Lipid Oxidation and Quality Parameters of Sausages Marketed Locally in the Town of São Paulo (Brazil)

CARLOS KUSANO BUCALEN FERRARI and ELIZABETH A. F. S. TORRES

Department of Nutrition – Faculty of Public Health, University of São Paulo, São Paulo, Brazil

Abstract

FERRARI C.K.B., TORRES E.A.F.S. (2002): **Lipid oxidation and quality parameters of sausages marketed locally in the town of São Paulo (Brazil)**. Czech J. Food Sci., **20**: 144–150.

Lipid oxidation constitutes one of the most important causes of the chemical deterioration of foods, especially meats. Many harmful effects on human health are associated with lipid oxidation. During a period of six weeks, samples were bought at random on city hall food markets (CHFMs) and were analysed for lipid oxidation (TBARS-test) and some quality factors – redox potential (Eh), pH and water activity (a_w). The mean of Eh was $X \pm \sigma_{n-1} = 39.03 \pm 26.30$ mV, ranging from –86.00 to 92.00 mV. pH mean value was $X \pm \sigma_{n-1} = 5.97 \pm 0.27$, ranging from 5.08 to 6.48. Comparing the CHFMs, no statistically significant differences were observed between them in respect to pH, Eh, and a_w values. TBARS mean value was $X \pm \sigma_{n-1} = 0.44 \pm 0.23$ mg/kg, ranging from 0.38 ± 0.19 mg/kg (CHFM-6) to 0.58 ± 0.31 mg/kg (CHFM-2), with extreme values of 0.22 mg/kg and 1.08 mg/kg. No statistically significant correlations between TBA test values and all tested variables were detected. According to the sensorial analysis criteria of GREENE and CUMUZE (1981), 16.67% of sausage samples could be rejected and 11.11% revealed critical TBARS values.

Keywords: lipid oxidation; sausages, meat; food market; quality factors

Abbreviations: a_w = water activity; **CHFMs** = City Hall Food Markets; **Eh** = redox potential; **MDA** = malonaldehyde; **SP** = State of São Paulo; **TBARS** = thiobarbituric-acid reactive substances

Sausages are the most important meat product consumed by the Brazilian population, contributing 1.7% to the total energy intake (MONTEIRO *et al*. 2000). In 1986, Brazilian industry produced about 25 000 tons of sausages. In 1993, 55 000 t were produced, and 45 000 t in the state of São Paulo alone (ANONYMOUS 1994; GONÇALVES 1995; SILVA 1995). Between 1994 and 1995, there was a 45% increase in the sausage production (SILVA 1995).

There are many factors that interfere with the food quality. Ingredients, food manufacturing, errors or prohibited alterations in the composition, a high concentration of mechanically deboned poultry meat, wrong marketing practices and poor refrigeration constitute some of these factors (PEARSON *et al*. 1977; HSU *et al*. 1977; DAWSON & GARTNER 1983; DONNELLY & ROBINSON 1995; FERRARI & TORRES 2000a, b).

The association of these factors with other problems that produce an elevation of thermal energy and food oxygenation induce lipid oxidation reactions (KANNER 1994; DONNELLY & ROBINSON 1995; RHEE 1988). Other factors, such as pH, a_w, Eh, and food packaging procedures could also be associated with lipid oxidation in foods (CHEN & WAIMALEONGORA-EK 1981; TORRES *et al*. 1994; WANG *et al*. 1995).

Lipid oxidation of unsaturated fatty acids is initiated by the abstraction of hydrogen in carbon adjacent to the unsaturated bound. The reaction continues by the propagation step that is characterized by decomposition of unstable peroxides and finally results in the production of stable lipid oxidation products of the termination step (RHEE 1988; KANNER 1994; DONNELLY & ROBINSON 1995).

Supported by Grants from "Fundação de Amparo ŕ Pesquisa do Estado de São Paulo" – FAPESP (No. 944848-2/95-5757-2), and "Conselho Nacional de Desenvolvimento Científico e Tecnológico" – CNPQ.

Most of the toxic products are formed in the termination step. Aldehydes (malonaldehyde, hydroxynonenal, hydroxyhexenal), ketones, hydrocarbons, epoxides, alcohol, and other organic molecules are formed (PEARSON *et al*. 1983; ESTERBAUER *et al*. 1991; KUBOW 1992; FERRARI 1998a). The presence of these compounds in foods is associated with warmed-over flavour (TIMS & WATTS 1958; PEARSON *et al*. 1977) and other food sensory alterations (GREENE & CUMUZE 1981), in addition to their marked relations to the pathogenesis of cardiovascular diseases (especially atherosclerosis), diabetes, nutritional disorders, cancer and other pathologies (PEARSON *et al*. 1983; ESTERBAUER *et al*. 1991; KUBOW 1992; FERRARI 1998a, b, 1999, 2000).

The aim of this paper was to evaluate lipid oxidation (by the TBA test) and its possible correlation with food quality parameters (Eh, pH, and a_w) in sausages sold on City Hall Food Markets, known as "sacolões", in the town of São Paulo, Brazil.

MATERIALS AND METHODS

Samples

During six consecutive weeks, six CHFMs marketing sausages were visited and thirty-six food samples were collected (n = 36). These methodology was important to verify that sausages were sold uninterruptedly, not only during that time period. Each sample weighing 250 g was collected in random by the food handler. With the exception of CHFM-6, which sold only poultry meat sausages, all CHFMs marketed Frankfurter sausages. It was not possible to assess the sausage producers because CHFM sellers can freely choose them, in view of low prices and availability (although the majority had chosen "Aurora's" company). The geographic distribution of CHFMs is represented in Table 1 (FERRARI 1998b). All experiments described below were carried out in triplicates.

2-thiobarbituric acid test (TBA-test)

The TBA-test determines the contents of malonaldehyde (MDA), 1,3-dicarbonyl aldehyde ($C_3H_4O_2$) and other 2-thiobarbituric acid reactive substances (TBARS) in foods. In the reaction between two TBA acid molecules and one MDA molecule, a red pigment is formed and detected spectrophotometrically by absorption of 530–532 nm. The distillation method developed by TARLADGIS *et al*. (1964) was used with some modifications (KUBOW 1992; TORRES *et al*. 1994; TORRES & OKANI 1997). Briefly, 10 g of sample and 50 ml of distilled water are put in a beaker and homogenized by virts for two minutes. The homogenate is transferred to a Kjeldahl flask. Subsequently, 47.5 ml of distilled water, 2.5 ml of HCl (4 mol/l), some anti-foaming drops, some glass beads, and 2 ml sulfanilamide solution (0.5% in 20% HCl solution) are added. The mixture is then distilled under intensive heating until 50 ml of distillate is collected in an Ernlemeyer flask. The flask is agitated. 5 ml aliquots are then withdrawn and transferred to test tubes to which 5 ml of 2-TBA solution (0.02 mol/l) are futther added. The test tubes are closed and heated in a water bath at 96°C for 35 min. After cooling, absorbance at 532 nm is read using an UV-vis spectrophotometer (CE1020 model, Cecil – UK).

Table 1. Geographic distribution of City Hall Food Markets* of São Paulo (SP), Brazil, selected for sample collection

Town region	Locality	Total per region
North	Vila Maria Alta	1
West	Butantã João Moura Rio Pequeno	3
Central	Barra Funda Bela Vista	2
Total		6

Source: Diretoria dos Sacolões da Secretaria Municipal do Abastecimento (SEMAB), São Paulo – 1997
*These CHFMs are called "sacolões"

Determination of redox potential (Eh) and pH

Both Eh and pH were measured with a portable potentio-meter containing KCl electrode that was calibrated at two points (pH = 4.0 and pH = 7.0) according to the book of instructions (FERRARI 1998b).

Determination of water activity (a_w)

a_w was measured by an automatic analyzer equipment developed by Aqualab-Decagon Devices Inc., model CX-2 (Washington/USA). a_w was expressed by the ratio of the pressure of food water vapour to the pure water vapour pressure (FERRARI 1998b).

Planning and evaluation of experiments

Parametric and non-parametric tests were used to evaluate the variables in the selected places and during the determined period of time. To evaluate possible correlations between the variables studied, SPSS 7.5.1 program for Windows was used.

RESULTS

TBARS values of CHFM sausages (mg TBARS/kg sample)

Table 2 presents the TBARS values of sausages marketed on CHFMs of the town of São Paulo. The mean of TBARS was $X \pm \sigma_{n-1} = 0.44 \pm 0.23$ mg TBARS/kg of sample. The values ranged from 0.38 ± 0.19 mg TBARS/kg (CHFM-6) to 0.58 ± 0.31 mg TBARS/kg (CHFM-2), with limits of 0.22 mg TBARS/kg and 1.08 mg TBARS/kg. The results of the analysis of variance and Kruskal-Wallis test (ANOVA) ($\chi^2 = 3.37$; $P = 0.6423$) did not reveal any statistically significant differences.

Table 2. TBARS values (mg of TBARS/kg of sample) of sausages marketed on six City Hall Food Markets of São Paulo*

Week	Locality						Mean	Standard deviation
	1	2	3	4	5	6		
1	0.32	0.39	0.23	0.46	0.58	0.35	0.39	0.12
2	0.28	1.06	0.43	0.23	0.36	0.76	0.52	0.32
3	0.31	0.88	0.56	0.25	0.22	0.38	0.43	0.25
4	0.30	0.42	0.26	0.96	0.52	0.25	0.45	0.27
5	1.08	0.30	0.39	0.42	0.43	0.26	0.48	0.30
6	0.34	0.47	0.54	0.44	0.35	0.29	0.41	0.10
Mean	0.44	0.58	0.40	0.46	0.41	0.38		
Standard deviation	0.31	0.31	0.14	0.26	0.13	0.19		

CHFMs: 1 – Vila Maria Alta; 2 – Barra Funda; 3 – Rio Pequeno; 4 – João Moura; 5 – Bela Vista; 6 – Butantã
*The samples were analysed in triplicate

Redox potential (Eh) of CHFMs sausages

The results of Eh for CHFMs sausages are shown in Table 3. Eh mean was $X \pm \sigma_{n-1} = 39.03 \pm 26.30$ mV. The mean values of Eh ranged from 17.33 ± 51.78 mV (CHFM-3) to 56.67 ± 25.70 mV (CHFM-1) with extreme values of –86.00 to 92.00 mV.

In the analysis of variance no statistically significant differences were observed. Kruskal-Wallis test did not reveal any statistically significant differences between the Eh means of six CHFMs ($\chi^2 = 3.14$; $P = 0.6785$).

pH

The mean pH values ranged from 5.72 ± 0.47 (CHFM-1) to 6.13 ± 0.21 (CHFM-4), with the mean equal to $X \pm \sigma_{n-1} = 5.97 \pm 0.27$, with lower pH value 5.08 and higher pH value 6.48.

Kruskal-Wallis test resulted in a χ^2 of 7.53, with $P = 0.1839$, revealing that there existed no statistically significant differences between the values of each CHFMs. The same results were obtained by the analysis of variance.

The pH values of sausages marketed on six CHFMs are given in Table 4.

Water activity (a_w)

Although a_w ranged from 0.95 to 0.99 values c $\pm \sigma_{n-1} = 0.97 \pm 0.01$, there were no statistically significant differences in the analysis of variance (Table 5). The χ^2 of Kruskall-Wallis was 6.98, with $P = 0.2219$.

Statistical tests for possible correlations between quality parameters

To verify possible correlations between the studied variables (a_w, pH, Eh, and TBARS values), three statistical tests were applied.

Pearson's correlation coefficient indicated a negative correlation between pH and Eh ($r = –0.50$; $P = 0.002$). No

Table 3. Redox potential (mV) of sausages marketed on six City Hall Food Markets of São Paulo*

Week	Locality						Mean	Standard deviation
	1	2	3	4	5	6		
1	69.00	45.00	37.00	65.00	49.00	26.00	48.50	16.39
2	32.00	51.00	33.00	47.00	31.00	39.00	38.83	8.45
3	27.00	35.00	47.00	30.00	36.00	49.00	37.33	8.91
4	46.00	45.00	52.00	38.00	30.00	57.00	44.67	9.67
5	74.00	48.00	–86.00	16.00	39.00	32.00	20.50	55.60
6	92.00	30.00	21.00	31.00	48.00	44.00	44.33	25.35
Mean	56.66	42.33	17.33	37.83	38.83	41.16		
Standard deviation	25.70	8.09	51.78	16.77	8.18	11.30		

CHFMs: 1 – Vila Maria Alta; 2 – Barra Funda; 3 – Rio Pequeno; 4 – João Moura; 5 – Bela Vista; 6 – Butantã
*The samples were analysed in duplicate

Table 4. pH of sausages marketed on six City Hall Food Markets of São Paulo*

Week	Locality						Mean	Standard deviation
	1	2	3	4	5	6		
1	5.43	5.94	6.18	5.86	5.84	5.87	5.85	0.24
2	6.26	5.98	6.24	5.98	6.12	6.03	6.10	0.13
3	6.16	6.10	5.91	6.20	6.02	5.93	6.05	0.12
4	5.94	5.99	5.83	6.09	6.23	5.77	5.98	0.17
5	5.47	5.95	5.97	6.48	6.11	5.65	5.94	0.35
6	5.08	6.20	6.37	6.18	5.87	5.86	5.93	0.46
Mean	5.72	6.02	6.08	6.13	6.03	5.85		
Standard deviation	0.46	0.10	0.21	0.21	0.15	0.13		

CHFMs: 1– Vila Maria Alta; 2 – Barra Funda; 3 – Rio Pequeno; 4 – João Moura; 5 – Bela Vista; 6 – Butantã
*The samples were analysed in triplicate

Table 5. Water activity of sausages marketed on six City Hall Food Markets of São Paulo*

Week	Locality						Mean	Standard deviation
	1	2	3	4	5	6		
1	0.96	0.98	0.97	0.99	0.99	0.97	0.98	0.01
2	0.95	0.95	0.95	0.96	0.98	0.96	0.96	0.01
3	0.97	0.95	0.97	0.98	0.96	0.97	0.97	0.01
4	0.96	0.97	0.99	0.98	0.98	0.98	0.98	0.01
5	0.96	0.97	0.97	0.96	0.98	0.97	0.97	0.01
6	0.96	0.96	0.96	0.97	0.96	0.97	0.97	0.01
Mean	0.96	0.96	0.97	0.97	0.97	0.97		
Standard deviation	0.01	0.01	0.01	0.01	0.01	0.01		

CHFMs: 1 – Vila Maria Alta; 2 – Barra Funda; 3 – Rio Pequeno; 4 – João Moura; 5 – Bela Vista; 6 – Butantã
*The samples were analysed in triplicate

correlations between TBARS and the variables studied were found.

Spearman's test also revealed a negative correlation of Eh and pH ($r = –0.7453$; $P < 0.05$). In Kendall's test the same result was obtained ($r = –0.6222$; $P < 0.05$). These two tests failed to prove correlations between TBARS values and all the other quality parameters.

DISCUSSION

In the town of São Paulo, the city hall food markets (or sacolões) can represent an important source of foods for the population since the food price policy is very attractive to the consumers.

However, there are several risks associated with hygiene and the quality of sausages. Apart from some problems with local hygiene and poor handling, some sellers often wash sausages with water which can increase the risk of contamination (FERRARI 1998b). It was observed in a previous study that the moisture content and the storage temperature were totally inadequate thus increasing the risk of lipid oxidation and transmission of foodborne diseases to the population although the fat content was lower than that reported by other studies (FERRARI & TORRES 2000a, b).

Water activity values found by us were significantly higher than those reported by LEE and STYLIADIS (1996) who determined a_w values of 0.91 and 0.95 in dehydrated and fresh sausages, respectively.

The pH data found in CHFM sausages could allow the multiplication of several bacterial pathogens including *Clostridium botulinum* (LEITÃO 1988). The pH values

obtained by us were lower than those reported by CARBALLO *et al*. (1991), who reported the mean of 6.2 ± 0.1. However, studying sausages marketed in Toronto, LEE and STYLIADIS (1996) determined pH means 6.2 for dehydrated, and 6.3 for fresh sausages, respectively. The statistical tests did not reveal any significant differences between CHFMs neither were any correlations found between pH and TBARS values, in contradiction to the study of CHEN and WAIMALEONGORA-EK (1981). In that paper the authors stated the lower is the pH, the higher is the lipid oxidation although that correlation was not statistically significant.

Lipid oxidation measured by TBARS

Lipid oxidation data did not show any statistically significant differences between the six CHFMs. However, the TBARS of sausages in this study were from 30% to 100% higher than the highest value ($\chi = 0.29$) observed in sausages by REAGAN *et al*. (1983). On the other hand, the TBARS values were comparable to those reported by SHAMBERGER *et al*. (1977) who studied hot dog sausages; and also by AWORONIN (1993) who worked with smoked poultry sausages.

Recently, LORENZO *et al*. (2000) reported that sausages of the "Botilho" type presented an average TBARS value equal to 0.96 mg TBARS/kg and that sausages of "Androlla" type contained 4.05 mg TBARS/kg. In this study, the average TBARS values were lower than those reported by LORENZO *et al*. (2000).

On the other hand, literature data demonstrate that raw and cooked beef slices (PEARSON *et al*. 1977; NEWBURG & CONCON 1980), cuts of cooked poultry with skin or canned poultry sliced in cubes (PETERS *et al*. 1994), hamburgers (SHAMBERGER *et al*. 1977), and charqui (TORRES *et al*. 1989, 1994), a Brazilian traditional meat product, present higher TBARS values than those reported here. Lipid oxidation in charqui can be five to nine times higher than the values determined in this study (TORRES *et al*. 1989).

One of the most important quality parameters affected by lipid oxidation is the sensorial quality of foods (MORRISSEY *et al*. 1998). GREENE and CUMUZE (1981) observed that TBARS values higher than 0.6 mg/kg were really detected by persons making sensory analysis. According to this quality criteria (GREENE & CUMUZE 1981), 16.7% (6/36) of sausage samples could be considered to be of inadequate sensorial quality, and other 11.1% (4/36) presented critical TBARS values.

In a previous study with charqui (TORRES *et al*. 1994), a positive correlation was shown between a_w and lipid oxidation that was not observed in this study.

Although the TBARS test does not measure MDA levels, it is important to note that chronic ingestion of lipid peroxidation products (MDA, 4-hydroxynonenal, hexenals, peroxides, etc.) is associated with an increased risk of many chronic non-transmittable diseases (PEARSON *et al*. 1983; KUBOW 1992; DJURIC *et al*. 1998; FERRARI 1998a).

MDA is able to induce changes in blood LDL lipoproteins, resulting in the formation of atherosclerotic plaques and, subsequently, of atherosclerosis and coronary artery disease (PEARSON *et al*. 1983; KUBOW 1992; HABERLAND *et al*. 1992; FERRARI 1998a, 2001). MDA is also mutagenic and carcinogenic *in vitro* and *in vivo* (BASU & MARNETT 1983; ESTERBAUER *et al*. 1991; FERRARI 2000).

Meat products are rich sources of lipid oxidation products, and chronic high ingestion of these offers a considerable risk to the public health.

Two independent research groups observed that higher consumption of sausages increased the risk of childhood leukemia, brain tumors, lymphomas, and soft-tissue sarcomas in different populations of the United States (PETERS *et al*. 1994; SARASUA & SAVITZ 1994).

Studying the role of diet in DNA oxidation, DJURIC *et al*. (1998) found a positive correlation between the meat consumption and oxidative DNA damage to human blood cells. These authors also determined a negative correlation between the vegetable consumption and oxidative DNA injury.

Several *in vitro*, *in vivo* (animal) and epidemiological studies revealed that a high meat consumption and a lower fruit and vegetable intake, are associated with an increased risk of atherosclerosis and certain types of cancer, as recently reviewed (FERRARI 2001).

Conclusions

- The Eh values found in this study were sufficient for multiplication of microaerophilic bacteria;
- Elevated values of a_w and pH were determined;
- With regard to the lipid oxidation, the TBARS values were intermediate;
- TBARS values of sausages marketed in CHFMs of São Paulo could be lower if high standards of quality during the production and storage were implemented and monitored by official authorities.

References

ANONYMOUS (1994): A produção de embutidos em 1993 em São Paulo. Rev. Nac. Carne, **18** (219): 16.

AWORONIN S.O. (1993): Quality of smoked chicken-Guinea-fowl sausage as affected by processing conditions and cold storage. Food Sci.Technol., **26**: 285–290.

BASU A.K., MARNETT L.J. (1983): Unequivocal demonstration that malondialdehyde is a mutagen. Carcinogennesis, **4**: 331–333.

CARBALLO J., CAVESTANY M., JIMÉNEZ-COLMENERO F. (1991): Effect of light on colour and reaction of nitrite in sliced pork bologna under different chilled storage temperatures. Meat Sci., **30**: 235–244.

CHEN T.C., WAIMALEONGORA-EK C. (1981): Effect of pH on TBA values of ground raw poultry meat J. Food Sci., **46**: 1946–1947.

DAWSON L.E., GARTNER R. (1983): Lipid oxidation in mechanically deboned poultry. Food Technol., **37**: 112–116.

DJURIC Z., DEPPER J.B., UHLEY V., SMITH D., LABABIDI S., MARTINO S., HEILBRUN L.K. (1998): Oxidative DNA damage levels in blood from women at a high risk for breast cancer are associated with dietary intakes of meats, vegetables and fruits. J. Am. Diet. Assn., **98**: 524–528.

DONNELLY J.K., ROBINSON D.S. (1995): Free radicals in foods. Free Radic. Res., **22**: 47–76.

ESTERBAUER H., SCHAUR R.J., ZOLLNER H. (1991): Chemistry and biochemistry of 4-hydroxynonenal, malonaldehyde and related aldehydes. Free Rad. Biol. Med., **11**: 8–128.

FERRARI C.K.B. (1998a): Lipid oxidation in food and biological systems: general mechanisms and nutritional and pathological implications. (In Portuguese with abstract in English.) Rev. Nutr., **11**: 3–14.

FERRARI C.K.B. (1998b): Lipid oxidation in sausages commercialized in "sacolões municipais" of São Paulo (SP), Brazil. (In Portuguese with abstract in English.) [Master Thesis.] Fac. Public Health, Univ. São Paulo.

FERRARI C.K.B. (1999): Oxidation of fats in foods: production of toxic substances in the human diet. (In Portuguese with abstract in English.) Rev. Inst. Hig. Med. Soc., **3**: 22–26.

FERRARI C.K.B. (2000): Biochemical and physical pro- and anti-oxidant factors associated with lipid oxidation in foods. (In Portuguese) Hig. Aliment., **14** (78/79): 37–44.

FERRARI C.K.B., TORRES E.A.F.S. (2000a): Physical and biochemical factors of industrialization, preparing and storaging of foods and their relationships with free radicals and lipid oxidation (In Portuguese) Hig. Aliment., **14** (68/69): 19–25.

FERRARI C.K.B., TORRES E.A.F.S. (2000b): Quality parameters in a food product of animal origin commercialized in the city of São Paulo. (In Portuguese) Hig. Aliment., **14** (75): 25–32.

GONÇALVES J.R. (1995): Qualidade e competitividade: requisitos para a industrialização de salsicha. Rev. Nac. Carne, **19** (220): 39–42.

GREENE B.E., CUMUZE T.H. (1981): Relationship between TBA numbers and inexperienced panelists' assessments of oxidized flavor in cooked beef. J. Food Sci., **47**: 52–54, 58.

HABERLAND M.E., FLESS G.M., SCANU A.M., FOGELMAN A.M. (1992): Malondialdehyde modification of lipoprotein(a) produces avid uptake by human monocyte-macrophages. J. Biol. Chem., **267**: 4143–4151.

HSU L.A., CIAMPI C.M.S., DELAZARI I., LAZARINE V.B., GALVÃO L.C.A., FIGUEIREDO I.B. (1977): Avaliação da qualidade de salsichas. Bol. Inst. Tecnol. Aliment., **53**: 93–107.

KANNER J. (1994): Oxidative processes in meat and meat products: quality implications. Meat Sci., **36***:* 169–189.

KUBOW S. (1992): Routes of formation and toxic consequences of lipid oxidation products in foods. Free Rad. Biol. Med., **12**: 63–81.

LEE M.B., STYLIADIS S. (1996): A survey of pH and water activity levels in processei salamis and sausages in Metro Toronto. J. Food Protect., **59**: 1007–1111.

LEITÃO M.F. DE F. (1988): Fatores que afetam o desenvolvimento microbiano em alimentos. In: ROITMAN I., TRAVASSOS L.R., AZEVEDO J.L. (Eds): Tratado de Microbiologia. Vol. 1. Manole Ed., São Paulo: 11–12.

LORENZO J.M., MICHINEL M., LÓPEZ M., CARBALLO J. (2000): Biochemical characteristics of two Spanish traditional dry-cured sausage varieties: Androlla and Botillo. J. Food Composit. Anal., **13**: 809–817.

MORRISSEY P.A., SHEEHY P.J.A., GALVIN K., KERRY J.P., BUCKLEY D.J. (1998): Lipid stability in meat and meat products. Meat Sci., **49** (Suppl.): S73–S86.

NEWBURG D.S., CONCON J.M. (1980): Malonaldehyde concentrations in food are affected by cooking conditions. J. Food Sci., **45**: 1681–1683, 1687.

PEARSON A.M., GRAY J.I., WOLZAK A.M., HORENSTEIN N.A. (1983): Safety implications of oxidized lipids in muscle foods. Food Technol., **37**: 121–129.

PEARSON A.M., LOVE J.D., SHORLAND F.B. (1977): "Warmed-over" flavor in meat, poultry, and fish. Adv. Food Res., **23**: 1–74.

PETERS J.M., PRESTON-MARTIN S., LONDON S.J., BOWMAN J.D., BUCKLEY J.D., THOMAS D.C. (1994): Processed meats and risk of childhood leukemia (California, USA). Canc. Caus. Contr., **5**: 195–202.

REAGAN J.O., LIOU F.H., REYNOLDS A.E, CARPENTER J.A. (1983): Effect of processing variables on the microbial, physical and sensory characteristics of pork sausage. J. Food Sci., **48**: 146–149, 162.

RHEE K.S. (1988): Enzymic and nonenzymic catalysis of lipid oxidation in muscle foods. Food Technol., **42**: 127–132.

SARASUA S, SAVITZ D.A. (1994): Cured and broiled meat consumption in relation to childhood cancer: Denver, Colorado (United States). Canc. Caus. Contr., **5**: 141–148.

SHAMBERGER R.J., SHAMBERGER B.A., WILLLS C.E. (1977): Malonaldehyde content of food. J. Nutr., **107**: 1404–1409.

SILVA P. DA (1995): O mercado de embutidos cresce no Brasil – reportagem de capa. Alim. Technol., **10** (61): 36–38,40–41.

SIU G.M., DRAPER H.H. (1978): A survey of the malonaldehyde content of retail meats and fish. J. Food Sci., **43**: 1147–1149.

TARLADGIS B.G., PEARSON A.M., DUGAN-JR. L.R. (1964): Chemistry of the 2-thiobarbituric acid test for detemination of oxidative rancidity in foods. II. Formation of the TBA-malonaldehyde complex without acid-heat treatment. J. Sci. Food Agric., **15**: 602–604.

TIMS M.J., WATTS B.M. (1958): Protection of cooked meats with phosphates. Food Technol., **12**: 240–243.

TORRES E.A.F.S., OKANI E.T. (1997): Teste de TBA: ranço em alimentos. Rev. Nac. Carne, **21** (243): 68–78.

TORRES E., PEARSON A.M., GRAY J.I., KU P.K. (1989): Lipid oxidation in charqui (salted and dried beef). Food Chem., **32**: 257–268.

TORRES E.A.F.S., SHIMOKOMAKI M., FRANCO B.D.G.M., LANDGRAF M., CARVALHO-JR. B.C., SANTOS J.C. (1994): Parameters determining the quality of charqui, an intermediate moisture product. Meat Sci., **38**: 229–234.

WANG F.S., JIANG Y.N., LIN C.W. (1995): Lipid and cholesterol oxidation in Chinese-style sausage using vacuum and modified atmosphere packaging. Meat Sci., **40**: 93–101.

Received for publication June 19, 2001
Accepted after corrections February, 19, 2002

Abstrakt

FERRARI C.K.B., TORRES E.A.F.S. (2002): **Oxidace lipidů a ukazatele jakosti u párků prodávaných na místních tržištích ve městě Sao Paulo (Brazílie)**. Czech J. Food Sci., **20**: 144–150.

Oxidace lipidů je jednou z nejvážnějších příčin zhoršování kvality potravin, zejména masných výrobků, a jsou s ní spojeny mnohé škodlivé vlivy na lidské zdraví. Během šesti týdnů jsme náhodně nakupovali vzorky potravin na městských potravinových tržištích (CHFMs) a zjišťovali jsme oxidaci lipidů (test TBARS) a některé ukazatele jakosti – redox potenciál (Eh), hodnotu pH a aktivitu vody (a_w). Průměrná hodnota Eh činila $X \pm \sigma_{n-1} = 39{,}03 \pm 26{,}30$ mV v rozmezí od –86,00 do 92,00 mV a průměrná hodnota pH $X \pm \sigma_{n-1} = 5{,}97 \pm 0{,}27$ v rozmezí od 5,08 do 6,48. U jednotlivých vzorků jsme nezjistili statisticky významné rozdíly mezi hodnotami pH, Eh a a_w. Průměrná hodnota testu TBARS činila $X \pm \sigma_{n-1} = 0{,}44 \pm 0{,}23$ mg/kg v rozmezí od $0{,}38 \pm 0{,}19$ mg/kg (CHFM-6) do $0{,}58 \pm 0{,}31$ mg/kg (CHFM-2) s extrémní hodnotou 0,22 mg/kg a 1,08 mg/kg. Mezi hodnotami testu TBA a všemi testovanými ukazateli jsme nezjistili statisticky významné korelace. Podle kritérií senzorické analýzy (GREENE & CUMUZE 1981) 16,67 % vzorků párků by mělo být znehodnoceno a 11,11 % mělo kritické hodnoty TBARS.

Klíčová slova: oxidace lipidů; párky; maso; potravinové tržiště; ukazatelé jakosti

Corresponding author:

Ass. Prof. ELIZABETH A.F.S. TORRES, PhD., Department of Nutrition, Faculty of Public Health, University of São Paulo (USP), Av. Dr. Arnaldo, 715 (2º andar), CEP: 01246-904, Cerqueira César, São Paulo (SP), Brazil

tel.: + 55 11 30 66 77 01, fax: + 55 11 852 67 48, e-mail: eatorres@usp.br