Animal welfare, etológia és tartástechnológia

Animal welfare, ethology and housing systems

Volume 9 Issue 3

Különszám/Special Issue

Gödöllő

2013

CONCENTRATION OF MALONDIALDEHYDE (MDA) IN MEAT PRODUCTS DURING PRODUCTION

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Abstract
Lipid oxidation is one of the major causes of quality deterioration in meat. Lipid oxidation is induced by oxy- and/or lipid free radical generation and results in the generation of toxic compounds such as the malondialdehyde and cholesterol oxidation products. The aim of this study was carried out to determine concentrations of malondialdehyde (MDA) in meat products (salami "Malokarpatska" and "Lovecka", frankfurter, Selected ham) during technological process. This study, we have demonstrated the presence of malondialdehyde a deleterious by product of lipid peroxidation in meat products. The results unequivocally showed that adding spice to homogenized samples significantly increased the formation of lipid-peroxidation products. Also in all samples were increased concentrations of MDA in beef as raw materials. The beef samples had higher MDA than the pork, pork bacon and leathery emulsion samples.

Key words: Malondialdehyde, meat, meat products, lipid oxidation

Introduction

Food lipids are principally triacylglycerides, phospoholipids and sterolsfound naturally in most biological materials consumed as food and added as functional ingredients in many processed foods. Lipids contribute many desirable qualities to foods, including attributes of texture, structure, mouth feel, flavour and colour. However, lipids are also one of the most chemically unstable food components and will readily undergo free-radical chain reactions that only deteriorate the lipids but also: produce oxidative fragments, some of which are volatile and are perceived as the off-flavors of rancidity **(German, 1999)**. Lipid oxidation is one of the major causes of quality deterioration in meat **(Jo and Ahn, 1998)**. Lipid oxidation is often responsible for quality loss via formation of rancid flavour and is affected by the duration and temperature of storage of meat. Lipid oxidation is the major form of deterioration in stored muscle foods. Oxidative reactions in meat are the most important factor in quality losses, including flavour, texture, nutritive value and colour. Lipid oxidation is induced by oxy- and/or lipid free radical generation and results in the generation of toxic compounds such as the malondialdehyde and cholesterol oxidation products **(Sun et al., 2002)**. Over the past 30 y, there has been accumulating evidence that lipid oxidation can play an important role in the processes of atherogenesis and carcinogenesis **(Li et al., 2010)**. **Fogelman et al. (1980)** reported that malondialdehyde an obligate product of the oxidation of arachidonic acid by lipoxygenase pathways. Dietary and environmental chemicals such as N-nitrosamines and their precursors (nitrate and nitrite) and malondialdehyde involved in the etiology of cancer and other related disease conditions are part of the challenges still facing the world today **(Okafor et al., 2007)**. One of the most important preservation methods for meat and meat products since compared with other methods is freezing, it leads to a minimal loss of quality during long-term storage **(Soyer et al., 2010)**.

Since the development of oxidation process in meat is important, related to its quality and consumer´s acceptance, the aim of this study was carried out to determine concentrations of malondialdehyde (MDA) in meat products (salami "Malokarpatska" and Lovecka", frankfurter, Selected ham) during technological process.

Materials and method

Sampling was done so that the samples were representative that to have the average composition and characteristics of the goods from which they were collected. The collection sample during the manufacturing process was carried out under the following scheme. ***"Lovecka salami"*** - was collected basic raw (beef, pork and pork bacon); than samples mixed meat with additives (salt,

Sodium Ascorbate, Erythorbic acid, ground black pepper, sugar, garlic, starter culture) and finally the actual sample of the finished product after heat treatment, cooling to 25°C and drying in climates with aw = 0.95. **"*Malokarpatska salami*"** – was collected basic raw (beef, pork and pork bacon); than samples mixed meat with additives (salt, spice extracts, Sodium Nitrite, highlighter flavor, */Lactobacillus/*) and finally the actual sample of the finished product after heat treatment. ***Frankfurter*** was collected basic raw (beef, pork, pork bacon, leathery emulsion), subsequent collection of homogenised meat product with additives (salt, ground sweet and hot peppers, polyphosphates and Ascorbic acid) and finally of sample with the finish product after smoked and free cooling to a core temperature of max. 4ºC. ***Selected ham*** was collected basic raw (pork thigh), than samples of homogenized meat with additives salt, Sodium Nitrite, sodium pyrophosphate, sodium tripolyphosphate, Ascorbic acid) and finish product after heat treatment. The randomly selected 115 samples of raw materials respectively finished products were prepared for analysis.

TBARS Analysis

Spectrophotometric Method : The meat homogenate (1 mL) prepared as above was taken into a disposable test tube (10 mL), and 2 mL of the TBA (Thiobarbituric acid, Sigma Aldrich) -TCA (Trichloroacetic acid, Sigma Aldrich) solution were added. The mixture was vortexed, heated in a 90°C water bath for 15 min, cooled in ice for 10 min and 4°C, and centrifuged at 2 000 g for 15 min. The absorbance of supernatant was measured at 531 nm with a microsample spectrophotometer. Values of TBARS were converted on mg MDA concentration on 1 kg meat.

Statistical analysis

We set the basic variation statistical values (arithmetic mean, standard deviation, coefficient of variation, standard error mean, minimum value, median and maximum value). One-way analysis of variance (ANOVA) and the Dunnett´s multiple comparison test were used for statistical evaluations. The level of significance was set at A ($P<0.001$); B ($P<0.01$); C ($P<0.05$).

Results and Discussion

The development of lipid oxidation in Salami "Lovecka" is presented in Table 1. In raw materials the amounts of malondialdehyde (MDA) increase in beef meat 0.708±0.114 mg/kg meat. **Popova et al. (2009)** indicated, the amounts of MDA at beef meat during chilled storage were in the range 0.17-0.32 mg/kg meat and reached 0.64 mg/kg meat on the 90^{th} day. Significant influence ($P<0.05$) on the development of oxidation was between beef meat and pork bacon. The highest levels were measured when raw materials homogenized and added additives (salt, Sodium Ascorbate, Erythorbic acid, ground black pepper, sugar, garlic, starter culture) 0.717±0.152 mg/kg meat, while finish product contained levels 0.641 mg/kg meat. Similar situation as salami "Lovecka" was in the salami "Malokarpatska" and it is presented in Table 2. From raw materials contained the highest concentration of MDA (0.683±0.091 mg/kg meat) beef meat. **Okafor (2005, 2007)** express, that fresh beef contained non-detectable amounts of MDA even after exposure to air for 6 – 8 h. The different concentrations of this relevant lipid peroxidation product (MDA) in these analysed samples indicate the different degrees of their deterioration (rancidity). These variations in concentration may be a consequence of differences in the methods of handling, storage conditions, age and source of the samples. After blending homogenized samples with additives was concentration of MDA (0.824 mg/kg meat) increased. **Li et al., (2010)** indicated that the malondialdehyde content in the cooked burger was significantly decreased by 71% with the addition of the spice mix (1.79±0.17 µmol/250 g meat). The effects of all processing steps, including raw products, add additives, process heat treatment, storage, on the quality of lipids in the final commodity are considerable **(German, 1999).** The MDA values in finish product in salami "Lovecká" was in the range from 0.360 to 0.740 mg/kg meat and in finish product in salami "Malokarpatská" was in the range from 0.430 to 0.880 mg/kg meat. We found statistically significant differences ($P<0.05$) in the concentration of MDA between pork bacon and homogenized samples in the salami "Malokarpatská". Significantly higher concentrations of MDA are found in the pork bacon and itself finished product "Malokarpatska" salami.

Table 1

The extent of lipid oxidation (mg MDA) in *salami "Lovecka"* during technological processing

	Salami "Lovecka"					
	Beef	Pork	Pork bacon	homogenized samples	Sample before smoked	Finish product
$\bar{x}$	0.708^{A}	0.530	0.492^{A}	0.717	0.650	0.641
SD	0.114	0.221	0.143	0.152	0.101	0.103
CV	16.04	41.60	29.14	21.15	15.54	15.98
SEM	0.0328	0.0636	0.0414	0.0438	0.0292	0.02955
MIN	0.510	0.190	0.320	0.510	0.0410	0.360
Median	0.700	0.460	0.460	0.720	0.670	0.655
MAX	0.980	0.810	0.780	0.950	0.750	0.740

Legend: $\bar{x}$ - mean SD – standard deviation, CV(%) – coefficient of variation, MIN – minimum value, MAX – maximum value, ^{A}P<0.05

Table 2

The extent of l lipid oxidation (mg MDA) in *salami "Malokarpatska"* during technological processing

	Salami "Malokarpatska"					
	Beef	Pork	Pork bacon	homogenized samples	Sample before smoked	Finish product
$\bar{x}$	0.683	0.513	0.468^{AB}	0.824^{A}	0.724	0.711^{B}
SD	0.091	0.235	0.170	0.280	0.194	0.147
CV	13.45	45.79	36.36	33.97	26.73	20.62
SEM	0.027	0.068	0.049	0.081	0.056	0.042
MIN	0.550	0.190	0.320	0.360	0.360	0.430
Median	0.710	0.435	0.385	0.780	0.715	0.745
MAX	0.850	0.810	0.810	1.250	1.150	0.880

Legend: $\bar{x}$ - mean SD – standard deviation, CV(%) – coefficient of variation, MIN – minimum value, MAX – maximum value, AP<0.05;BP<0.01

In Table 3 is presented the development of MDA in the frankfurter during technological processing. There was a significant increase of MDA in beef meat 0.673 mg/kg meat and in sample before smoked frankfurter 0.592 mg/kg meat. Levels of MDA were decreased in pork bacon 0.468±0.170 mg/kg meat, leathery emulsion 0.477±0.162 mg/kg meat and finish product 0.448±0.110 mg/kg meat. There were statistically different between beef and finish product (P<0.05) and between sample before smoked and itself finish product frankfurter (P<0.01).

Table 3

The extent of lipid oxidation (mg MDA) in the *frankfurter* during technological processing

	Frankfurter					
	Beef	Pork	Pork bacon	Leathery emulsion	Sample before smoked	Finish product
$\bar{x}$	0.673^{B}	0.516	0.468	0.477	0.592^{A}	0.448^{AB}
SD	0.168	0.193	0.170	0.162	0.105	0.110
CV	24.93	37.37	36.33	33.96	17.78	24.35
SEM	0.049	0.056	0.049	0.047	0.030	0.032
MIN	0.360	0.250	0.310	0.230	0.360	0.270
Median	0.660	0.450	0.385	0.485	0.630	0.435
MAX	0.980	0.790	0.810	0.710	0.740	0.580

Legend: $\bar{x}$ - mean SD – standard deviation, CV(%) – coefficient of variation, MIN – minimum value, MAX – maximum value, ^{A}P<0.05;^{B}P<0.01

The highest levels of MDA were measured in the pork thigh as raw materials the production of selected ham (0.529±0.216 mg/kg meat)

Table 4

The extent of lipid oxidation (mg MDA) in *selected ham* during technological processing

	Selected ham			
	Pork thigh	Homogenized sample	Sample after heat treatment	Finish product
$\bar{x}$	0.529	0.524	0.493	0.473
SD	0.216	0.230	0.210	0.108
CV	40.89	43.81	42.60	22.78
SEM	0.063	0.066	0.061	0.031
MIN	0.270	0.240	0.210	0.310
Median	0.430	0.420	0.435	0.450
MAX	0.820	0.850	0.790	0.710

Legend: $\bar{x}$ - mean SD – standard deviation, CV (%) – coefficient of variation, MIN – minimum value, MAX – maximum value,

Lipid oxidation involves changes in meat colour which is one of the important quality parameters as well as is affected by the duration and temperature of storage meat **(Gatellier et al., 2005).** In order to reduce the negative impact of the oxidation on the meat quality retailers use vacuum packaging. On the other hand through vacuum packing meat continues its maturation process in a safe manner, becomes tender, with a better taste and excellent colour **(Smet et al., 2005)**.

This study, we have demonstrated the presence of malondialdehyde a deleterious by product of lipid peroxidation in meat products. The results unequivocally showed that adding spice to homogenized samples significantly increased the formation of lipid-oxidation products. **Li et al. (2010)** reported that inhibition of the formation of malondialdehyde by antioxidants during the cooking of meat products may result in reduces concentrations of malondialdehyde in plasma and urine. Also in all samples were increased concentrations of MDA in beef as raw materials. The beef samples had higher MDA than the pork, pork bacon and leathery emulsion samples. The different concentrations of this relevant lipids peroxidation product (that is MDA) in this products and samples indicate the different degrees of their deterioration. Although, the Acceptable Daily Intake (ADI) for malondialdehyde has not been set or its concentration that can cause toxicity established, increased levels of lipid peroxidation products have been associated with a variety of chronic diseases in both humans and animal model systems.

Acknowledgements

This study was supported with VEGA grant No. 1/2417/05 and KEGA 049SPU-4/2011 of the Slovak Ministry of Education.

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