International Food Research Journal 21(4): 1507-1514 (2014)
Journal homepage: *http://www.ifrj.upm.edu.my*

Effects of temperature and storage time on the quality of alimentary animal fats

*Flavia, P., Zorica, V. and Delia, B.

Technical University of Cluj-Napoca, North University Center of Baia Mare, Department of Chemistry and Biology, 76 Victoriei str., 430112, Baia Mare, Romania

Article history

Received: 9 November 2013
Received in revised form: 7 February 2014
Accepted: 8 February 2014

Keywords

Alimentary animal fat
Ooxidation
Hhydrolysis
Storage
Fatty acids profile

Abstract

Experimental research were effectuated to establish the effect of storage time under refrigeration (+2°C) and freezing (-18°C) on the quality of three alimentary animal fats: pork lard, beef tallow and poultry fat. In assessing the various stages of oxidative changes, iodine value (IV), saponification value (SV), refractive index value (RIV), peroxide value (PV) and thiobarbituric acid reactive substances test (TBARS) were determined to identify and measure primary and secondary oxidation compounds, fatty acids profile and acidity value (AV) were determined for measuring the degree of lipolysis. All quality parameters, except iodine and refractive index values, increased during storage at both temperatures. Sample of fats stored at +2°C preserved acceptable characteristics for 90 days in the case of pork lard, 150 days in the case of beef tallow and 60 days in the case of poultry fat. PV of pork lard stored at -18°C increased from 1.52 to 12.87 during frozen storage for 210 days, while PV of poultry fat increased from 3.11 to 15.82; TBARS of pork lard increased from 1.26 to 11.80, while for poultry fat increased from 2.16 to 12.90 during frozen storage for 210 days. The total contents of monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids decreased significantly ($P < 0.05$) after 210 days of storage at +2°C for all fat samples. Acceptability tolerance was found to be 210 days for beef tallow, 150 days for pork lard and 120 days for poultry fat stored at -18°C.

Introduction

Animal products industry faced with the situation of unwanted sensory and physicochemical changes of alimentary fats, reason for that it is of great interest the knowledge of physicochemical parameters evolution in both refrigerated and frozen storage, for accurate knowledge of their validity and to ensure consumer protection. Obtaining of alimentary animal fats in Romania is mostly a home industry. They are produced at home by melting raw material fats between a temperature range of 65-75°C, followed by filtration to remove solid impurities and water. A major portion of this fats are utilized for culinary cooking and frying of different foods.

The keeping quality of alimentary animal fats is governed by such factors as storage temperature, permeability of the packaging material to air and moisture and type of animal feed (Rawls and Van Santen, 1990). Oxidation of food is responsible for degradation of the sensory characteristics and nutritional value, lipids are very susceptible to the prooxidant factors, this process once started can be slowed, but can not be stopped, lowering the life of the food (Banu, 2001).

Off-flavours, nutritional losses and other deteriorative changes in animal fats are concerned with the changes that result from their reaction with atmospheric oxygen, i.e., oxidative rancidity, or by hydrolytic reactions catalyzed by lipases from food or from microorganisms (Akamittath, Brekke and Schanus, 1990). The effects of hydrolytic reactions can be minimized by cold storage, good transportation, careful packaging and sterilization. However, oxidative rancidity cannot be stopped by lowering the temperature of storage since it is a chemical reaction with low activation energy (Berset and Cuvelier, 1996; Andreo *et al*., 2003; Andres *et al*., 2004).

Oxidation can cause damage to cell membranes and DNA (Moller and Wallin, 1998) that may be involved in aging process (Lozano *et al*., 2006), hypertension (Russo *et al*., 1998) and cancer growth (Navarro *et al*., 1999). 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 (Rawls and Van Santen, 1990; Shahidi, 1998).

Some publications have assessed the effects of irradiation and light exposure on lipid stability in beef, pork, poultry and turkey (Carlez *et al.*, 1995; Andreo *et al*., 2003; Monin *et al*., 2003; Núñez *et al*., 2003; Olsen Elisabeth *et al*., 2005; Carrasco *et al.*, 2005; Cava *et al.*, 2005; Biolatto *et al.*, 2007)

*Corresponding author.
Email: *flavia_maries@yahoo.com*
Tel: +40740053395; Fax: +40262175268

or on the shelf life of foods like oats, cream cheese and butter (Kolakowska, 2002; Fatouh *et al*., 2007; Krause *et al.*, 2007).

In melted fats, hydrolysis takes place more slowly, as the water content is very low (less than 1%), and the enzymes were destroyed during the melting process (Jensen and Newburg, 1995; Laslo, 1997). However, there is still a lack of systematic studies for evaluation the quality of alimentary animal fats under different storage conditions. The main purpose of this study was to investigate the oxidative and hydrolytic stability of three alimentary animal fats (pork lard, beef tallow and poultry fat) during refrigerated (+2°C) and frozen storage (-18°C). For monitoring the deterioration during storage and evaluation of fats stability, methods include iodine value (IV), saponification value (SV), peroxide value (PV), thiobarbituric acid reactive substances (TBARS), refractive index value (RIV), acid value (AV), and fatty acids composition were used. Regulatory agencies posed important limits for acceptability and quality of fats for human consumption: for example, 10 meq O_2/kg of fat is the limit of acceptability for PV and, for TBARS value, the limit is 8 mg malondialdehyde/kg of fat (Romanian Standard SR EN 14082, 2003).

Materials and Methods

Materials

The research was conducted on three types of alimentary animal fats: pork lard, beef tallow, and poultry fat. Raw material fats (bacon, raw tallow and raw poultry fat) were collected immediately after obtaining from the slaughtered animals. The raw material fats were melted at a temperature between 65-75°C in opened boilers, followed by filtration to remove solid impurities and water. In order to carry out fats analyses during storage for 210 days, more samples of 50 g from each fat were packed in closed jars, stored under refrigeration (+2°C) and freezing (-18°C), and at various time intervals were used for chemical analysis. All chemicals used were of analytical grade and obtained from Merck (Germany).

Chemical analysis

Iodine value

Iodine value was determined using Hanus method. Approximately, 0.5 g sample (dissolved in 15 mL CCl_4) was mixed with 25 mL Hanus solution (IBr) to halogenate the double bonds. After storing the mixture in dark for 30 min., excess IBr was reduced to free I_2 in the presence of 20 mL of KI (100 g/L) and 100 mL distilled water. Free I_2 was measured by titration with 24.9 g/L $Na_2S_2O_3 \cdot 5H_2O$ using starch (1.0 g/100 mL) as an indicator. IV was calculated as g I_2/100 g sample (Romanian Standard SR EN 14082, 2003).

Saponification value

Fifty milliliters alcoholic KOH (40 g/L) was added to approximately 5.0 g of fat and the mixture was gently boiled until the sample was completely saponified. Excess KOH was titrated with HCl (43.01 mL/L) in the presence of phenolphthalein indicator (1 g/100 mL). Saponification value was expressed as mg of KOH required to saponify 1 g sample (Romanian Standard SR EN 14082, 2003).

Peroxide value

Peroxide value was determined using UV-VIS T60U spectrophotometer (Bibby Scientific, London, UK): operating temperature 5–45°C; field wavelength 190-1100 nm; wave length accuracy 0.1 nm. This protocol was based on the spectrophotometric determination of ferric ions (Fe^{3+}) derived from the oxidation of ferrous ions (Fe^{2+}) by hydroperoxides, in the presence of ammonium thiocyanate (NH_4SCN). Thiocyanate ions (SCN^-) react with Fe^{3+} ions to give a red-violet chromogen that can be determined spectrophotometrically, the absorbance of each solution was read at 500 nm. To quantify PV, a calibration curve (absorbance at 500 nm vs. Fe^{3+} expressed in μg) was constructed and peroxide value was expressed as meq O_2/kg sample (ISO 3976, 2006).

TBARS determination

TBARS determination was carried out as follows: TBA Reagent (0.02 M 2-thiobarbituric acid in 90% glacial acetic acid) was prepared, then 1 g of fat sample was weight into a glass-stoppered test tube and 5 mL of TBA reagent was added. The tube was stoppered and the contents were mixed. Then, the tube was immersed in a boiling water bath for 35 min. A distilled water-TBA reagent blank was also prepared and treated like the sample. After heating, the sample was cooled in tap water for 10 min. A portion was transferred to a cuvette and the optical density of the sample was read against the blank at a wavelength of 538 nm in a UV-VIS T60U model spectrophotometer. The optical density value was converted to the moles of malondialdehyde per gram of sample by using a standard curve. A standard curve was prepared by making appropriate dilutions of the 1 x 10-3 M 1,1,3,3-tetraethoxypropane standard solution, to give amounts ranging from 1 x 10^{-8} to 7 x 10^{-8} mol

of malondialdehyde in 1 mL. These dilutions were reacted with TBA reagent and the optical densities were measured at the wavelength of 538 nm in the spectrophotometer. Samples with an optical density higher than 0.5 were diluted to a known degree to get accurate values (Tarladgis, Watts and Younthan, 1960).

Refractive index

The values of refractive index are conditioned by the nature and proportion of fatty acids. To determine the refractive index we used the PAL-RI (Tokyo, Japan) with the following technical characteristics: field: 1,3306-1,5284; resolution: 0.0001; accuracy: ± 0.0003; measuring temperature: 5-45°C (resolution 1°C); measuring time: 3s; in accordance with the requirements of EMC Directive 93/68/EEC.

Acid value

The method consists in neutralizing acidity with sodium hydroxide 0.1 N, using phenolphthaleine, as an indicator. Acidity was expressed as oleic acid g to 100 g sample (Romanian Standard SR EN 14082, 2003).

GC analysis

Fatty acid composition was determined using gas chromatography (GC-FID) Shimadzu GC-17 A (Tokyo, Japan) coupled with flame ionisation detector. Gas chromatography column is Alltech AT-Wax, (60 m x 0.32 mm x 0.5 μm), stationary phase (polyethylene), used helium as carrier gas at a pressure of 147 kPa, temperature of the injector and detector was set to 260°C, the oven programm was the following: 70°C for 2 min., then the temperature was raised up to 150°C with a gradient of 10°C/min., a level of 3 min. and the temperature was raised up to 235°C with a gradient of 4°C/min. Identification and quantification of FA were prerformed by comparison with standards. Results were expressed as g/100 g total fatty acids (Romanian Standard SR EN 14082, 2003).

Statistical analysis

All analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean ± standard deviation (X ± SD). Significant differences between samples were tested by Student's t-test.

Results and Discussion

In the present study, deterioration rates of three alimentary animal fats (pork lard, beef tallow and poultry fat) frequently utilized in Romania for culinary cooking and frying of different foods, were determined under different storage conditions. Chemical analyses, such as IV, SV, PV, TBARS, RIV, AV and fatty acid composition were carried out to monitor fats quality under defined storage conditions.

Chemical analyses results for pork lard, beef tallow and poultry fat are presented in Tables 1–4, respectively. In general, it was observed, in all fat samples, that SV, PV, TBARS and AV gradually increased, while IV and RIV decreased during both temperatures storage. The decreasing of IV and RIV values indicates a reduction of fat unsaturation that was considerably lower at -18°C than at +2°C during storage.

A statistical significance ($P \leq 0.01$) of IV compared with control sample was registered on the 210th day for pork lard and poultry fat during both temperature storage, while for beef tallow was registered a very significat differences ($P \leq 0.001$) during refrigerated storage; between IV, RIV and storage time there was registered an inverse correlation, correlation coeficient was R = -0.913. Storage temperatures showed statistical significance ($P \leq 0.01$) on RIV variation for all fat samples.

SVs of samples increased at both storage temperatures, the biggest increase occurred in pork lard stored at +2°C (Table 1). SV is defined as the amount of alkali required to saponify fatty acids in a given weight of fat and is a measure of molecular weight. Oxidation and hydrolysis bring about lipid breakdown, forming aldehydes and ketones as the end-products or free fatty acids. It is possible that aldehydes and ketones may contribute to the increase in SV.

AV, PV and TBARS values of all fat samples showed similar patterns, comparable to one another. There are limits for acceptability and quality of fats for human consumption: for PV the limit of acceptability is 10 meq O_2/kg of fat and, for TBARS value, this limit is 8 mg malondialdehyde/kg of fat (Romanian Standard SR EN 14082, 2003).

PV of pork lard reached the acceptability limit for human consumption in 90 days, for beef tallow in 150 days and for poultry fat in 60 days during storage at +2°C; while during storage at -18°C the acceptability limit was reached in 150 days for pork lard and 120 days for poultry fat. Beef tallow sample stored at -18°C did not exceed the acceptability limit within 210 days (Table 2). Starting approximately from 90 days, the effect of storage temperature was statistically significant in all fat samples during refrigerated storage, measured as PV, TBARS and AV.

Table 1. Changes in the quality of pork lard stored at two different temperatures

Days of storage	IV (mg I_2/g)	SV (mg KOH/g)	PV (meq O_2/kg)	TBARS (mg MDA/kg)	RIV (refractive indices)	AV (g oleic acid)
at +2°C						
1	66.8±0.7	196±2	1.52±0.07	1.26±0.06	1.4598±0.0003	0.27±0.07
30	65.3±0.5[a]	199±2	2.84±0.04[a]	2.72±0.02[a]	1.4597±0.0006	0.55±0.03[a]
60	63.5±0.4[a]	201±3[a]	5.90±0.05[b]	4.20±0.03[a]	1.4594±0.0006	0.89±0.05[b]
90	57.1±0.7[a]	202±1[a]	9.83±0.01[b]	7.40±0.01[b]	1.4590±0.0005[a]	0.96±0.08[b]
120	56.3±0.8[b]	205±1[b]	10.92±0.09[c]	9.20±0.01[b]	1.4591±0.0003[a]	1.09±0.07[b]
150	54.1±0.3[b]	209±3[b]	12.34±0.08[c]	10.30±0.03[c]	1.4586±0.0007[b]	1.13±0.09[c]
180	51.8±0.1[b]	211±3[b]	13.56±0.02[c]	11.70±0.04[c]	1.4584±0.0006[b]	1.24±0.08[c]
210	48.6±0.5[b]	213±1[b]	15.84±0.06[c]	12.60±0.07[c]	1.4581±0.0005[b]	1.30±0.07[c]
at -18°C						
1	66.8±0.7	196±2	1.52±0.07	1.26±0.06	1.4598±0.0003	0.27±0.07
30	66.3±0.5	197±1	2.14±0.02[a]	2.20±0.01[a]	1.4597±0.0007	0.40±0.03[a]
60	64.5±0.4[a]	195±1	4.95±0.01[b]	3.90±0.02[a]	1.4595±0.0004	0.67±0.05[a]
90	62.1±0.7[a]	199±3[a]	6.73±0.01[b]	5.25±0.05[b]	1.4593±0.0005[a]	0.84±0.09[b]
120	60.3±0.8[a]	198±3[a]	8.47±0.03[b]	6.40±0.01[b]	1.4592±0.0008[a]	0.89±0.04[b]
150	59.1±0.3[b]	201±1[b]	9.76±0.02[b]	7.56±0.02[b]	1.4589±0.0003[b]	1.08±0.09[b]
180	55.8±0.1[b]	204±2[b]	10.92±0.02[c]	9.20±0.02[c]	1.4587±0.0006[b]	1.12±0.07[c]
210	52.6±0.5[b]	206±3[b]	12.87±0.07[c]	11.80±0.05[c]	1.4585±0.0008[b]	1.24±0.06[c]

Values are expressed as the mean ± standard deviation of three determinations, [a](0.01< P ≤0.05); [b](0.001< P ≤0.01); [c](P ≤ 0.001)

Table 2. Changes in the quality of beef tallow stored at two different temperatures

Days of storage	IV (mg I_2/g)	SV (mg KOH/g)	PV (meq O_2/kg)	TBARS (mg MDA/kg)	RIV (refractive indices)	AV (g oleic acid)
at +2°C						
1	45.6±0.7	199±3	1.24±0.01	1.06±0.04	1.4563±0.0006	0.19±0.04
30	44.7±0.6	201±2	2.33±0.02[a]	2.12±0.01[a]	1.4563±0.0003	0.27±0.02[a]
60	43.5±0.5[a]	201±3	4.95±0.01[a]	3.85±0.02[a]	1.4562±0.0007	0.45±0.03[a]
90	41.8±0.4[a]	205±1[a]	6.27±0.04[b]	5.20±0.01[b]	1.4560±0.0005[a]	0.71±0.01[b]
120	37.1±0.4[b]	207±1[a]	8.71±0.02[b]	6.78±0.05[b]	1.4555±0.0003[a]	0.86±0.04[b]
150	36.3±0.3[b]	208±3[b]	9.68±0.02[b]	7.87±0.03[b]	1.4552±0.0004[b]	0.93±0.01[b]
180	35.4±0.2[b]	210±3[b]	11.57±0.01[c]	9.10±0.04[c]	1.4549±0.0002[b]	1.12±0.03[c]
210	34.9±0.3[c]	212±2[b]	12.48±0.03[c]	10.79±0.06[c]	1.4544±0.0005[b]	1.27±0.02[c]
at -18°C						
1	45.6±0.7	199±3	1.24±0.01	1.06±0.04	1.4563±0.0006	0.19±0.04
30	45.1±0.5	199±2	1.92±0.02[a]	1.92±0.05[a]	1.4563±0.0007	0.23±0.02
60	44.6±0.3[a]	201±2	3.47±0.01[a]	2.45±0.04[a]	1.4562±0.0005	0.39±0.02[a]
90	42.6±0.2[a]	200±1	4.87±0.03[a]	3.64±0.03[a]	1.4561±0.0003[a]	0.52±0.01[a]
120	41.6±0.1[a]	201±3	5.75±0.01[b]	4.38±0.06[b]	1.4559±0.0006[a]	0.67±0.01[a]
150	39.8±0.6[b]	204±1[a]	7.69±0.02[b]	5.87±0.07[b]	1.4556±0.0004[b]	0.78±0.03[b]
180	37.9±0.2[b]	205±2[a]	8.56±0.04[b]	6.70±0.01[b]	1.4553±0.0005[b]	0.84±0.01[b]
210	36.5±0.4[b]	207±1[b]	9.49±0.03[b]	7.80±0.06[b]	1.4551±0.0006[b]	0.98±0.05[b]

Values are expressed as the mean ± standard deviation of three determinations, [a](0.01< P ≤0.05); [b](0.001< P ≤0.01); [c](P ≤ 0.001)

TBARS values of fat samples also increased during storage, like PV. TBARS of pork lard reached the acceptability limit for human consumption in 90 days, for beef tallow in 150 days and for poultry fat in 60 days during refrigerated storage; while during frozen storage the acceptability limit was reached in 150 days for pork lard and 120 days for poultry fat. Beef tallow sample stored at -18°C did not exceed the acceptability limit within 210 days.

Among fat samples it was observed that the largest increase in TBARS values occurred in poultry fat for both storage temperatures (Table 3). Song *et al.* (2010) have studied the thermal oxidation of tallow and analysed the peroxide value, p-anisidine value (p-AV), acid value and the volatile compounds produced at different oxidation conditions. They reported that beef flavor precursors, such as hexanal, 1-octen-3-ol, (E,E)-2,4-decadienal and (E,E)-2,4-heptadienal, reached a maximum value when heated at 140°C for 2 h, whereas at the same temperature PV and p-AV were at high levels, and AV was relatively low.

Ramirez and Cava (2005) have compared the effect of frying in different culinary fats (pig lard, butter, olive oil and sunflower oil) on lipid oxidation of intramuscular fat of fried pork loin chops. They reported a significant increase in lipid oxidation index, measured as TBARS, in all samples except for butter during pork loin chops frying. They also found that absorbances at 420 nm of methanol extracted coloured materials were significantly higher in pig lard loin chops than in samples fried in olive and sunflower oils while fatty acid composition of the samples fried with pig lard did not differ from that of raw loin chops.

AVs for all fat samples, showed an increase for both storage temperatures. The biggest increase in AV was seen in poultry fat samples. Increase in AV is generally associated with lipases activity originating from biological tissue or microorganisms. The acceptable limit for AV is reported to be 1 g oleic acid (Romanian Standard, 2003). The study showed that this limit was exceeded after 90 days of storage at +2°C for pork lard, 150 days for beef tallow and 60 days for poultry fat; while during storage at -18°C the limit was exceeded after 120 days for pork lard and 120 days for poultry fat. Beef tallow sample stored at -18°C did not exceed the acceptability limit within

Table 3. Changes in the quality of poultry fat stored at two different temperatures

Days of storage	IV (mg I_2/g)	SV (mg KOH/g)	PV (meq O_2/kg)	TBARS (mg MDA/kg)	RIV(refractive indices)	AV (g oleic acid)
at +2°C						
1	74.8±0.3	194±1	3.11±0.03	2.16±0.02	1.4613±0.0006	0.22±0.03
30	73.9±0.1	198±1[a]	6.84±0.02[a]	4.63±0.04[a]	1.4610±0.0008	0.45±0.05[a]
60	73.1±0.2[a]	200±3[a]	9.10±0.01[a]	7.70±0.05[a]	1.4608±0.0005	0.67±0.02[b]
90	72.5±0.5[a]	201±2[a]	11.83±0.01[b]	8.90±0.01[b]	1.4604±0.0007[a]	1.00±0.08[b]
120	71.3±0.2[b]	202±1[b]	13.32±0.03[b]	10.95±0.04[b]	1.4599±0.0004[a]	1.10±0.01[b]
150	69.4±0.3[b]	204±3[b]	14.84±0.05[b]	11.30±0.03[b]	1.4596±0.0005[b]	1.15±0.02[c]
180	67.2±0.4[b]	206±3[b]	15.56±0.04[c]	13.70±0.06[c]	1.4590±0.0003[b]	1.22±0.04[c]
210	65.6±0.3[b]	209±2[b]	17.14±0.06[c]	14.60±0.07[c]	1.4582±0.0002[b]	1.35±0.06[c]
at -18°C						
1	74.8±0.3	194±1	3.11±0.03	2.16±0.02	1.4613±0.0006	0.22±0.03
30	74.1±0.3	195±2	4.95±0.02[a]	3.73±0.01[a]	1.4612±0.0005	0.39±0.03[a]
60	73.8±0.1[a]	196±2	6.28±0.01[a]	5.40±0.04[a]	1.4610±0.0006	0.54±0.05[a]
90	73.0±0.4[a]	197±1	8.13±0.01[a]	6.85±0.03[a]	1.4609±0.0004	0.72±0.06[b]
120	72.3±0.5[a]	199±3[a]	9.32±0.03[b]	7.25±0.05[b]	1.4605±0.0002[a]	0.97±0.04[b]
150	70.2±0.2[b]	201±1[a]	11.64±0.05[b]	9.30±0.03[b]	1.4600±0.0006[a]	1.07±0.08[b]
180	68.7±0.4[b]	202±2[b]	13.76±0.04[b]	11.34±0.07[b]	1.4597±0.0007[b]	1.16± 0.02[c]
210	66.5±0.1[b]	205±3[b]	15.82±0.06[c]	12.90±0.06[c]	1.4590±0.0003[b]	1.25±0.06[c]

Values are expressed as the mean ± standard deviation of three determinations, [a](0.01< P ≤0.05); [b](0.001< P ≤0.01); [c](P ≤ 0.001)

Table 4. Variations in total fatty acids composition (g/100 g of dry weight) of alimentary animal fats stored at two different temperatures

Fatty acids	Pork lard			Beef tallow			Poultry fat		
	Control	After 210 days of storage at +2°C	After 210 days of storage at -18°C	Control	After 210 days of storage at +2°C	After 210 days of storage at -18°C	Control	After 210 days of storage at +2°C	After 210 days of storage at -18°C
14:0	0.51 ± 0.68	0.65 ± 0.82	0.88 ± 0.44	1.56 ± 0.94	1.16 ± 0.36	1.29 ± 0.09	0.35 ± 0.30	0.47 ± 0.15	0.38 ± 0.15
15:0	0.47 ± 0.10	0.85 ± 0.09	0.80 ± 0.09	1.47± 0.06	1.24 ± 0.01	1.38 ± 0.02	0.78 ± 0.04	0.89 ± 0.01	0.82 ± 0.04
16:0	1.01 ± 0.47	0.91 ± 0.58	1.05 ± 0.85	1.68 ± 0.60	1.29 ± 0.06	1.59 ± 0.33	0.96 ± 0.50	1.06 ± 0.32	0.93 ± 0.52
16:1	1.71 ± 0.68	1.77 ± 0.55	1.74 ± 0.26	1.10 ± 0.93	0.97 ± 0.13	1.04 ± 0.21	1.31 ± 0.04	0.86 ± 0.72	1.19 ± 0.06
16:2	0.55 ± 0.07	0.36 ± 0.06	0.47 ± 0.03	0.48 ± 0.05	0.15 ± 0.01	0.36 ± 0.04	0.75 ± 0.07	0.59 ± 0.09	0.62 ± 0.09
16:3	0.30 ± 0.04	0.25 ± 0.06	0.28 ± 0.03	0.28 ± 0.02	0.13 ± 0.01	0.21 ± 0.09	0.54 ± 0.05	0.31 ± 0.09	0.49 ± 0.11
16:4	0.20 ± 0.05	0.12 ± 0.08	0.15 ± 0.05	0.17 ± 0.06	0.05 ± 0.01	0.14 ± 0.01	0.56 ± 0.10	0.35 ± 0.20	0.55 ± 0.18
17:0	0.91 ± 0.10	0.88 ± 0.08	0.92 ± 0.06	1.69 ± 0.13	1.70 ± 0.05	1.72 ± 0.05	0.53 ± 0.07	0.52 ± 0.02	0.58 ± 0.08
18:0	0.67 ± 0.51	0.87 ± 0.03	0.79 ± 0.49	1.43 ± 0.20	1.29 ± 0.02	1.37 ± 0.25	0.67 ± 0.11	0.55 ± 0.06	0.61 ± 0.12
18:1	1.85 ± 0.65	1.89 ± 0.59	1.86 ± 0.83	0.97 ± 0.34	0.58 ± 0.38	0.89 ± 0.43	1.15 ± 0.14	0.87 ± 0.63	1.13 ± 0.52
18:2	0.47 ± 0.80	0.33 ± 0.83	0.45 ± 0.29	0.42 ± 0.18	0.31 ± 0.18	0.39 ± 0.20	0.63 ± 0.06	0.42 ± 0.58	0.49 ± 0.06
18:3	0.36 ± 0.48	0.20 ± 0.31	0.33 ± 0.09	0.29 ± 0.11	0.16 ± 0.05	0.24 ± 0.13	0.55± 0.01	0.41 ± 0.01	0.43 ± 0.01
18:4	0.12 ± 0.33	0.07 ± 0.20	0.09 ± 0.06	0.09 ± 0.35	0.03 ± 0.06	0.06 ± 0.27	0.79± 0.21	0.53 ± 0.20	0.81 ± 0.26
Total FA	9.13 ± 0.68	7.97± 0.90	9.49 ± 0.37	11.63 ± 1.74	9.06 ± 0.31	10.68 ± 0.34	9.57± 0.60	7.93 ± 0.52	9.01 ± 0.76
Total SFA	3.39 ± 0.36	3.41± 0.17	4.25 ± 0.18	7.83 ± 0.79	6.68 ± 0.17	7.61± 0.18	3.29± 0.22	3.49 ± 0.17	3.32 ± 0.26
Total MUFA	3.56 ± 0.78	3.26 ± 0.31	3.52 ± 0.39	2.07 ± 0.34	1.55 ± 0.39	1.93 ± 0.55	2.46 ± 0.26	1.73 ± 0.10	2.32 ± 0.31
Total PUFA	2.18 ± 0.54	1.30 ± 0.44	1.77 ± 0.15	1.73 ± 0.60	0.83 ± 0.10	1.14 ± 0.17	3.82 ± 0.11	2.61± 0.23	3.37 ± 0.18

Values are expressed as the mean ± standard deviation of three determinations, [a](0.01< P ≤0.05); [b](0.001< P ≤0.01); [c](P ≤ 0.001)

210 days.

There are reports on free fatty acid values, values at which the aroma is detected. O'Connor and O'Brien (2006) reported for the total free fatty acids a limit of 1.2-1.5 meq/100 g fat (0.8-1.0 μmoli/mL) when flavour can be detected by experienced tasters and 2.0-2.2 meq/100 g fat (1.3-1.4 μmoli/mL) when flavour can be detected by ordinary consumers. In the present study it was found that poultry fat was the most sensitive to hydrolytic deterioration among the examined fat samples and showed the lowest oxidative stability. Sample of fats stored at +2°C preserved acceptable characteristics for 90 days in the case of pork lard, 150 days in the case of beef tallow and 60 days in the case of poultry fat, while acceptability tolerance was found to be 210 days for beef tallow, 150 days for pork lard and 120 days for poultry fat stored at -18°C.

The total lipids of the control samples showed a predominance of saturated fatty acids (SFA) for tallow, while for pork lard and poultry fat there was a predominance of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) (Table 4). Analysis revealed an effect of the storage temperature on the overall fatty acid composition of fats after 210 days of storage compared with control. There was registered a significant differences ($P < 0.05$) in total fatty acids after 210 days of storage at +2°C, and no significant differences ($P > 0.05$) after 210 days of storage at -18°C compared with control.

The content of SFA increased during storage of both temperatures for pork lard and poultry fat, while for tallow was registered a decrease. The content of MUFA and PUFA decreased significantly ($P < 0.05$) after 210 days of refrigerated storage for all fat samples, while after 210 days of frozen storage the decrease was not significant. Variation in fatty acid composition of different animal fats could be related to storage temperature, frozen storage preserving their acceptability properties.

In another study, the fatty acid composition of melted buffalo tallow was monitored during frozen storage. The composition of control sample was 57.13% SFA, 34.47% MUFA and 8.4% PUFA of total fatty acids. It was reported a significant differences ($P < 0.05$) in PUFA and no significant differences ($P > 0.05$) in MUFA and SFA after 120 days of storage at -18°C compared with control (Pop and Laslo, 2009). Olsen Elisabeth *et al.* (2007) measured the composition of pork adipose tissue and melted fat

from the same tissue with Raman spectroscopy. They reported that IV ranged from 58.2 to 90.4 g iodine added per 100 g fat, PUFA ranged from 7.8% to 31.7%, MUFA from 35.2% to 51.5% and SFA from 29.1 to 46.6% of total fatty acids. They also observed that Raman measurements on melted fat gave lower prediction errors compared to measurements on adipose tissue.

Conclusions

The effects of temperature and storage time on quality of alimentary animal fats was examined. Sample of fats stored at +2°C preserved acceptable characteristics for 90 days in the case of pork lard, 150 days in the case of beef tallow and 60 days in the case of poultry fat. Fat samples stored at -18°C had almost twice longer shelf life than had samples stored at +2°C. Variation in fatty acid composition of different animal fats could be related to storage temperature, frozen storage preserving their acceptability properties.

References

Ahn, J. H., Kim, Y. P., Seo, E. M., Choi, Y. K. and Kim, H. S. 2008. Antioxidant effect of natural plant extracts on the microencapsulated high oleic sunflower oil. Journal of Food Engineering 84 (3): 327–334.

Akamittath, J. G., Brekke, C. J. and Schanus, E. G. 1990. Lipid oxidation and colour stability in restructured meat systems during frozen storage. Journal of Food Science 55 (10): 1513−1517.

Andreo, A. I., Doval, M. M, Romero, A. M. and Judis, M. A. 2003. Influence of heating time and oxygen availability on lipid oxidation in meat emulsions. European Journal of Lipid Science and Technology 105 (3): 207–213.

Andres, A. I., Moller, J. K., Adamsen, C. E. and Skibsted, L. H. 2004. High pressure treatment of dry-cured ham. Effect on radical formation, lipid oxidation and colour. European Food Research and Technology 219 (2): 205−210.

Banu, C. 2001. Nutrition and health. Targoviste, Romania: Macarie Press.

Berset, C. and Cuvelier, M. E. 1996. Methodes d'evaluation du degree d'oxydation des lipides et de mesure du pouvoir antioxidant. Science des Aliments 16 (3): 219-245.

Biolatto, A., Gabriela Grigioni, Irueta Maertin, Ana Sancho, Taverna, M. and Norma Pensel 2007. Seasonal variations in the odour characteristics of whole milk powder. Food Chemistry 103 (10): 960-967.

Carlez, A., Veciana-Nogues, T. and Cheftel, J. C. 1995. Changes in colour and myoglobin of minced beef meat due to high pressure processing. Lebensmittel-Wissenschaft und-Technologie 28 (4): 528−538.

Carrasco, A., Tárrega, R., Ramírez, M. R., Mingoarranz, F. J. and Cava, R. 2005. Colour and lipid oxidation changes in dry-cured loins from free-range reared and intensively reared pigs as affected by ionizing radiation dose level. Meat Science 69 (6): 609−615.

Cava, R., Tárrega, R., Ramirez, M. R., Mingoarranz, F. J. and Carrasco, A. 2005. Effect of irradiation on colour and lipid oxidation of dry-cured hams from free-range reared and intensively reared pigs. Innovative Food Science and Emerging Technologies 6 (2): 135−141.

Fatouh, A. E., Mahran, G. A, El Gandour, M. A. and Singh, R. K. 2007. Fractionation of buffalo butter oil by supercritical carbon dioxide. Lebensmittel-Wissenschaft und-Technologie 40 (11): 1687–1693.

International Standard ISO 3976/IDF 74 2006. Milk fat. Determination of peroxide value.

Jensen, R. G. and Newburg, D. S. 1995. Bovine milk lipids. In Jensen R. G. (Eds). Handbook of milk composition, p. 543–575. San Diego, USA: Academic Press.

Kolakowska, A. 2002. Lipid oxidation in food systems. In Sikorski, Z. E. and Kolakowska, A. (Eds). Chemical and functional properties of food lipids, p. 133–160. Florida, USA: CRC Press.

Krause, A. J., Miracle, R. E., Sanders, T. H., Dean, L. L. and Drake, M.A. 2007. The effect of refrigerated and frozen storage on butter flavor and texture. Food Chemistry 89 (1): 57-65.

Laslo, C. 1997. Quality control of meat and meat products. Cluj-Napoca, Romania: Alma Mater Press.

Lozano, P. R., Miracle, E. R., Krause, A. J., Drake, M. A. and Cadwallader, K. R. 2006. Effect of cold storage and packaging material on the major aroma components of sweet cream butter. European Journal of Lipid Science and Technology 108 (3): 349-355.

Moller, P. and Wallin, H. 1998. Adduct formation, mutagenesis and nucleotide excision repair of DNA damage produced by reactive oxygen species and lipid peroxidation product. Mutation Research 410 (2): 271–290.

Monin, G., Hortós, M., Diaz, I., Rock, E. and Garcia-Regueiro, J. A. 2003. Lipolysis and lipid oxidation during chilled storage of meat from Large White and Pietrain pigs. Meat Science 64 (1): 7–12.

Navarro, J., Obrador, E., Carreter, J., Petschen, I., Avino, J. and Perez P. 1999. Changes in glutathione status and the antioxidant system in blood and cancer cells associate with tumor growth *in vivo*. Free Radical Biology and Medicine 26 (3/4): 410–418.

Núñez, R., Carrasco, A., Tárrega, R., Mingoarranz, F. J., Ramírez, M. R. and Cava, R. 2003. Colour and lipid oxidation changes in dry-cured Iberian ham treated with high hydrostatic pressure. Development of a response surface model to optimize the combination of pressure and holding time. World Congress on Dry-Cured Ham Cáceres, Spain.

Olsen Elisabeth, Vogt, G., Ekeberg, D., Sandbakk, M., Pettersen, J. and Nilsson, A. 2005. Analysis of the early stages of lipid oxidation in freeze-stored pork back fat and mechanically poultry meat. Journal of Agicultural and Food Chemistry 53 (3): 338-348.

Olsen Elisabeth, Rukke, E., Flátten, A. and Isaksson,

T. 2007. Quantitative determination of saturated, monounsaturated and polyunsaturated fatty acids in pork adipose tissue with non-destructive Raman spectroscopy. Meat Science 76 (5): 628-634.

O'Connor, T. P. and O'Brien, N. M. 2006. Lipid oxidation. In Springer (Eds). Advanced dairy chemistry, p. 557-600. New York, USA: Academic Press.

Pop Flavia and Laslo, C. 2009. Research regarding changes in the chemical composition of animal fats during freezing storage. The Annals of the University Dunarea de Jos of Galati, Fascicle VI Food Technology 32 (1): 33-38.

Rawls, H. R. and Van Santen, P. J. 1990. A possible role for singlet oxygen in the initiation of fatty acid autoxidation. Journal of the American Oil Chemists' Society 47 (1): 121–125.

Ramirez, M. and Cava, R. 2005. Changes in colour, lipid oxidation and fatty acid composition of pork loin chops as affected by the type of culinary frying fat. Lebensmittel-Wissenschaft und-Technologie 38 (7): 726-734.

Russo, C., Oliviero, O., Girelli, D., Faccini, G., Zenari, M. L. and Lombardi, S. 1998. Antioxidant status and lipid peroxidation in patients with essential hypertension. Journal of Hypertension 16 (11): 1267–1271.

Shahidi, F. 1998. Indicators for evaluation of lipid oxidation and off-flavor development in food. In Contis, E. T., Ho, C. T., Parliment, C. J., Shahidi, F. and Spanier, A. M. (Eds). Food flavors: Formation, analysis, and packaging influences, p. 55–68. Proceedings of the 9th international flavor conference, The George Charalambous memorial symposium, UK: Elsevier.

Song, S., Zhang, X., Hayat, K., Liu, P., Chengsheng, J., Shuqin, X., Xiao, Z., Tian, H. and Niu, Y. 2010. Formation of the beef flavour precursors and their correlation with chemical parameters during the controlled thermal oxidation of tallow. Food Chemistry 115 (3): 435-443.

Tarladgis, B. G., Watts, B. M. and Younthan, B. T. 1960. A distillation method for the quantitative determination of malonaldehyde in rancid foods. Journal of the American Oil Chemists' Society 37 (1): 44–48.

Romanian Standard SR EN 14082, Bucharest, 2003. Animal fats. Determination of iodine value; Determination of moisture and volatile substances; Determination of fatty acid composition.