TECHNOLOGICAL ASPECTS OF ACID DECONTAMINATION OF CARCASSES

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Introduction

There were many experiments undertaken to prolong the shelf-life of meat and meat products. Many publications deal with this problem; among others we can mention[1–5]. It is clear that the surface treatment of carcasses by spraying with lactic acid solution reduces the surface microbial counts and thus increases the shelf-life and provides food safety.

This method appears repeatedly in the context with the tendency to prolong the shelf-life of packaged meat in oxygen atmosphere. The meat for packaging must have actually extremely low microbial counts and these strict requirements include also very low microbial counts on the carcasses. Thus the need for long shelf-life of packaged meat means also the surface treatment of carcasses at the end of the slaughter line.

At the moment of slaughtering the meat is almost sterile so that the primary contamination concerns in particular the meat surface. Later the microorganisms penetrate into deeper layers of meat. When this primary contamination is reduced, the shelf-life of meat can be significantly prolonged. Thus it is advantageous to decontaminate the surface of carcasses to increase their shelf-life and to enable the safe distribution. A number of methods were suggested for the surface decontamination. The mostly used lactic acid acts by decreasing pH, and due to its bactericidal properties, stops growth of bacteria.

Lactic acid is often used for surface decontamination as it is a natural component of meat produced during postmortal glycolysis and thus it is not a typical additive[6]. The application of organic acids cannot replace the rules of high hygiene and good manufacturing practice, but it may be used as an additional hurdle contributing to prolonging the shelf-life. In this respect, there is good experience with surface treatment of the chilled poultry using lactic acid which reduces the initial bacterial count and causes a delay of the start of logarithmic phase of their growth[2].

The moment and the mode of acid application are very important and they are often underrated. Concentration of the acid in the range of 1–2 % is generally accepted. Less attention is given to the temperature of acid, which should be similar to the temperature of carcass surface. The acid treatment may be done at different places of the slaughterhouse. However, it should be done as soon as possible, i.e. when most of the microorganisms are present on the meat surface and they have not yet penetrated into deeper layers.

The influence of acid decontamination on the appearance (colour) of carcass surface is differently assessed in the literature. The information about colour changes affected by lactic acid to brighter or brownish are opposite to those that no changes occur. In our own experiments we found that lactic acid caused brighter colour of meat surface, while changes in hue were negligible. However, no significant influence of lactic acid on myoglobin oxidation was observed by direct reflectance spectrometry[7].

Another possibility of carcass surface decontamination is a combination of lactic acid spray with hot steam. We continue our research on this topic, and the results will be published.

The use of the mentioned decontamination treatments, although well known and widely used, often and repeatedly invokes the discussions about their effectivity, economy and possible colour changes. The price of the treatment and its influence on weight losses are also discussed. These circumstances were the subject of our study.

In present experiments some aspects of surface acid decontamination of beef and pork carcasses were studied. The decontamination effect of different temperature of lactic acid spray-solution was evaluated. In addition, the effect of citric acid was compared with that of lactic acid. Besides the effect on shelf-life prolongation, the effect of lactic acid on the yield or on the weight losses during storage was evaluated. From these values the economy of treatment was assessed.

Materials and methods

M a t e r i a l s

Lactic acid Purac FCC 80 (80 % L(+) lactic acid, Purac Gorinchem, Netherlands)

Citric acid (crystalline ČSN 66 15 14; Variant s.r.o., Všetaty, CR)

Pork and beef carcasses were treated immediately at the end of slaughter line, before entry to the chilling tunnel.

Decontamination solution was prepared by dilution of 2 % of L(+) lactic acid (Purac FCC 80) in water. The temperature of solution at the moment of treatment was in most cases 45 °C; in some cases ("cold treatment"), this temperature was 15 °C. A manual sprayer was used for application of the solutions on the carcass surface. The

application of a 2% solution of citric acid was carried out in the same way. Warm tap water (40 °C) was always used as control.

All additives were applied immediately at the end of the slaughter line. Then the carcasses were chilled in an air tunnel and stored at about +3°C.

M e t h o d s

The total counts of mesophilic microorganisms were determined according to the ČSN ISO 4833 standard. Every 10 g of sample was homogenised with 100 g of physiological solution and diluted following the expected microbial counts. The amount of 1 ml of diluted sample was placed on Petri dishes and covered with 15 ml of PCA (temperature 40–45 °C). After mixing, the Petri dishes were stored at 37 °C. After 24 or 48 h of cultivation, the total counts were related to 1 g of the sample.

The total counts of psychrophilic microorganisms were determined in the same way, only cultivation was carried out on the PCA for 72 h at 15 °C (ČSN ISO 560100 standard).

Weight losses were determined using a hanging balance Mettler Toledo ID5 MultiRange and Mettler Toledo ID7. The carcasses were weighed immediately after decontamination (30 min post mortem), after rapid cooling (3 h post mortem) and after 24 h and 48 h of cold storage.

The economical evaluation consisted in the evaluation of mass balance during rapid cooling and subsequent cold storage and a comparison of the yield with material costs for lactic acid treatment.

Results and discussion

The results of experiments show that the application of lactic acid on the carcasse surface is effective on industrial scale. In all cases the application of organic acids inhibited the growth of microorganisms on the surface of carcasses and the shelf-life was prolonged.

It is generally recommended to prefer warm solutions of lactic acid for the carcass decontamination. We tested the temperature decrease during the application and we were able to find that the drops of lactic acid solution at the moment when they fall on the carcass surface are up to 10 °C cooler than the original solution. We ascribe this temperature decrease partly to the heat exchange between drops and surrounding air and partly to evaporation of water from drops, which have a relatively high surface. Thus the temperature of drops of about 35–40 °C on the meat surface corresponds to the temperature of 45 °C of the original solution.

A comparison of the two solution temperatures was carried out in order to find out whether the solution temperature has any effect on the microbial counts on the carcass surface. It was proved (see Fig. 1 and 2) that the effect of lactic acid is higher, if its solution is warm (45 °C) in comparison with the cold solution (15 °C). The effect was higher with pork carcasses (Fig.1) than with beef carcasses (Fig. 2). In the case of the carcasses that were decontaminated with warm lactic acid solutions, the lag phases were prolonged by one day; during following days of cold storage, the differences decreased.

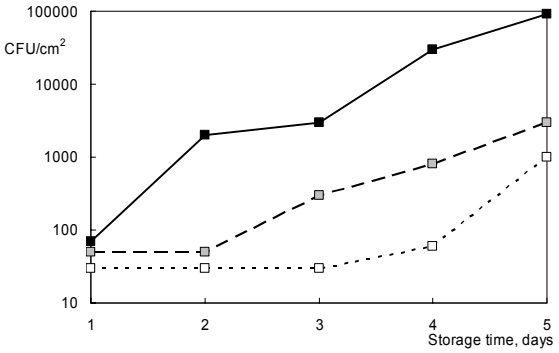

Fig. 1. **Effect of decontamination using lactic acid spray on the total counts of psychrophilic microorganisms on pork carcass surface;** ■ control, ▣ lactic acid 15 °C, □ lactic acid 45 °C

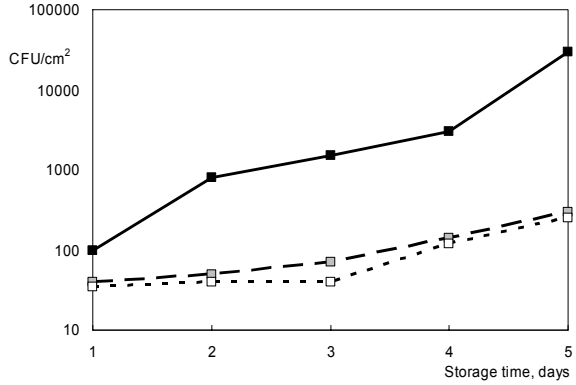

Fig. 2. **Effect of decontamination using lactic acid spray on the total counts of psychrophilic microorganisms on beef carcass surface;** ■ control, ▣ lactic acid 15 °C, □ lactic acid 45 °C

Although the decontamination of carcass surface by lactic acid treatment shows in all cases a positive effect on the decrease in microbial counts and thus on the shelf life, this was not the main goal of the investigation. The aim of this investigation was to assess whether this beneficial decontamination process negatively affects the economy of production, in other words, whether it increases weight losses during cooling and subsequent cold storage of carcasses.

It was proved that the weight losses during cold storage were surprisingly lower in lactic acid-treated carcasses in comparison with control samples sprayed with water. The explanation of this effect can be found in changes of protein structure on the surface. The lactic acid treatment probably induces denaturation of the proteins on the sur-

Table I
Effect of temperature of lactic acid solution on the weight losses of pork carcasses

		Weight losses [%]			Total
		1 h	24 h	48 h	
Control		1.05	1.43	0.62	3.10
	s.d.	0.10	0.09	0.08	0.13
Lactic acid 45 °C		0.88	1.07	0.47	2.43
	s.d.	0.12	0.02	0.06	0.14
Lactic acid 15 °C		0.51	1.12	0.48	2.13
	s.d.	0.13	0.03	0.05	0.14

Table II
Effect of temperature of lactic acid solution on the weight losses of beef carcasses

		Weight losses [%]			Total
		1 h	24 h	48 h	
Control		0.56	1.07	0.51	2.14
	s.d.	0.04	0.05	0.06	0.11
Lactic acid 45 °C		0.22	0.72	0.59	1.52
	s.d.	0.02	0.04	0.04	0.10
Lactic acid 15 °C		0.33	0.95	0.51	1.78
	s.d.	0.02	0.04	0.04	0.02

face and leads to pore closure; evaporation of water from the meat surface is reduced. The differences in weight losses between lactic acid-treated carcasses and controls were 0.6–1.0 % in the case of pork (see Table I – last column) and 0.3–0.6 % in the case of beef carcasses (see Table II – last column). These differences are related to different tissues on the carcasse surface. Whereas in beef carcass the muscle tissue prevails, the surface of pork half-carcass is covered by skin. Differences in weight losses caused by lactic acid (different temperatures) during cooling, cold storage (first 24 and 48 h) and total counts are also evident from Figs. 3 and 4. The influence of lactic acid in comparison with citric acid is evident from Figs. 5 and 6 and from Tables III and IV.

Because of reduced weight losses after cooling and subsequent storage, the costs for decontamination treatment are compensated; moreover, the application of an organic acid resulted in economic profit (see Tables V and VI).

Economy of the use of decontamination treatment

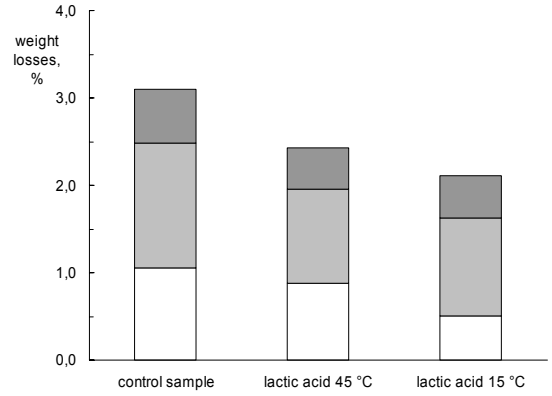

Fig. 3. **Effect of temperature of the lactic acid solution on the weight losses (pork carcasses);** ■ 48 h, □ 24 h, □ 1 h

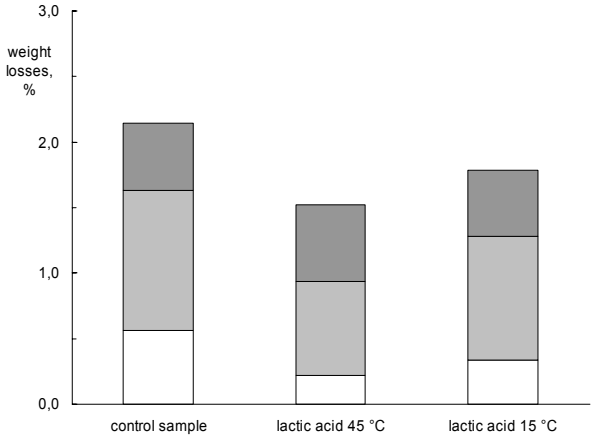

Fig. 4. **Effect of temperature of the lactic acid solution on the weight losses (beef carcasses);** ■ 48 h, □ 24 h, □ 1 h

Table III
Effect of acid solution on the weight losses of pork carcasses

		Weight losses [%]		Total
		1 h	24 h	
Control		0.64	1.35	1.98
	s.d.	0.11	0.12	0.16
Lactic acid 45 °C		0.43	1.09	1.59
	s.d.	0.08	0.12	0.14
Citric acid		0.52	1.21	1.73
	s.d.	0.08	0.09	0.14

Table IV
Effect of acid solution on the weight losses of beef carcasses

		Weight losses [%]		Total
		1 h	24 h	
Control		0.49	0.95	1.45
	s.d.	0.04	0.05	0.06
Lactic acid 45 °C		0.31	0.93	1.24
	s.d.	0.04	0.04	0.04
Citric acid		0.31	1.00	1.32
	s.d.	0.03	0.04	0.03

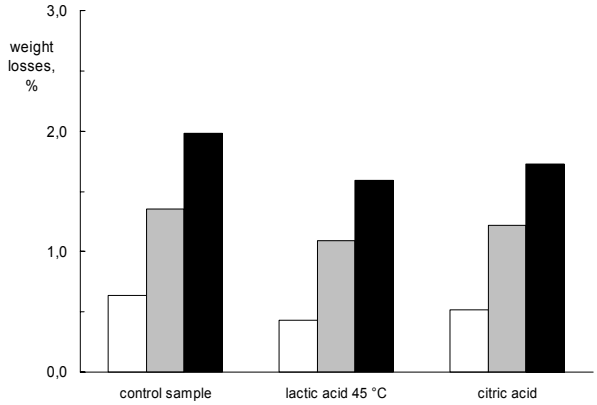

Fig. 5. **Effect of decontamination by the organic acids on the weight losses (pork carcasses);** □ 1 h, ▒ 24 h, ■ total

involves several aspects. Indirect effect (hardly identifiable) consists in the reduction of meat damage caused by spoilage. Enforcement is easy, because it leads to an increase in turnover. The occurrence of spoilage including health and subsequently legal consequences is limited.

To calculate the direct effect, it is necessary to take into account the costs for the used substance (lactic acid), depreciation of a sprinkling device and also the effect of spraying on the weight losses during cooling and cold storage. In this sense the particular data were missing.

It was shown that net costs are compensated by lowering weight losses during rapid chilling and cold storage of carcasses.

The lactic acid decreases weight losses during cooling and cold storage (see above). The differences in restriction of weight losses may be ascribed to the kind of acid and its temperature. Lactic acid decreased weight losses more than citric acid, even the same concentrations of the acids were used. Using a warm (45 °C) solution of lactic acid, lower weight losses are evident than if a cool (15 °C) solution was used. It is possible to assume that spraying by lactic acid invokes surface changes (protein denaturation, change of dissociation of functional groups), which lead to

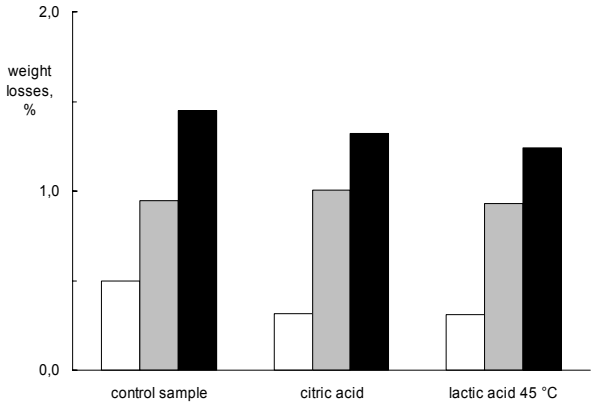

Fig. 6. **Effect of decontamination by the organic acids on the weight losses (beef carcasses);** □ 1 h, ▒ 24 h, ■ total

Table V
Costs calculation for decontamination of pork carcasses

	Carcass weight [kg]	Carcass price [CZK]	Solution price [CZK]	Total price [CZK]	Weight loss [%]	Final price [CZK]		Savings [CZK]		
						per carcass	per kg	per carcass	per kg	per year
Control	80	4000	0,00	4000,00	1,98	4080,80	51,01	–	–	–
Lactic acid	80	4000	1,00	4001,00	1,59	4065,64	50,82	15,16	0,19	3 030 000
Citric acid	80	4000	0,36	4000,36	1,73	4070,78	50,88	10,02	0,13	2 000 000

preconditions: 1000 pigs/day, 200 workday/year, carcass weight 80 kg, carcass price 4000 CZK

Table VI
Costs calculation for decontamination of beef carcasses

	Carcass weight [kg]	Carcass price [CZK]	Solution price [CZK]	Total price [CZK]	Weight loss [%]	Final price [CZK]		Savings [CZK]		
						per carcass	per kg	per carcass	per kg	per year
Control	300	21000	0,00	21000,00	1,45	21308,98	71,03	–	–	–
Lactic acid	300	21000	2,00	21002,00	1,24	21265,69	70,89	43,29	0,14	433 000
Citric acid	300	21000	0,70	21000,70	1,32	21281,62	70,94	27,36	0,09	274 000

preconditions: 50 cattles/day, 200 workday/year, carcass weight 300 kg, carcass price 21000 CZK
price of decontamination device: 250 000 CZK, returnability ca. 1 month, rate of exchange 1€ = 32 CZK

lower water evaporation and, in consequence, to a decrease in weight losses.

Economic evaluation is made in Tables V and VI. The calculation is based on the postulate that 1 litre of lactic acid Purac costs 80 CZK, thus 1 litre of 2.5% decontamination solution costs 2 CZK. The price of 1 kg of citric acid is 35 CZK and the price of 1 litre of 2% decontamination solution is 0.70 CZK. To decontaminate one pork carcass, 0.5 l of solution is required and to decontaminate beef carcass a solution volume of 1 litre is necessary. The profit resulting from one year use of this treatment is apparent from the data shown in tables. An approximate price of the decontamination device is about 250,000 CZK and this investment is returnable in a month.

Though the intention of the surface decontamination is not to increase the carcass weight, the calculations mentioned above evidence that there is no need of additional costs. On the contrary, the decontamination even brings secondary economical benefit.

Conclusions

The lactic acid treatment is effective in prolongation of shelf life of carcasses. The use of a warm (45 °C) solution of lactic acid is more effective for the purpose than that of a cold one (15 °C). The warm lactic acid solution is also more effective than that of citric acid. The secondary effect of surface decontamination is a decrease in weight losses during chilling and cold storage. The lower weight losses compensate the costs of decontamination.

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P. Pipek[a], P. Fíla[a], J. Jeleníková[a], J. Brychta[b], and M. Miyahara[c] *([a] Department of Food Preservation and Meat Technology, Institute of Chemical Technology, Prague, [b] State Veterinary Institute, Jihlava, Czech Republic, [c] Department of Animal Sciences and Resources, Nihon University, Fujisawa, Japan):* **Technological Aspects of Acid Decontamination of Carcasses**

Some aspects of surface acid decontamination of beef and pork carcasses with lactic acid or citric acid solutions were studied. A warm (45 °C) solution of lactic acid was more effective in shelf life prolongation than a cold one (15 °C). Citric acid was less effective than lactic acid. Treatment with lactic or citric acid reduces weight losses in carcass chilling and storage. Consequently, the costs of the decontamination treatment are compensated.