# FAT OXIDATION IN PORK SALTED AND CURED BY USING THE ENCAPSULATED SODIUM CHLORIDE

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## Background

Numerous researches indicate that sodium chloride added to meat may have a negative, pro-oxidative effect (Decker & Xu, 1998, Kanner et al. 1991, Rhee & Ziprin 2001). There are many causes if this phenomenon and it is observed both in meat stored in chilled room as well as in meat during freezing, although this last process decreases rate of fat oxidation (Kanner 1994, Mc Carthy et al. 2001, Andersen & Skibsted, 1991). The use of many different techniques such as vacuum or modified atmosphere packaging, applying of antioxidants or other substances may additionally decrease the processes of fat oxidation (Rhee, 1999, Bloukas & Honikel 1992, Freybler et al. 1993). Some scientists analysing salt influence on fat changes suggest that instead of common salt containing sodium chloride, the encapsulated salt should be used (Decker & Xu, 1998, Lee et al. 1997).

## Objective

The aim of this study is to evaluate the influence of microencapsulated salt on the extent of fat oxidation in meat stored in chilled room (2-4$^0$C) for 14 days and in freezer (-18$^0$C) for 3 months. Its influence was also compared with other methods limiting fat oxidation in meat.

## Material and methods

*Longissimus dorsi* muscle cut out from pork loin (L) and deboned neck (N) were used in this study. Meat was taken from chilled pork half-carcasses 24h after slaughter and after previous selection in respect to quality. Only normal quality muscles were taken, free from quality defects such as PSE or DFD. Meat was considered of normal quality when the pH value was higher than 5,5, electrical conductivity not greater than 8mS/cm, and meat surface colour ranged from pink to light red. Pork loin and neck were cut into 35 – 40mm slices. They were divided into three groups designated after salt injection or dry salting for storage for 2 and 14 days at 2$^0$C and for 3 months at -18$^0$C. In each group 8 experimental subgroups were formed (they are listed below). From 6 to 7 slices of meat were designed to each subgroup. They were salted or cured using kitchen or microencapsulated salt (Cap Shure 85 Salt, Balchem Corp.), sodium nitrite and lactic acid. Type of used additive and its amount in different subgroup was as follows: 1) Sk - sodium chloride (2%), 2) Sm - microencapsulated sodium chloride (2,3%), 3) SkA - sodium chloride (2%) and sodium nitrite (0,00125%), 4) SmA - microencapsulated sodium chloride (2,3%) and sodium nitrite (0,00125%), 5) SkAK - sodium chloride (2%), sodium nitrite (0,00125%), lactic acid (0,03%), 6) SmAK - microencapsulated sodium chloride (2%), sodium nitrite (0,00125%), lactic acid (0,03%), 7) SkK - sodium chloride (2%) and lactic acid (0,03%), 8) SmK - microencapsulated sodium chloride (2,3%) and lactic acid (0,03%).
The amount of added microencapsulated salt was increased by 15% as compared to the amount of ordinary salt. This weight share responded microencapsulating substance. When during salting lactic acid was used the amount of added salt was decreased by 0,5%, because it increased the salty taste of meat. The majority of curing components was added by injection of brine in amount of 20%. Microencapsulated salt was added on the surface of slices. Meat was placed in plastic bags (laminate polyamide-polyethylene of permeability: $O_2$ – 50 cm$^3$/m$^2$/24h; $CO_2$ - 140 cm$^3$/m$^2$/24h and water - 6÷8g/m$^2$/24h). Later they were vacuum closed (vacuum 50mbar) and stored in chilled conditions at the temperature of 2 – 4$^0$C for 2 and 14 days period and at temperature of -18$^0$C for 3 months. In case of frozen meat before the measurements, it was defrosted by storage for 24h at 6$^0$C. After the storage meat slices were heated using "Rational" oven at 150$^0$C for about 13 – 15 min. with forced air circulation until they reached internal temperature of 68$^0$C. After the meat was chilled to room temperature some of the slices were minced, others were stored in chilled room at 2 – 4$^0$C for 2 days. During storage the samples were exposed to light of 200 lux intensity. In both cases (after heating and prolonged cool storage) the oxidative fat changes were evaluated by estimation of TBA value (Salih et al. 1987). This method bases on colorimetric estimation of compounds created during reaction between 2- thiobarbituric acid (TBA) and products of lipid oxidation after heating of the examined sample in acidic environment. All experiments were repeated three times.

## Results and discussion

Results of TBA value evaluation (expressed in mg of malonaldehyde per 1 kg of sample) in examined samples are presented in table. Statistical analysis showed, that the type of raw meat (loin muscle and neck) and sample (subgroups in experiment) along with time of salting/curing and exposure to light as well as the type of the salt significantly influenced oxidative processes in lipids. Significant changes were observed between samples treated with sodium nitrite – SzA, SmA, SzAK, SmAK and samples without nitrite – Sz, Sm, SzK, SmK. Usage of nitrite allowed to reach the lowest TBA value. They were usually higher in case of neck, which contained more fat. The effect of nitrite was so efficient, that it was difficult to notice differences between influence of regular and microencapsulated salt and addition of lactic acid on fat oxidation processes. The obtained results showed that meat acidity usually slightly improved antioxidative influence of nitrite, although the differences between samples that were cured and those which were not treated, were statistically insignificant. Lactic acid used together with sodium chloride only (SzK and SmK samples) usually lowered the TBA value, but only in case of loin. Its influence on fat in neck was diverse. After 2 days of salting, TBA values estimated for SzK and SmK samples were higher than values in case of Sz and Sm samples, and after frozen storage reached average values usually higher than in samples where no acid was used (table). Usage of brine containing regular salt (with or without lactic acid) as compared to samples treated with sodium nitrite led to higher susceptibility of meat lipids to oxidative spoilage (table). Microencapsulated salt "85 Salt" modified this process. Its oxidative influence was noticeable after heating and additional storage combined with exposure to light. Unfavourable influence of light was noticed also by Andersen and Skibsted (1991), Bertelsen et al. (200) and Morell et al. (2000). Due to lipid exposure to light, active forms of oxygen, its singlet, are created. They react directly with lipid acids creating hydroperoxides, which further during their decomposition to free radicals, initiate and develop oxidative chain reactions. Favourable influence of salt microencapsulation connected mainly with restraining the speed of fat oxidation was found mainly in loin. Mean TBA values estimated for this muscle after 48h of cold storage connected with light exposure, independent of salting time, were lower in case of usage of microencapsulated salt. This was not observed during neck evaluation, although the level of fat oxidation expressed by the TBA value was higher. Such difference could have been a consequence of two events. Neck contained more fat, thus extent of oxidation expressed by TBA number recalculated per 100g of tissue was larger. However, it would be probably lower than in loin, if TBA values were recalculated to the amount of fat in the muscle. Neck containing more fat as compared to loin, has usually less triacyloglicerol, which contain polyunsaturated lipid acids (Pikul 1997). This might have influenced the restriction of oxidation and protective action of capsule was not so emphasised as it was observed in loin. Encapsulation of salt may decrease the speed of fat oxidation

processes, also by limiting iron ions release from the muscle tissue, which are the stimulators of oxidation and are washed out by salt with proteins. This process, with usage of microencapsulated salt, may generally take place only during heating, after the salt has been released from protective layer. In case of ordinary kitchen salt, extraction of proteins connected with additional release of iron ions, may be a long-lasting process, taking place even during storage before the final cooking procedure. In this connection, number of released $Fe^{++}$ and $Fe^{+++}$ may be higher, which should lead to larger oxidation, also after heating (Brøndum et al. 2000).

**Conclusions**

1. Among analysed factors, which slow down the fat oxidation process, sodium nitrite used for meat curing was the most effective.
2. Favourable effect of microencapsulated salt on decrease of speed of lipid oxidation processes in meat was especially noticeable during its further storage after heating and it varied depending on type of raw meat, thus type of fat, which it contains.

**Literature**

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Table. TBA number of pork after its heating and storage in chilled conditions (mg of malonaldehyde per 1 kg of sample)

| Type of the sample | Type of raw material | Duration of salting/curing and conditions of meat storage | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2 days (2-4°C) | | 14 days (2-4°C) | | 3 month (-18°C) | |
| | | *duration of storage after heating and exposition to light at 2-4°C (h)* | | | | | |
| | | *0* | *48* | *0* | *48* | *0* | *48* |
| **Sz**[***] | **N**[***] | $0,35^{eB**}\pm0,11^{*}$ | $1,54^{bA}\pm0,44$ | $0,91^{dA}\pm0,13$ | $2,17^{aA}\pm0,13$ | $0,43^{eB}\pm0,24$ | $2,21^{aA}\pm0,20$ |
| | **L** | $0,27^{eB}\pm0,29$ | $1,25^{cB}\pm0,15$ | $0,29^{eB}\pm0,16$ | $1,15^{cC}\pm0,36$ | $1,53^{bA}\pm0,26$ | $1,53^{bB}\pm0,15$ |
| **Sm** | **N** | $0,34^{eB}\pm0,05$ | $1,69^{bA}\pm0,48$ | $0,58^{dA}\pm0,13$ | $2,48^{aA}\pm0,26$ | $0,47^{eB}\pm0,25$ | $2,38^{aA}\pm0,54$ |
| | **L** | $0,40^{eB}\pm0,41$ | $1,00^{eB}\pm0,18$ | $0,42^{eB}\pm0,27$ | $0,84^{dD}\pm0,15$ | $0,82^{dB}\pm0,66$ | $1,36^{cB}\pm0,36$ |
| **SzA** | **N** | $0,16^{fC}\pm0,06$ | $0,19^{fC}\pm0,01$ | $0,22^{eB}\pm0,09$ | $0,35^{eE}\pm0,09$ | $0,24^{eC}\pm0,11$ | $0,50^{eC}\pm0,10$ |
| | **L** | $0,12^{fC}\pm0,09$ | $0,07^{fC}\pm0,06$ | $0,11^{fC}\pm0,06$ | $0,16^{fE}\pm0,10$ | $0,04^{fC}\pm0,03$ | $0,04^{fD}\pm0,04$ |
| **SmA** | **N** | $0,17^{fC}\pm0,04$ | $0,19^{fC}\pm0,02$ | $0,24^{eB}\pm0,09$ | $0,31^{eE}\pm0,04$ | $0,29^{eC}\pm0,08$ | $0,58^{dC}\pm0,31$ |
| | **L** | $0,06^{fC}\pm0,02$ | $0,05^{fC}\pm0,03$ | $0,05^{fC}\pm0,03$ | $0,06^{fE}\pm0,04$ | $0,08^{fC}\pm0,07$ | $0,01^{fD}\pm0,005$ |
| **SzAK** | **N** | $0,19^{fC}\pm0,04$ | $0,21^{fC}\pm0,02$ | $0,21^{fB}\pm0,06$ | $0,25^{eE}\pm0,03$ | $0,25^{eC}\pm0,06$ | $0,42^{eC}\pm0,10$ |
| | **L** | $0,12^{fC}\pm0,10$ | $0,09^{fC}\pm0,05$ | $0,06^{fC}\pm0,04$ | $0,04^{fE}\pm0,02$ | $0,02^{fC}\pm0,01$ | $0,03^{fD}\pm0,03$ |
| **SmAK** | **N** | $0,21^{fC}\pm0,02$ | $0,20^{fC}\pm0,01$ | $0,20^{fB}\pm0,06$ | $0,27^{eE}\pm0,03$ | $0,24^{eC}\pm0,07$ | $0,40^{eC}\pm0,18$ |
| | **L** | $0,12^{fC}\pm0,06$ | $0,07^{fC}\pm0,03$ | $0,07^{fC}\pm0,04$ | $0,02^{fE}\pm0,01$ | $0,03^{fC}\pm0,04$ | $0,04^{fD}\pm0,03$ |
| **SzK** | **N** | $0,80^{dA}\pm0,27$ | $1,82^{bA}\pm0,28$ | $0,65^{dA}\pm0,12$ | $1,82^{bB}\pm0,28$ | $1,04^{cA}\pm0,17$ | $2,70^{aA}\pm0,05$ |
| | **L** | $0,34^{eB}\pm0,15$ | $0,80^{dB}\pm0,10$ | $0,35^{eB}\pm0,28$ | $0,87^{dD}\pm0,17$ | $0,72^{dB}\pm0,16$ | $1,06^{cB}\pm0,16$ |
| **SmK** | **N** | $0,68^{dA}\pm0,04$ | $1,85^{bA}\pm0,17$ | $0,63^{dA}\pm0,09$ | $1,86^{bB}\pm0,04$ | $1,16^{cA}\pm0,40$ | $2,33^{aA}\pm0,23$ |
| | **L** | $0,83^{dA}\pm0,10$ | $0,36^{eC}\pm0,36$ | $0,36^{eB}\pm0,36$ | $0,69^{dD}\pm0,34$ | $0,78^{dB}\pm0,51$ | $1,41^{cB}\pm0,17$ |

[*] - standard deviation, [**] - means marked with small letter denote statistically significant differences within all compared groups ($P\leq0,05$); capital letters indicate statistically significant differences for particular time of observations ($P\leq0,05$), [***] - explanation – see in text