# The effect of added lactates to quality of freshly marinated meat

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*scientific paper*

**Summary**

*The effect of added potassium and sodium lactate to organoleptic characteristics and sustainability of marinated fresh meat was researched in this paper. Researches were conducted on marinated pork neck and shoulder. Bacteriological, physical- chemical analyses and organoleptic researches were also conducted. Added lactates influenced the pH value, total bacterial count and organoleptic characteristics of the product, but they did not influence the peroxide number and the content of fatty acids in samples during storage. The addition of lactates to products made of marinated meat extends their shelf life and maintains organoleptic characteristics of the product.*

***Keywords:*** *lactate, marinated meat, organoleptic characteristics*

## Introduction

Marinades are a complex mixture of spices and ingredients which prolong the sustainability of a product (Björkroth, 2005). They create or enhance aroma, maintaining the level of moist in a treated product, and at the same time they contribute to the food economy (Hoogenkamp, 1999).

Traditionally, meat was marinated in wine vinegar (acetic acid) or in wine, which are still used to that purpose, but except for them some other ingredients are also used, like: soy sauce, citrus juice, whey, yogurt, etc.

In order to extend the shelf life, processes of injection and tumbling of solutions which most frequently contain organic acid salts (lactates, citrates) or phosphates, then salt in a desired ratio with a later addition of the mixture of spices during tumbling (McGee et al.,2003; Alvarado and Sams, 2004).

Meat can be marinated in two ways: by injecting a solution in muscle tissue or by meat tumbling. By injecting a marinade solution into the meat, it quickly and deeply penetrates the meat and it is equally distributed. The thinner meat parts, the quicker the process and it develops continuously. In tumbling, both meat and marinade solution are put into a machine where they are stirred under vacuum for certain period of time (20 – 30 minutes) until the meat absorbs it. Marinating must be performed at low temperatures in order to prevent the increase in the temperature of meat and subsequent conditions suitable for bacterial growth.

Marinated meat is packed in different ways into plastic dishes with a film, by vacuuming or modified atmosphere packaging, and end product is kept at low temperatures for 3 – 5 days.

Lactates added to the product in processing process can efficiently prohibit, i.e. slow the development of the unwanted microflora in meat and products. Lactate activity is based on a strong bacteriostatic effect through the ability of lactates to affect the decrease of water activity. The effect of lactates to prevention of microbial development in the product is explained by the so-called lactate effect. Lactate in a non-dissociated condition diffuses into microbial cells where it dissociates and causes an increase in acidity (Paul et al., 2007). Except for the bacteriostatic effect, lactates contribute to production profitability which results from their effect to decrease the shrinkage of the product, which appears during thermal treatment and storage (shrinkage decrease 1-3%). Lactates contribute to development of desirable organoleptic characteristics and they affect positively the development of color, texture, taste and odor of the product (Bloukas et al., 1997).

The usual share of lactates added to total product weight is 2-5%, which depends on the kind of product. Sustainability of the product

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can be increased by using lactates for 30 to 110%, depending on the used quantity and kind of the product. Researches have shown that the addition of 1-2% of Na-lactate to vacuum-packed fresh pork sausages extended their shelf life for at least two weeks. Lag phase (initial growth phase) of aerobic bacteria was prolonged and the growth of anaerobic bacteria of lactic acid which produce acid was prevented (Brewer et al., 1993). Šmidt et al., (2009) researched the effect of potassium and sodium lactate to minced beef, packed in a modified atmosphere at 2°C and 8°C. The beef meat was treated with 4% potassium lactate, 4% sodium lactate, and the combination of 2% potassium lactate and 2% sodium lactate. In comparison to untreated samples of beef meat, the improvement in microbiological and organoleptic grade of samples was visible with the addition of lactates in all combinations. Tan and Shelef (2002) were researching the effect of sodium lactate and lactates to chemical and microbiological changes in cooled and frozen minced meat. Treating the meat with 2% sodium lactate or potassium lactate and 1 or 2% NaCl extended the shelf life of minced pork stored at 2°C from 7 to 14 days.

The color of meat has a crucial role for a potential buyer or consumer. Even though a lactate has been described as a stabilizer of color in raw and cooked meat product, a biochemical mechanism by which a lactate improves the stability of color of muscles is not completely clear. Research results of Mancini and Ramanathan (2008) confirmed a positive influence of lactates to stability of meat color.

This paper researched the influence of potassium and sodium lactate to sustainability of marinated products of pork meat, organoleptic characteristics, shrinkage in thermal treatment and prevention of oxidative changes. The researches were conducted in meat industry Danicad.o.o., Podravkad.d.

Table 1 **Chemical composition of marinated pork neck and shoulder**

| Chemical composition | Sample | Marinated pork neck | Marinated pork shoulder |
|---|---|---|---|
| water content | 1 | 68.30 | 72.56 |
| | 2 | 68.89 | 71.12 |
| | 3 | 67.86 | 72.22 |
| fat content | 1 | 4.30 | 2.54 |
| | 2 | 7.21 | 2.64 |
| | 3 | 5.99 | 1.75 |
| NaCl % | 1 | 2.09 | 2.00 |
| | 2 | 2.00 | 1.88 |
| | 3 | 2.58 | 2.17 |

sample 1- without lactate addition
sample 2- with potassium lactate
sample 3- with sodium lactate

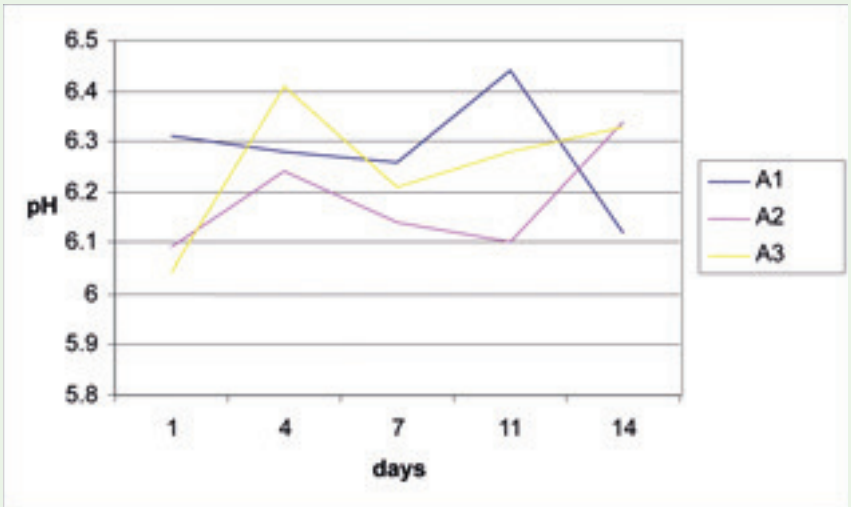


Figure 1 **Change in marinated pork neck pH values during storage**
A1 marinated pork neck A2 marinated pork neck with potassium lactate
A3 marinated pork neck with sodium lactate

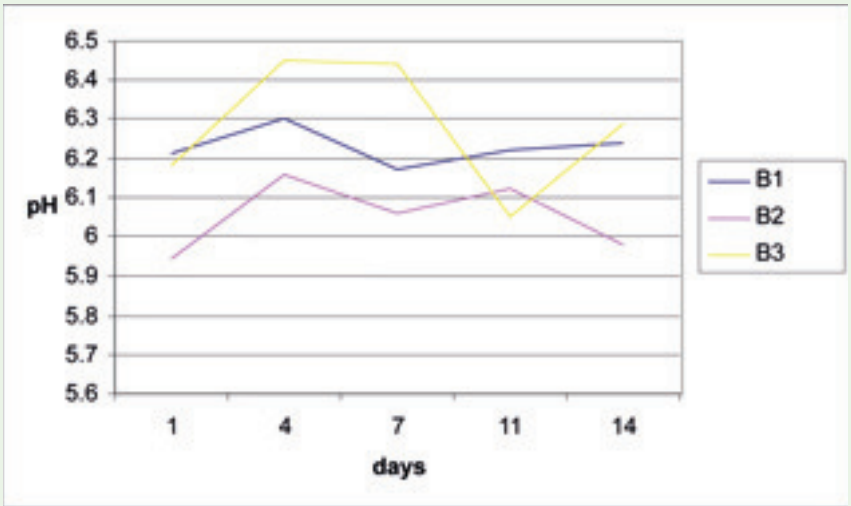


Figure 2 **Change in marinated pork shoulder pH values during storage**
B1 marinated pork shoulder B2 marinated pork shoulder with potassium lactate
B3 marinated pork shoulder with sodium lactate

## Material and methods

Pork meat was obtained in industrial slaughter of meaty pigs, 110 kg

Table 3 **Total aerobic mesophilic count in marinated meat samples during storage**

| samples / days | cfu/g of sample | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 4 | 5 | 6 | 7 | 11 | 14 |
| A1 | $1.3x10^5$ | $2.0x10^5$ | $6.0x10^4$ | $1.9x10^6$ | $>10^6$ | $>10^6$ | $1.1x10^9$ |
| A2 | $9.6x10^3$ | $5.6x10^3$ | $6.1x10^3$ | $4.8x10^3$ | $1.2x10^5$ | $2.8x10^5$ | $1.2x10^7$ |
| A3 | $3.8x10^4$ | $2.1x10^4$ | $5.0x10^4$ | $2.7x10^5$ | $6.0x10^4$ | $1.4x10^6$ | $5.8x10^8$ |
| B1 | $1.2x10^4$ | $1.1x10^4$ | $4.0x10^3$ | $7.0x10^4$ | $2.4x10^5$ | $2.3x10^8$ | $5.8x10^8$ |
| B2 | $1.6x10^4$ | $7.2x10^3$ | $3.6x10^3$ | $1.0x10^4$ | $3.8x10^3$ | $1.1x10^4$ | $1.2x10^4$ |
| B3 | $6.0x10^3$ | $6.0x10^3$ | $3.0x10^3$ | $1.0x10^4$ | $4.4x10^3$ | $1.9x10^5$ | $4.8x10^7$ |

A1 marinated pork neck A2 marinated pork neck with potassium lactate
A3 marinated pork neck with sodium lactate
B1 marinated pork shoulder B2 marinated pork shoulder with potassium lactate
B3 marinated pork shoulder with sodium lactate

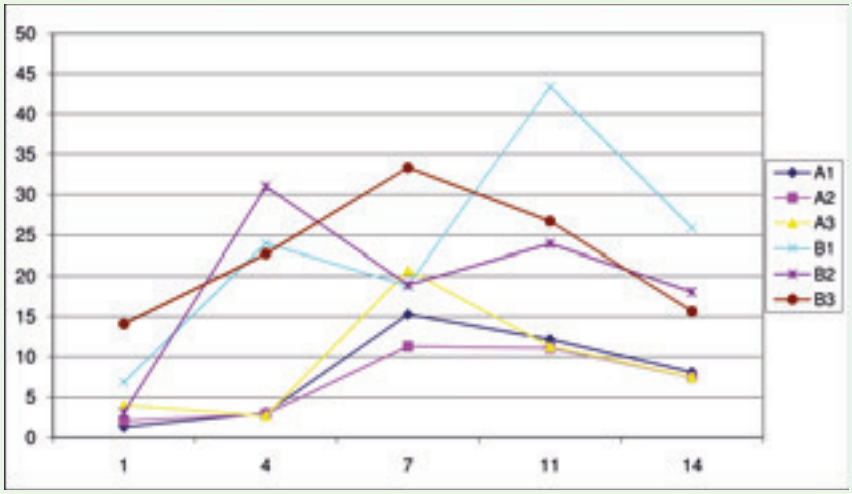


Figure 3 **Free fatty acids content in marinated meat during storage**

A1 marinated pork neck A2 marinated pork neck with potassium lactate
A3 marinated pork neck with sodium lactate
B1 marinated pork shoulder B2 marinated pork shoulder with potassium lactate
B3 marinated pork shoulder with sodium lactate

of weight.

Pig carcasses were cooled up to +4°C. Shoulder meat without bones, skin and subcutaneous fatty tissue, as well as boneless pork neck were used for marinating. The meat of shoulder and neck was sliced manually to steaks.

As secondary raw materials for the production of the marinated product there were used:

- Marinade Braten und Grillgewürz (RAPS, Austria); table salt (Solana Pag); Purasal S – sodium lactate (PURAC, USA); Purasal PD4 – potassium lactate (PURAC, USA); Promi cut (sodium polyphosphate E450/E451); vegetable oil (Zvijezda, Zagreb); water-ice in 50:50 ratio.
- Marinade "Braten und Grillgewürz" contains spices (pepper, paprika, herbs), flavor enhancer; monosodium glutamate (E621), glucose (dextrose).

Promi cut contains sodium diphosphate and triphosphate E450/451.

Purasal S consists of natural sodium lactate.

Purasal PD4 consists of L-potassium lactate and sodium diacetate.

Three groups of samples of pork shoulder and three groups of samples of pork neck were prepared in the aim of research, and they differed in the addition of means for extending the shelf life of products, which were added to meat samples in quantity of 3%.

Sample group A1 contains pork neck, marinated, without the addition of means for extending the shelf life.

Sample group A2 contains pork neck, marinated, with the addition of Purasal PD 4.

Sample group A3 contains pork neck, marinated, with the addition of Purasal S.

Sample group B1 contains pork shoulder, marinated, without the addition of means for extending the shelf life.

Sample group B2 contains pork shoulder, marinated, with the addition of Purasal PD 4.

Sample group B3 contains pork shoulder, marinated, with the addition of Purasal S.

Fresh boneless meat of shoulder and neck was used for sample preparation, 4°C.

Each sample group was weighed, and calculation of the brine was made. Meat samples were added 10% brine of 0-4°C.

Mixing of meat and marinade was performed manually. Samples were packed in styrofoamplates, closed by a stretch film and stored in a cold storage at +2°C.

pH value was determined by a digital pH meter "Testo 230" (Testo, Germany, 2004).

Determining water as the basic constituent in samples was performed by a standard ISO method

**MARINATED PORK NECK** *(modified QDA.)* **MARINATED PORK SHOULDER** *(modified QDA.)*

Figure 4 **Sensory profiling of marinated meat by a modified QDA method – 1st day**
A1 marinated pork neck
A2 marinated pork neck with potassium lactate
A3 marinated pork neck with sodium lactate
B1 marinated pork shoulder
B2 marinated pork shoulder with potassium lactate
B3 marinated pork shoulder with sodium lactate

**MARINATED PORK NECK** *(modified QDA.)* **MARINATED PORK SHOULDER** *(modified QDA.)*

Figure 5 **Sensory profiling of marinated meat by a modified QDA method - 6th day**
A1 marinated pork neck
A2 marinated pork neck with potassium lactate
A3 marinated pork neck with sodium lactate
B1 marinated pork shoulder
B2 marinated pork shoulder with potassium lactate
B3 marinated pork shoulder with sodium lactate

(ISO 6886/1996). Fat was determined by the Soxlet method. Salt was determined by a standard titration method by Volhard (ISO 1841/1996). Peroxide number was determined by iodometric method according to ISO method (3960/1998).

The content of fatty acids in the fat of marinated products was determined by the gas chromatography of their methyl esters. Fat is extracted by the WeibullStoldt method (ISO, 763/1982), after which methyl esters were prepared by the standard method (ISO, 5508 and 5509/2000).

The analysis of fatty acids was conducted by using a Varian 3900 gas chromatograph (Varian Analytical Instruments, Walnut Creek, USA) equipped with a flame ionization detector with electronic flow control (DEFC) and split/splitless CP-1177 injector with electronic flow control (IEFC). Fatty acids are identified by the standard mixture expressed as % of total fatty acids (by the normalization method).

Total aerobic mesophilic bacterial count, *Salmonella* spp., *Staphylococcus aureus, Escherichia coli,* sulphite-reducing clostridia and *Listeria monocytogenes*were determined in microbiological researches. These researches were performed according to the Regulation on microbiological criteria for food (Anon., 2008) and Guidance on microbiological food criteria (Anon., 2011).

Sensory researches were conducted by the modified QDA method (the combination of scoring and QDA). The product is quantified in all its qualitative characteristics by the QDA method. A general impression of raw meat is evaluated, then surface appearance of raw meat, color of raw meat, odor of raw meat, structure of raw meat by touch, general impression of roasted meat, surface appearance of roasted meat, color of roasted meat, odor of roasted meat, taste of roasted meat, saltiness of roasted meat, structure of roasted meat, and after taste of roasted meat.Thermal treatment of meat was conducted in an oven at 200°C/45 min. Each sample was put into the oven on a separate aluminium foil with the addition of 3 spoons of oil to pork shoulder samples and 2 spoons of oil to pork neck samples.

## Results and discussion

The results of certain chemical compounds' analysis were presented in Table 1, and the results of measuring pH values during the process of storage were shown on Figures 1 and 2. Samples without the addition of lactates had a higher initial pH value than those with the addition of lactates, which is in accordance with the professional literature data (Brewer et al., 1995). pH values were

**MARINATED PORK NECK** **MARINATED PORK SHOULDER** *(modified QDA.)*

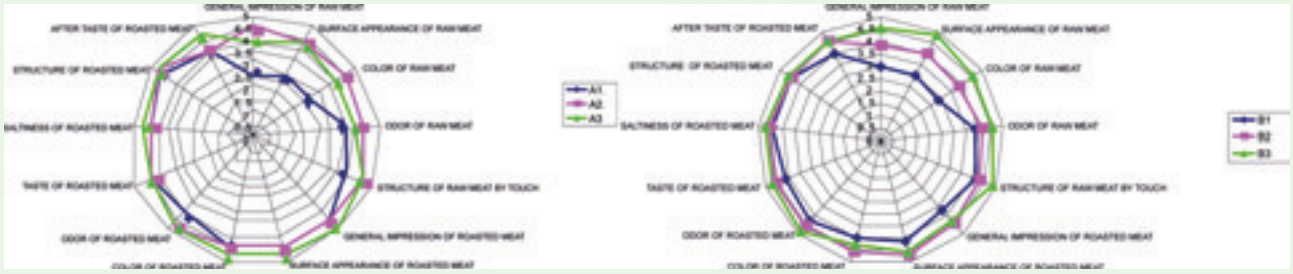

Figure 6 **Sensory profiling of marinated meat by a modified QDA method - 11th day**
A1 marinated pork neck
A2 marinated pork neck with potassium lactate
A3 marinated pork neck with sodium lactate
B1 marinated pork shoulder
B2 marinated pork shoulder with potassium lactate
B3 marinated pork shoulder with sodium lactate

changing during storage. Pork neck samples with the addition of lactates had higher pH values than the initial ones on the 14th day of storage, as well as higher pH value than the samples without the addition of lactates. Brewer et al. (1995) consider that sodium lactate decreases the fall in pH value by decreasing the growth of lactic acid bacteria, especially in vacuum packaged meat products. In comparison to the initial pH values, the changes in pH values on the 14th day of storage are lower in the samples of pork shoulder than in the samples of pork neck.

In control samples of pork neck and pork shoulder during storage there appears the growth in peroxide number from 0 (mmol O2/kg of fat) to 0.92 (mmol O2/kg of fat) at the most. Changes in peroxide number during storage did not differ significantly in the samples with or without lactates.

The share of free fatty acids (Figure 3) grows until the 7th day in the samples of pork neck, i.e. until the 11th day in the samples of pork shoulder, after which it decreases. The highest share of free fatty acids on the 14th day of storage was in the samples of pork shoulder without the addition of lactates. In the samples of pork neck on the 14th day of storage there weren't noticed significant differences in the content of free fatty acids with or without the addition of lactates. Decomposition of triacylglycerol and phospholipids can cause the increase in the share of free fatty acids, whereas the decrease can be explained with peroxidation of free fatty acids (Püssa et al., 2009).

The percentage of saturated fatty acids in total fatty acids ranged from 37.62 to 46.57%, monounsaturated from 38.04 to 48.94% and polyunsaturated from 6.89 to 11.87%. During storage there appeared the growth in share of saturated fatty acids which caused the decrease in the share of unsaturated fatty acids, which is in accordance with the results of research by Xu et al. (2008).

Out of saturated fatty acids in total fatty acids, the highest values belonged to palmitic acid, then stearic, and the lowest belonged to myristic and heptadecanoic acid.

Out of unsaturated fatty acids in total fatty acids, the highest values belonged to oleic, then linoleic and the lowest belonged to palmitoleic acid.

Total aerobic mesophilic bacterial count grows in all samples of marinated product during storage (Table 3). It is visible that total bacterial count grows the most in samples without the addition of lactates, whereas the least growth of total bacterial count is in the samples with the addition of potassium lactate. Bacteriostatic activity is possible because of the capability of lactates to influence the decrease of water activity in the product (Bloukas et al., 1997), and bacterial development intensity depends on it.

Samples of pork neck without the addition of lactates were microbiologically safe until the 7th day of storage, whereas the sample of pork shoulder without the addition of lactates was microbiologically safe on the 7th day of storage too.

Samples of marinated meat with the addition of sodium lactate and potassium lactate were microbiologically safe on the 11th day of storage, except for the sample of pork neck with the addition of sodium lactate whose total bacterial count was somewhat increased and was $1.4x10^6$cfu/g. Samples of pork shoulder with the addition of potassium lactate were microbiologically safe on the 14th day of storage. Considering the fact that these are the samples with Purasal PD4, which contains sodium diacetate along with potassium lactate, it is possible that the obtained results are a consequence of synergy of both compounds. By researching the influence of potassium and sodium lactate to beef meat, Šmidt et al. (2009) obtained the most desirable microbiological values on the samples with the addition of potassium lactate.

## Einfluss von Laktaten auf die Qualität des frisch marinierten Fleisches

**Zusammenfassung**

*In dieser Arbeit wurde der Einfluss von Pottasche- und Natriumlaktat auf organoleptische Eigenschaften des Erhaltungszustands des frisch marinierten Fleisches untersucht. Die Untersuchungen wurden auf frisch mariniertem Schweinehals und Vorderschinken vorgenommen. Es wurden bakteriologische, physisch-chemische Analysen und organoleptische Untersuchungen durchgeführt. Die Zufügung von Laktaten beeinflusste den pH-Wert, gesamte Bakterienzahl und organoleptische Eigenschaften des Erzeugnisses, hatte jedoch keinen Einfluss auf Peroxidnummer und Zusammensetzung der Fettsäuren in Fleischmustern während der Lagerung. Die Zufügung von Laktaten verlängerte den Erzeugnissen aus mariniertem Fleisch sowohl den Erhaltungszustand (Gültigkeitsdauer) als auch bewahrte sie organoleptische Eigenschaften des Erzeugnisses auf.*

***Schlüsselwörter**: laktaten, marinierten Fleisch, organoleptische Eigenschaften*



## Influsso dell'aggiunta di lattati sulla qualità della carne fresca marinata

**Somario**

*Quest'articolo focalizza l'influsso dell'aggiunta di lattati di potassio e sodio sulle caratteristiche organolettiche e la sostenibilità della carne fresca marinata. Le ricerche sono state fatte sul collo di maiale e sulla spalla. Sono state fatte le analisi batteriologiche, fisico-chimiche, e gli esami organolettici. L'aggiunta di lattai aveva influsso sul valore pH, il numero totale di batteri e le caratteristiche organolettiche del prodotto, e non aveva nessun influsso sul numero perossido e la composizione di acidi grassi nei campioni durante l'immagazzinamento. L'aggiunta di lattati ai prodotti di carne marinata aveva prolungato la loro data di scadenza, ed ha anche conservato le loro caratteristiche organolettiche.*

***Parole chiave:** lattato, carne marinata, caratteristiche organolettiche*


The results of microbiological analyses of all groups of samples are in accordance with requirements of the Regulation on microbiological criteria for food (Official Gazette of the Republic of Croatia 74/08), and they apply to following bacteria: *S. aureus* < $10^3$ cfu/g; *E. coli* <$10^3$ cfu/g; sulphite-reducing clostridia < $10^2$ cfu/g; *Salmonella* spp. 0 cfu/25g and *L. monocytogenes* 0 cfu/ g.

The researches have shown that the addition of lactates prolongs the lag phase of aerobic bacteria growth and prevents the growth of anaerobic lactic bacteria that produce acid (Brewer et al., 1993; Cegielska-Radziejewska andPikul, 2004), so shelf life of the product is extended by it. Certain studies have shown an antilisterial activity of sodium lactate, sodium acetate and sodium diacetate in meat (Mbandi and Shelef, 2001; 2002a; 2002b).

In the first 8 days of storage of the product there wasn't any significant aberration in organoleptic characteristics in the samples with or without added lactates (Figures 4-6). Significant aberrations were noticed on the 11$^{th}$ day of storage. The samples with the addition of lactates were evaluated as significantly better than the samples without the addition of lactates. The surface appearance of pork neck raw meat in the sample without the addition of lactates was evaluated with a lower grade in comparison to the sample of pork neck with the addition of sodium and potassium lactate. The structure of roasted meat without the addition of lactates was somewhat firmer, and after taste was changed. Surface appearance of pork shoulder raw meat in the sample without the addition of lactates was also evaluated with a lower grade in comparison to the sample of pork shoulder with the addition of sodium lactate which was suitable. The sample of pork shoulder with the addition of potassium lactate showed some aberrations. The color of marinated meat in the samples without the addition of lactates had a lower stability in comparison to the color of marinated meat with the addition of sodium and potassium lactate, so the research confirmed the results of previous researches emphasizing a positive effect of lactates to stability of meat color (Cegielska-Radziejewska and Pikul, 2004). After 14 days of storage, all samples were of impaired quality with highest aberration in the samples without the addition of lactates. The samples without the addition of lactates were not suitable for consumption.

## Conclusion

The addition of lactates during the production of marinated fresh meat is desirable because it extends the shelf life and it doesn't impair organoleptic characteristics along the way. The samples with the addition of lactates on the 11$^{th}$ day of storage had significantly better organoleptic characteristics than the samples without the addition of lactates, and the samples with the addition of sodium lactate were evaluated as the best. After 14 days of storage, all samples were of impaired organoleptic characteristics, with highest aberration in the samples without the addition of lactates, which were not suitable for consumption any more.

## References


**Anonymus** (2008): Pravilnik o mikrobiološkim kriterijima za hranu (N. N. 74/08)

**Anonymus** (2011): Vodič za mikrobiološke kriterije za hranu Ministarstvo poljoprivrede, ribarstva i ruralnog razvoja

**Alvarado, C. Z., A. R. Sams** (2004): Early postmortem injection and tamble marination effects on broiler beast meat tendernes. *Poultry Sci.* 83,1035-1038

**Björkroth, J.** (2005): Microbiological ecology of marinated meat products. *Meat Sci.* 70, 477-480

**Bloukas, J. G., E. D. Paneras, G. C. Four-**

**nitizis** (1997): Sodium lactate and Protective culture Effects on Quality Characteristics and shelf-life of low-fat Frankfurters produced with Olive Oil. *Meat Sci.* 45, 223-238

**Brewer**, **M.S., F. K. McKeith, S. E. Martin, A. W. Dallmier, J. Meyer** (1991): Sodium lactate effects on shelf life, sensory and physical characteristics of fresh pork sausage. *J. Food Sci.* 56, 1176-1178.

**Brewer**, **M.S., F. K. McKeith, G. Sprouls** (1993): Sodium lactate effect on shelf-life, sensory and physical characteristics of vacuum package freshpork sausage. *J. Muscle Foods* 4, str.179-192

**Brewer, M.S., K. Rostogi Bharati, L. Argoudelis Sprouls, K. Guy** (1995): Sodium Lactate/ Sodium Chloride Effects on Aerobic Plate Counts and Color of Aerobically Packaged Ground Pork. *J. Food Sci.* 60, 58-62

**Cegielska-Radziejewska, R., J. Pikul** (2004): Sodium lactate addition on the quality and shelf life of refrigerated sliced poultry sausage packaged in air or nitrogen atmosphere. *J. Food Protect.* 67, 601-606

**Hoogenkamp**, **H.** (1999): Marinating magic. *Meat Int.* **9** (1) 37-39

**Mancini, R.A., R. Ramanathan** (2008): Sodium lactate influences myoglobin redox stability in vitro. *Meat Sci.* 78, 529-532

**Mbandi**, **E., L. A. Shelef** (2001): Enhanced inhibition of *Listeria monocytogenes* and *Salmonella* Enteritidis in meat by combination of sodium lactate and diacetate, *J. Food Protect.* 64, 640-644

**Mbandi**, **E., L. A. Shelef** (2002a): Enhanced antimicrobial effects of combination of lactate and diacetate on *Listeria monocytogenes* and *Salmonella* spp. in beef bologna. *Int. J. Food. Micribiol.* 76, 191-198

**Mbandi**, **E., L. A. Shelef** (2002b): Automated measurements of antilisterial activities of lactate and diacetate in ready-to –eat meat. *J. Microbiol. Methods* 49, 307-314

**McGee**, **M. R., K. L. Henry, J. C. Brooks, J. B. Morgan** (2003): Injection of sodium tripolyphosphate, and sodium lactate improves Werner-Baltzer shear and senzory characteristics of pre-cooked inside round roast. *Meat Sci.* 64, 273-277

**Paul**, **S.K., G. Samanta, G. Halder, P. Biswas** (2007): Effect of a combination of organic acid salts as antibiotic replacer on the performance and gut health of broiler chickens. Livestock Research for rural development 19, 1-8

**Püssa, T., P. Raudsepp, P. Toomik, R. Pallin, U. Maeorg, S. Kuusik, R. Soidla, M. Rei,** (2009): A study of oxidation products of free polyunsaturated fatty acids in mechanically deboned meat. *J. Food Composition and Analysis* 22, 307–314

Šmidt **G., M. Kovačić, I. Gregurić, I. Bertinovec** (2009): Učinak kalijevog i natrijevog laktata na održivost junećeg mljevenog mesa pri različitim uvjetima skladištenja, *Meso* 1 , 22-31.

**Tan**, **W., L. A. Shelef** (2002): Effects of sodium chloride and lactates on chemical and microbiological change cin refrigerated and frozen fresh ground pork. *Meat Sci.* 62, 27-32

**Xu, W., X. Xu, G. Zhou, D. Wang, C. Li** (2008): Changes of intramuscular phospholipids and free fatty acids during the processing of Nanjing dry-cured duck. *Food Chem.* 110, 279-284

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