Effect of salting on back fat hydrolysis and oxidation

E K Tunieva, V V Nasonova, I A Stanovova, K I Spiridonov and A A Kurzova
The V.M.Gorbatov All-Russian Meat Research Institute, Russian Academy of Agricultural Sciences, Moscow, Russian Federation

E-mail: lenatk@bk.ru

Abstract. Technological factors significantly affect the rate of hydrolytic and oxidative changes in fat. The aim of the research was to study the effect of sodium chloride on hydrolysis and oxidation of fat raw material, including the impact of thermal treatment. Back fat was minced, sodium chloride was added (in amounts of 0.0, 2.0, 3.5 or 5.0%), then it was thermally treated or not. Determination of the acid value (AV) was carried out by titration with aqueous potassium hydroxide of free fatty acids in the ether-alcohol solution of back fat; the peroxide value (PV) was based on oxidation of iodhydric acid with peroxides contained in fat followed by titration of released iodine with sodium thiosulphate. The thiobarbituric acid value (TBAV) was determined by the development of stained substances due to interaction of fat oxidation products with 2-thiobarbituric acid and measurement of color intensity using a spectrophotometer. Adding 5.0% sodium chloride to back fat led to a 30.1% decrease in AV. Addition of 2.0% sodium chloride inhibited the development of the oxidation products and led to a 17% decrease in the PV and to a 25% decrease in TBAV (р<0.05). In the presence of 5.0% sodium chloride, the secondary oxidation products significantly increased by 34.1% (р<0.05) and 24.3% (р<0.05) on days 1 and 3 of storage, respectively. Thermal treatment mitigated the effect of sodium chloride on the indicators of hydrolytic and oxidative spoilage (р>0.05). The results obtained showed an ambiguous effect of sodium chloride on the processes of fat oxidation, depending on dosage and the use of thermal treatment, justifying the necessity to develop approaches that allow reduction of the sodium chloride content in meat products that are not subjected to thermal treatment.

1. Introduction
Non-meat ingredients in formulations that are used for formation of the necessary technological properties of meat and organoleptic characteristics of finished products play an important role in the development of hydrolysis and oxidation products. Table salt is an essential component in all types of meat products and its effect on the oxidative changes in fats is quite considerable. Despite a large number of studies on safety and quality formation in meat products in the process of salting, available literature data regarding the effect of table salt on the mechanism of oxidative processes are rather controversial. According to some data, sodium chloride has an anti-oxidative effect [1] or has no effect on the fat chemical properties [2], while other studies demonstrate the pro-oxidative effects [3-5] of table salt. Inconsistency of data concerning the effect of salt on the mechanism of oxidative processes is rather controversial. According to some data, sodium chloride has an anti-oxidative effect [1] or has no effect on the fat chemical properties [2], while other studies demonstrate the pro-oxidative effects [3-5] of table salt. Inconsistency of data concerning the effect of salt on the chemical changes in lipids, apparently, can be explained by differences in selection of subjects of research, which, as a rule, are various types of meat with different meat tissue content and, consequently, with different water content, as well as finished products produced with various types of technological treatment.
Changes in fat during storage are commonly measured using three parameters. The acid value (AV) of fat characterizes the depth of the hydrolytic degradation of fats and when studying back fat during storage, it is an indicator of the oxidative spoilage along with the peroxide value (PV), which indicates the degree of the fat oxidative spoilage. The thiobarbituric acid value (TBAV) assesses accumulation of secondary fat oxidation products (aldehydes).

An example of a sodium chloride effect is modification of heme of muscle tissue proteins, which catalyzes lipid oxidation. With a complex substrate such as meat or fat and in the process of salting, the number of factors that can have a considerable effect on fat hydrolysis and oxidation is significant, and these processes can occur as a consequence of only indirect effects of sodium chloride on fats. Thus, to fully understand the mechanisms of how salt affects the development of products of oxidative spoilage, it is necessary to individually consider potential factors that influence the character of the table salt effect on fat oxidation, including salt dose, type of thermal treatment and absence/presence of meat tissue. In this connection, the aim of this research was to study the effect of different sodium chloride doses on the hydrolytic and oxidative changes in back fat before and after thermal treatment.

2. Materials and Methods
Samples of pork back fat (2nd class) from 2-year-old Large White pigs were comminuted in a grinder with a 3 mm grind plate, and sodium chloride (0.0, 2.0, 3.5 or 5.0 %) was added. Salted back fat was thermally treated or not, and stored at 4±2°C for 1 and 3 days.

The AV was determined by titration of free fatty acids in an ether-alcohol solution of fat with an aqueous solution of KOH; PV was measured by oxidation of iodhydric acid with peroxides contained in the fat followed by titration of released iodine with sodium thiosulphate. Determination of TBAV was by development of stained substances due to interaction of fat oxidation products with 2-thiobarbituric acid; color intensity was measured spectrophotometrically.

3. Results and Discussion
Sodium chloride concentration had an ambiguous effect on the rate of fat hydrolysis and oxidation product formation (figure 1). Back fat with 2.0% table salt showed a 20.6% decrease in AV by day 3 of storage; when the salt dose was 5.0%, the AV reduced by 30.1% compared to unsalted back fat (p<0.05), apparently, due to a water activity decrease caused by the amount of sodium chloride, which facilitated a retardation of hydrolytic changes in the fat. With that, thermal treatment mitigated the effect of table salt on the AV (p<0.05) compared to unsalted back fat (figure 2).

![Figure 1. Effect of sodium chloride dose on the acid value of back fat during storage.](image-url)
However, the same trends were not observed when PV (figures 3 and 4) or TBAV (figures 5 and 6) were used to assess primary or secondary oxidative spoilage of the salted back fat.

When 2.0 % table salt was added to back fat, the indicators of oxidative spoilage decreased on day 3 by 17% for PV and by 25 % for TBAV, compared with unsalted back fat.

An increase in the sodium chloride dose up to 3.5 % did not significantly affect the PV (p>0.05) compared with control back fat (figure 3). With that, as a result of thermal treatment, the PV (an indicator of oxidative spoilage) decreased by 11.1-31.1 % and 15.1-20.7 % depending on the sodium chloride dose on days 1 and 3 of storage, respectively. Moreover, as a result of thermal treatment, the effect of table salt on the hydrolytic and oxidative changes in the back fat decreased.
Figure 4. Effect of sodium chloride dose on the peroxide value of back fat after thermal treatment.

Figure 5. Effect of sodium chloride dose on the thiobarbituric acid value of back fat during storage.

Up to 3.5% salt did not significantly affect the formation of secondary oxidation products in back fat after 1 day of storage ($p>0.05$), as shown by TBAVs measured (figure 5). However, after 3 days of storage, a 25% decrease in the TBAV ($p<0.05$) was observed in the presence of 2.0% of table salt. An increase in the sodium chloride dose up to 3.5% did not significantly change the oxidation rate, since the TBAV was similar to that of fat with 2.0% added salt. However, when 5.0% salt was added, a substantial increase in the oxidation products, as measured by TBAV, occurred (34.1 %, $p<0.05$, and 24.3 %, $p<0.05$ on days 1 and 3 of storage, respectively). As a result of the thermal treatment, the TBAV decreased by 5.2-6.3 % ($p<0.05$) and 14.7-24.9 % ($p<0.05$) after 1 and 3 days of storage, respectively.
Figure 6. Effect of sodium chloride dose on the thiobarbituric acid value of back fat after thermal treatment.

The data obtained are consistent with the results of a previous study on the effect of salts on the qualitative composition of volatile substances that are formed in back fat in the process of salting. For example, addition of sodium chloride at levels of 2.0 and 3.5% inhibited the oxidative changes in polyunsaturated fatty acids compared to an unsalted sample. However, an increase in the table salt dose up to 5.0% facilitated an increase in the amount of saturated fatty acids formed due to oxidation of unsaturated acids. This tendency was characteristic both for volatile and etherified fatty acids. It was established that back fat salted with 2.0 and 3.5% table salt produced lower levels of secondary oxidation products. However, sodium chloride in higher doses acted as a pro-oxidant, initiating oxidation of fatty acids to form carbonyl compounds as well as the products from fatty acid interaction with ammonia, hydrogen sulfide and other substances that are formed as a result of amino acid breakdown [6].

4. Conclusion
This study has contributed to our understanding of the ambiguous effect of sodium chloride on the hydrolytic and oxidative changes of salted back fat. Based on the results obtained, it can be concluded that addition of up to 2.0% table salt to back fat facilitates retardation of fat’s hydrolytic and oxidative changes. However, sodium chloride in high doses acts as a catalytic agent for fat’s oxidative changes. With that, thermal treatment mitigated the negative effect of table salt on fat oxidation. Since decreasing the amount of table salt in meat products will lead to deterioration of their taste and technological characteristics, it is necessary to use approaches that lessen these changes. First of all, the anti-oxidative protection of meat raw materials should be increased by the additional use of antioxidants for meat products with a high salt content that are not subjected to thermal treatment (uncooked smoked and air-dried meat products). Secondly, technological recommendations on varying sodium chloride content due to the use of salt substitutes in meat products must be developed.

References
[1] Andres A I, Cava R, Ventanas J, Muriel E and Ruiz J 2004 Lipid oxidative changes throughout the ripening of dry-cured Iberian hams with different salt contents and processing conditions Food Chem. 84(3) 375–81
[2] Calligaris S and NicoliMc 2006 Effect of selected ions from lyotropic series on lipid oxidation rate Food Chem. 94(1) 130-4
[3] Gheisari H R, Moller J K S, Admasen C E and Skibsted L H 2010 Sodium Chloride or Heme Protein Induced Lipid Oxidation in Raw, Minced Chicken Meat and Beef Czech J. Food Sci.
28 364–75

[4] Rhee K S and Ziprin Y A 2001 Pro-oxidative effects of NaCl in microbial growth-controlled and uncontrolled beef and chicken Meat Sci. 57 105–12

[5] Jin G, He L, Zhang J, Yu X, Wang J and Huang F 2012 Effects of temperature and NaCl percentage on lipid oxidation in pork muscle and exploration of the controlling method using response surface methodology (RSM) Food Chem. 131(3) 817–25

[6] Tunieva E K and Ivankin A N 2015 Influence of sodium chloride on the composition of the volatiles formed during oxidation of lard Vse o Mjase 2 27-30 (in Russian)