pork salami formulation using response surface methodology. Meat Science. **66**: 689–701.

Ordóñez M., Rovira J., Jaime I. (2001): The relationship between the composition and texture of conventional and low-fat frankfurter. International Journal of Food Science and Technology. **36**: 749–758.

Paulsen P., Bauer F., Vali S. (1997): Biogene Amine in Rohwuersten. 1. Methodische Aspekte zur Bestimmung biogener Amine, **77**: 450–452.

Pinho O., Ferreira Implvo., Mendés E., Oliveira B.M., Ferreira M. (2001): Effect of temperature on evolution on free amino acid and biogene amine contents during storage of Azetao cheese. Food Chemistry, **76**: 287–291.

Rubio B., Martínez B., García-Cachán M.D., Rovira J., Jaime I. (2008): Effect of the packaging method and the storage time on lipid oxidation and colour stability on dry fermented salami salchichón manufactured with raw material with a high level of mono and polyunsaturated fatty acids. Meat Science, **80**: 1182–1187.

Saláková A., Kameník J., Pavlík Z., Buchtová H. (2010): Vliv skladování syrového vepřového sádla (–18°C) na kvalitu trvanlivých fermentovaných salámů. In: XXXVI. Seminář o jakosti potravin a potravinových surovin – "Ingrovy dny", MZLU, Brno.

Silvestri G., Santarelli S., Aquilanti L., Beccaceci A., Osimani A., Tonucci F., Clementi F. (2007): Investigation of the microbial ecology of Ciauscolo, a traditional Italian salami, by culture-dependent techniques and PCR-DGGE. Meat Science, **77**: 413–423.

Soyer A., Ertas A.H. (2007): Effect of fat level and storage time on lipid oxidation and color stability of naturally fermented Turkish salamis (sucuk). Journal of Muscle Food, **18**: 330–340.

Stahnke L.H., Tjener K. (2007): Influence of processing parameters on cultures performance. In: Toldrá F. (ed.): Handbook of Fermented Meat and Poultry. Blackwell Publishing, Ames: 187–194.

Standara S., Polák P., Kameník J., Budig J. (1994): Formation and content of biogenic amine in Czech raw salamis. In: Congress 40th ICoMST, Hague.

Stiebing A., Kühne D., Rödel W. (1993): Fettqualität – Einfluß auf die Lagerstabilität von schnittfester Rohwurst. Fleischwirtschaft, **73**: 1169–1172.

Szczesniak A.S. (2002). Texture is sensory property. Food Quality and Preferences, **13**: 215–225.

Talon R., Lebert I., Lebert A., Leroy S., Garriga M., Aymerich T., Drosinos E.H., Zanardi E., Ianieri A., Fraqueza M.J., Patarata L., Lauková A. (2007): Traditional dry fermented salamis produced in small-scale processing units in Mediterranean countries and Slovakia.1: Microbial ecosystems of processing environments. Meat Science, **77**: 570–579.

Vidal-Carou M.C., Veciana-Nogués M.T., Latorre-Moratala M.L. (2007): Biogenic amines: risks and control. In: Toldrá F. (ed.): Handbook of Fermented Meat and Poultry, Blackwell Publishing, Ames: 455–468.

Vyhláška MZe č. 326/2001. Sb. Sbírka zákonů 2001, část 126: 7414.

Zanardi E., Dorigoni V., Badiani A., Chizzolini R. (2002): Lipid and colour stability of Milano-type salamis: effect of packing conditions. Meat Science, **61**: 7–14.

Received for publication July 12, 2011
Accepted after corrections October 31, 2011

Corresponding author:

MVDr. Josef Kameník, CSc., Veterinární a farmaceutická universita Brno, Fakulta veterinární hygieny a ekologie, Ústav hygieny a technologie masa, Palackého 1–3, 612 42 Brno, Česká republika
tel. + 420 541 562 008, e-mail: kamenikj@vfu.cz