SCIENTIFIC AND PROFESSIONAL PAPERS

THE EFFECT OF POTASSIUM AND SODIUM LACTATE ON SUSTAINABILITY OF MINCED BEEF MEAT AT DIFFERENT STORAGE CONDITIONS

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SUMMARY

Fresh minced beef which was treated with potassium lactate (PL) and sodium lactate (NaL) at the amount of 4% when added individually and 2% each when combined, was packaged in a modified atmosphere made of O_2 and CO_2 in 80%:20% ratio, and stored at 2ºC and 8ºC for 7 days. Samples were analyzed on the first, fourth, sixth and seventh day. Results of the analyses showed that the influence of PL and NaL on the number of aerobic mesophyllic bacteria is equal; therefore the treated samples stored at 2ºC in all combinations remained under control limits through entire time of storage. In case of storage at 8ºC, on the fourth day already, the untreated (control) samples exceed limit value for log10 cfu from 6,00 to 6,17, so by the regulation limits they become inadequate for that type of product. By organoleptic sample analysis of the surface and in the cross cut in preference test, the samples treated with PL were evaluated higher than the samples treated with NaL or a combination of salts. Among individual characteristics that were being evaluated (color, discoloration, retail appearance, off- odor intensity, odor acceptability), the samples treated with NaL showed the largest aberration with smell evaluation, where the samples were evaluated worse than the untreated (control) samples in both temperature regimes.

Key words: *sodium lactate, potassium lactate, minced beef, modified atmosphere, storage conditions*

INTRODUCTION

Prolongation of the time period from the slaughter, over cooling, cutting up, processing, packaging, storing and distribution of meat until it reaches the end consumer sets up a demand for producers and meat- packers for introducing new technological obstacles for multiplying microorganisms. Surface- contamination and temperature varying i.e. the (un)possibility of keeping the chain cool from the beginning to the end of fresh meat manipulation, have the key effect to them. The challenge in achieving safety and control over a product is related to the choice of packaging, material for packaging, conditions of production, storing and distribution, and all that in the goal of optimizing organoleptic traits and microbiological parameters which, as indicators of the achieved safety level, represent a marketing and commercial effect for the producer. Understanding the mechanism of activity of certain factors is a key for adjusting conditions for keeping standard characteristics of a product, even when important parameters for some product vary, and especially for constant improvement of product safety. Fresh meat is a very nondurable product sensitive to external influences such as the temperature, conditions and period of storing, type of packaging, and internal ones among which the key role belongs to surface- contamination. Some extra actions are necessary in conditions of inevitable change of temperature in order to keep meat safe for a consumer. These actions can be achieved with adding salt, together with a proper choice of packaging and the content of the atmosphere. Lactates appear as the logical choice, considering their natural presence in muscle tissue. In human and animal organism lactates appear as metabolites on places and in functions which haven't been sufficiently researched yet. Researches have shown that except as a product of an anaerobic decomposition of pyruvate with the increased physical effort, lactate appears in an organism in increased concentrations after an operation (Chatam, 2002), as well as an important intermediator in the process of healing and regeneration of a damaged tissue (Gladden, 2004).

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The effect of sodium salts on sustainability of foodstuff has been long known and thoroughly researched, although the mechanism of activity itself hasn't been clarified to the end. In relation to fresh meat, except for sodium lactate, potassium lactate is widely used as well, especially because of the tendency of reducing sodium intake in nutrition; although sodium salts can not be completely bypassed because of their antimicrobial effect (Sofos, 1984). In choosing additives, type of packaging and storage conditions, our research was influenced by the works of Jayasingh et al. (2002) who were researching sensory traits of minced beef packed in a modified atmosphere with high oxygen content; Abd El-Rhman et al. (1997) who were storing samples of minced beef sampled at retail shops at 4ºC and 25ºC. Seyfert (2006) was researching the effect of potassium lactate and the type of meat on shelf- life of fresh pork sausages in light up and unlighted retail shops. Zeitoun (1992) analyzed the samples of fresh chicken treated with a buffer lactic acid/ sodium lactate, packed in a modified atmosphere (90% $C0_2$ / 10% O_2); and stored at 6ºC. After a thorough consideration, it has been decided to treat minced beef with combinations of potassium and sodium lactate, which haven't been used in a combination in any work so far, to pack it in a modified atmosphere and store at 2ºC and 8ºC.

MATERIAL AND METHODS

Fresh beef trimmings of the II and III category were minced with a 5 mm diameter of cutting panel, and after that they were portioned on servings sized 100 mm : 180 mm : 35 mm (width :length :height), one part without additives as control (untreated) samples, whereas sodium lactate was added to other parts (commercial name Purasal S, a liquid with mass portion in a solution 58,8-61,2% w/w, with the sodium portion of 12,1-12,6% w/w , PURAC producer), that is potassium lactate (commercial name Purasal P HiPure 60, liquid with mass portion in a solution 58-62% w/w, with the potassium portion of 17,7-18,9% w/w, PURAC producer). The procedure of sample preparation is shown in Table 1. The number of control samples was determined by the number of the analyses as parallel with each series of the treated samples. Series of samples with the addition of 4% of individual liquid, as well as the series with the addition of 2% of sodium lactate (NaL) and 2% of potassium lactate (PL) were produced. After portioning, samples were packed in a modified atmosphere with gases ratio 80%:20% (O_2:CO_2).Then follows separating, marking and storing at 2ºC and 8ºC for seven days. Samples were being excepted for microbiological analysis – determining the number of microorganisms per g or mL, and for sensory analysis where they were being researched according to individual parameters which were evaluated by numbers on a scale, on the first, fourth, sixth and seventh day in each series. A total of about three hundred samples were prepared, out of which around two hundred and fifty were analyzed both microbiologically and sensory. Microbiological research on the entire number of microorganisms was performed according to the regulation HRN ISO 4833:2003. Sensory analysis was performed on a series of samples on surface and cross cut for the following parameters: color, discoloration, retail appearance, off- odor intensity, odor acceptability (modified according to Gill et al., 2003) (Table 1).The results between the samples in a series were also compared (method of preference) in a comparison test. Appearance and odor of samples were researched, as well as cross cut appearance. After determining preference, samples are evaluated on points according to obtained preference in a way that the best sample out of four according to evaluator's preference gets 4 points, the following one 3 points, the third one 2 points and the fourth one 1 point. A certain sum is obtained by summing points for each sample, which in relation to the maximum number of points disposed categorizes a sample globally on a sampling day at certain storing conditions to a rank from the first to the fourth one. The researches were being performed during the period of five months and the results represent average values.

▼ **Figure 1.** Sample preparation scheme – production of minced beef meat

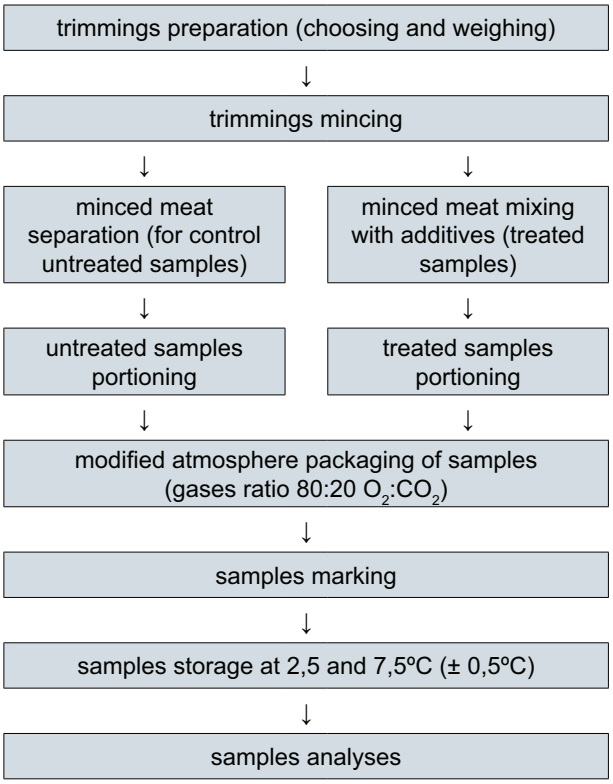


Table 1. Table for grade input - organoleptic analysis of samples – fresh minced meat

Sample definition	Untreated (A)		Treated (B)		Treated (C)		Treated (D)	
Analysis	Surface	Cross cut	Surface	Cross cut	Surface	Cross cut	Surface	Cross cut
Color scale								
Discoloration scale								
Retail appearance scale								
Odor intensity								
Odor acceptability								
Preference test								
Outlook								
Odor								
Cross cut outlook								

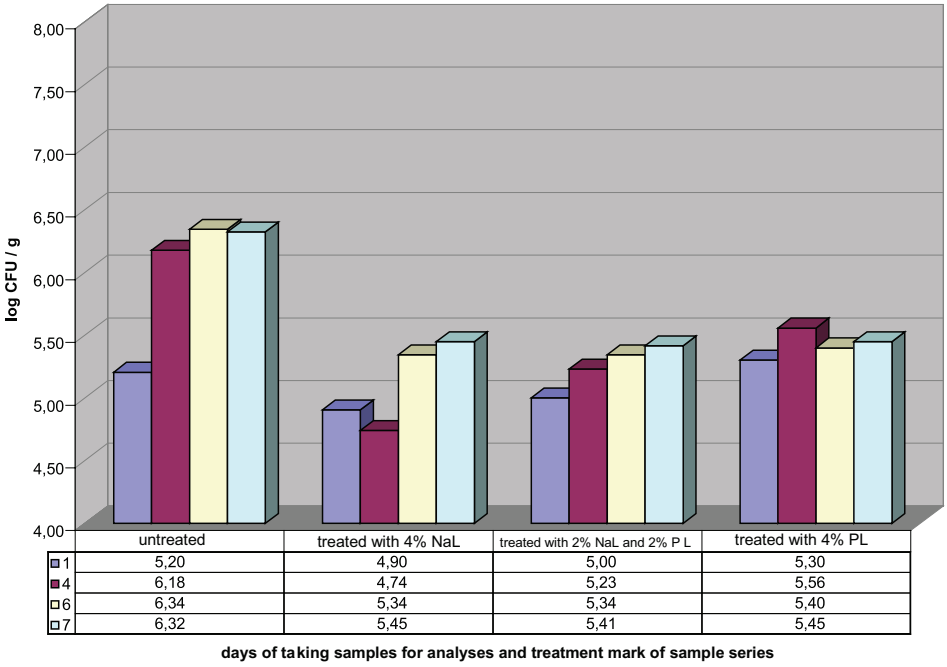
RESULTS AND DISCUSSION

The microbiological analysis of the samples has shown that the untreated (control) samples had the highest values of the entire number of microorganisms (Figures 2 and 3). The treated samples stored at 2ºC have shown the proportional growth of log10 CFU number through seven days of storage. With series of samples treated with 4% NaL there was a decrease in value on the fourth day of storage for 0.4 log10 CFU, and then a growth was recorded up to 5,45 log10 CFU on the seventh day of storage. With the series of samples treated with 4% PL the number of bacteria grew to the maximum of 5.41 log10 CFU on the last day of storage. Exceeding the border value from 6.00 to 6.17 appears only with the series of untreated samples on the fourth, sixth and seventh day. A regular growth of microorganism number reappears during the storage at 8ºC, except in the series of samples treated with 4% of NaL. The number of bacteria in that series was decreased for one log10 CFU on the fourth day of storage in relation to the values of the other treated samples. The number of bacteria determined on the sixth and seventh day stagnates around the value of 6.25 log10 CFU. That appearance could be explained with bacteriocidal effect of NaL, and after that there appears an overgrowing of other microorganisms to which new conditions are favorable (and they were inhibited by microflora which is naturally present. But, that fact is only an assumption which should be confirmed by specific analyses of the listed samples. All samples exceeded the value of 6.00 log10 CFU on the seventh day of storage, whereas it happened on the untreated samples on the fourth day already, and on the sixth day it happened on the samples treated with 4% NaL. The series of the untreated samples where there was determined the entire number of bacteria of 6.68 log10 CFU is not safe for using.

The organoleptic evaluation of series of samples has shown that there is regularity in relation to the results of microbiological researches. Therefore on the scale of colors (Table 2) samples of minced beef meat have the value from 4 to 9 (light red – mildly brownish), where the usual value is 6 for the type of a sample. The highest stability in sustaining the desired color has been showed by the series of samples treated with 4% of PL, stored at 2ºC and 8ºC both on the surface and in the cross cut appearance. The other samples got about equal grades within the same storing conditions. The series of untreated samples had somewhat lower values than those treated with 4% of NaL and those treated with 2% of NaL and PL. The samples treated with 4% of PL were again evaluated with the best grades at both temperatures of storage and surface and cross cut appearance while evaluating sample discoloration (Figures 4 and 5). The series of untreated samples had somewhat lower values than those treated with 4% of NaL and 2% of NaL and PL, the same as with the evaluation of color. Also, the treated samples had about equal values in the grade. To sum up, discoloration wasn't higher than 50% on any sample.

The grade of retail appearance shows the same results as obtained with evaluation of sample discoloration (Figures 6 and 7). It is interesting that all the samples have shown a lower value in a grade on the sixth day; whereas on the seventh day the value is increased (the samples had a better retail appearance). The samples varied from undesirable to desirable (1,5-6,5). Totally, the series of samples treated with 4% PL got the best grades. By ana-

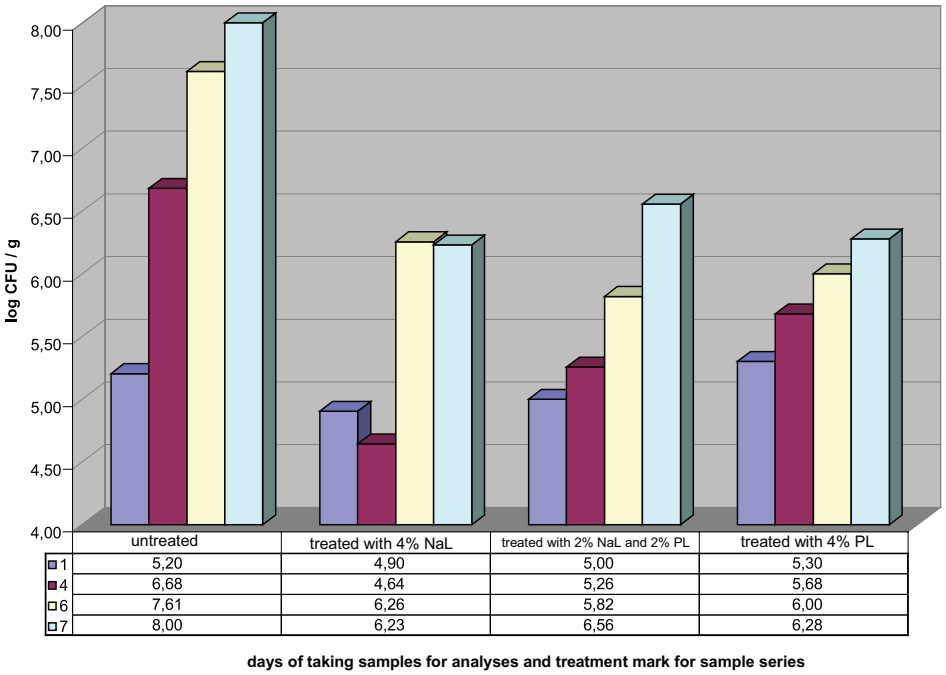
Figure 2. Results of microbiological analysis – total aerobic counts (log10 cfu) in samples stored at 2ºC (PL – potassium lactate; NaL – sodium lactate)



	untreated	treated with 4% NaL	treated with 2% NaL and 2% P L	treated with 4% PL
1	5,20	4,90	5,00	5,30
4	6,18	4,74	5,23	5,56
6	6,34	5,34	5,34	5,40
7	6,32	5,45	5,41	5,45

days of taking samples for analyses and treatment mark of sample series

Figure 3. Results of microbiological analysis – total aerobic counts (log10 cfu) in samples stored at 8ºC (PL – potassium lactate; NaL – sodium lactate)



	untreated	treated with 4% NaL	treated with 2% NaL and 2% PL	treated with 4% PL
1	5,20	4,90	5,00	5,30
4	6,68	4,64	5,26	5,68
6	7,61	6,26	5,82	6,00
7	8,00	6,23	6,56	6,28

days of taking samples for analyses and treatment mark for sample series

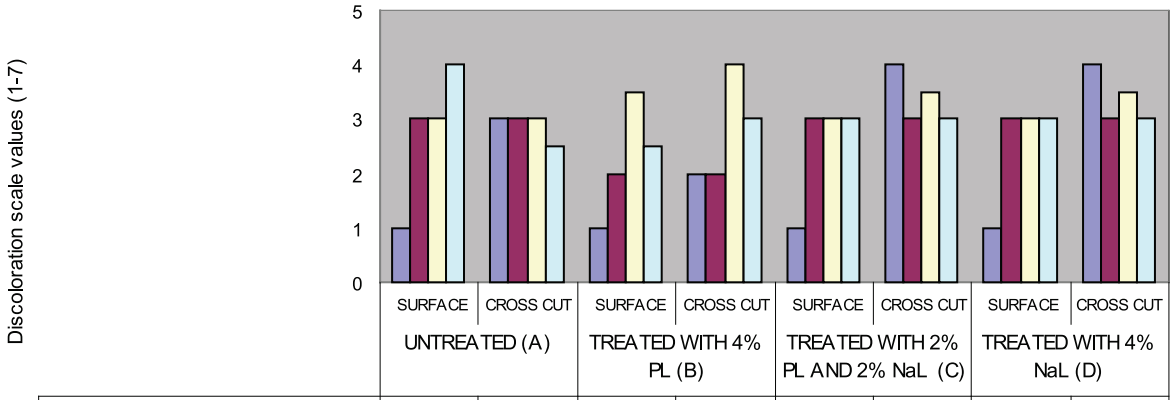
lyzing an overview of average values on an off- odor scale (Figures 8 and 9), as well as of odor acceptability (Figures 10 and 11) for untreated sample and samples treated with different combinations of lactates, stored at 2ºC, it can be seen that among the treated samples the best results are shown by the series of samples treated with 4% PL, whereas the lowest values are shown by the series of samples treated with 4% NaL (sample odor on both the surface and cross cut). The untreated samples have shown the lowest values at both temperatures of storage, and the similar values have been shown by the samples treated with 4% NaL as well. The untreated samples have shown the worst values at both temperatures of storage, and similar values have also been shown by the samples treated with 4% NaL. The best results at the evaluation of series of samples stored at 8ºC are again shown by the sample treated wit 4% of PL. Again, it is interesting to notice that the samples under evaluation on the seventh day of storage have better values as a rule than the samples in the same series which have been evaluated on the sixth day of storage. The obtained results are in accordance with those obtained by Jayasingh et al. (2002) by researching minced beef packed in a modified atmosphere with high oxygen content. He found out that color and the entire number of microorganisms are equal in the treated and the control group (as it is the case with the samples stored at 2ºC and treated with combinations of lactates), but both thiobarbituric number, as a record standard of oxidation degree, and sensory acceptability of packing in the atmosphere with the increased content of oxygen were significantly lower after six or ten days in relation to the samples of the control group. Abd El-Rhman et al.

Table 2. Overview of results on color scale for surface and cross cut

Color scale (1-11)	Untreated		Treated*					
	A		B		C		D	
Day of analyses/ storage conditions	Surface	Cross cut	Surface	Cross cut	Surface	Cross cut	Surface	Cross cut
1. day	5,5	7	5,5	6	5,5	7	5,5	7
4. day / 2ºc	8	7	6	6	7	7	7	8
4. day / 8ºc	8	8	7	7	8	8	8	8
6. day / 2ºc	5,5	6	4	5	5	6	5	6
6. day / 8ºc	6,5	6	4,5	5	5,5	5,5	6,5	5,5
7. day / 2ºc	7,5	8	6	7	7	7	7	7
7. day / 8ºc	9	6	7	7	8	7	8	6,5

Value explanation: 4=light red, 5=bright red, 6=slightly dark red, 7=moderately dark red, 8=very dark red, 9=slightly brownish
* Treated: B = treated with 4% P-lactate; C = treated with 2% P- lactate and 2% Na- lactate; D= treated with 4% Na-lactate

Figure 4. Discoloration scale values for samples stored at 8ºC

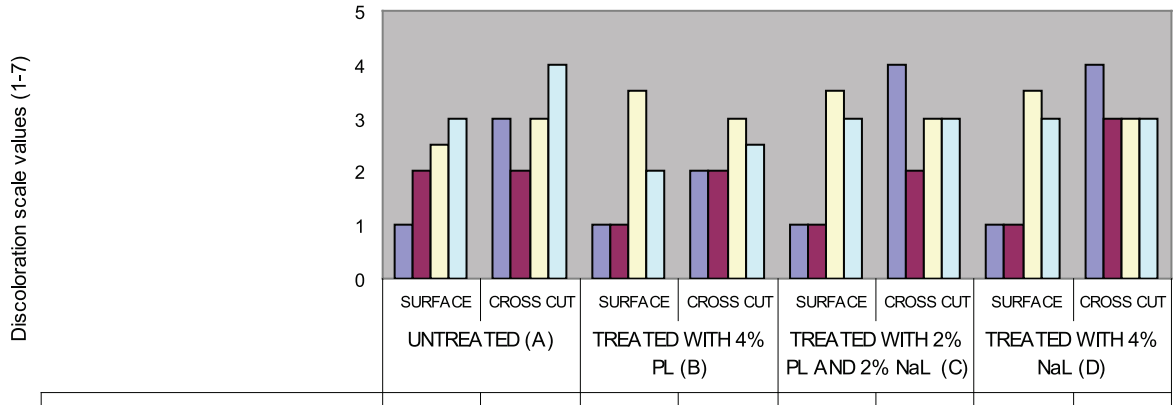


DISCOLORATION SCALE 1.DAY	1	3	1	2	1	4	1	4
DISCOLORATION SCALE 4.DAY	3	3	2	2	3	3	3	3
DISCOLORATION SCALE 6.DAY	3	3	3,5	4	3	3,5	3	3,5
DISCOLORATION SCALE 7.DAY	4	2,5	2,5	3	3	3	3	3

Value explanation: 1=no discoloration, 2=1-10% discoloration, 3=11-25% discoloration, 4=26-50% discoloration, 5=51-75% discoloration, 6=76-99% discoloration, 7=completely discolored (100%)
* Treated: B = treated with 4% P-lactate; C = treated with 2% P- lactate and 2% Na- lactate; D= treated with 4% Na-lactate

(1997) learned that samples of minced beef meat in retail keep the acceptable color and they are without off- odors if stored at 4ºC up to five days. With the samples stored at 25ºC there appear the unwanted changes and an increase in the number of microorganisms which exceed allowed values even after twelve hours of storage. By comparing series of samples in our research treated with combinations of lactates, stored at 2ºC, that is 8ºC, it can be seen that suitable characteristics for the type of product are kept during all seven days of storage, whereas

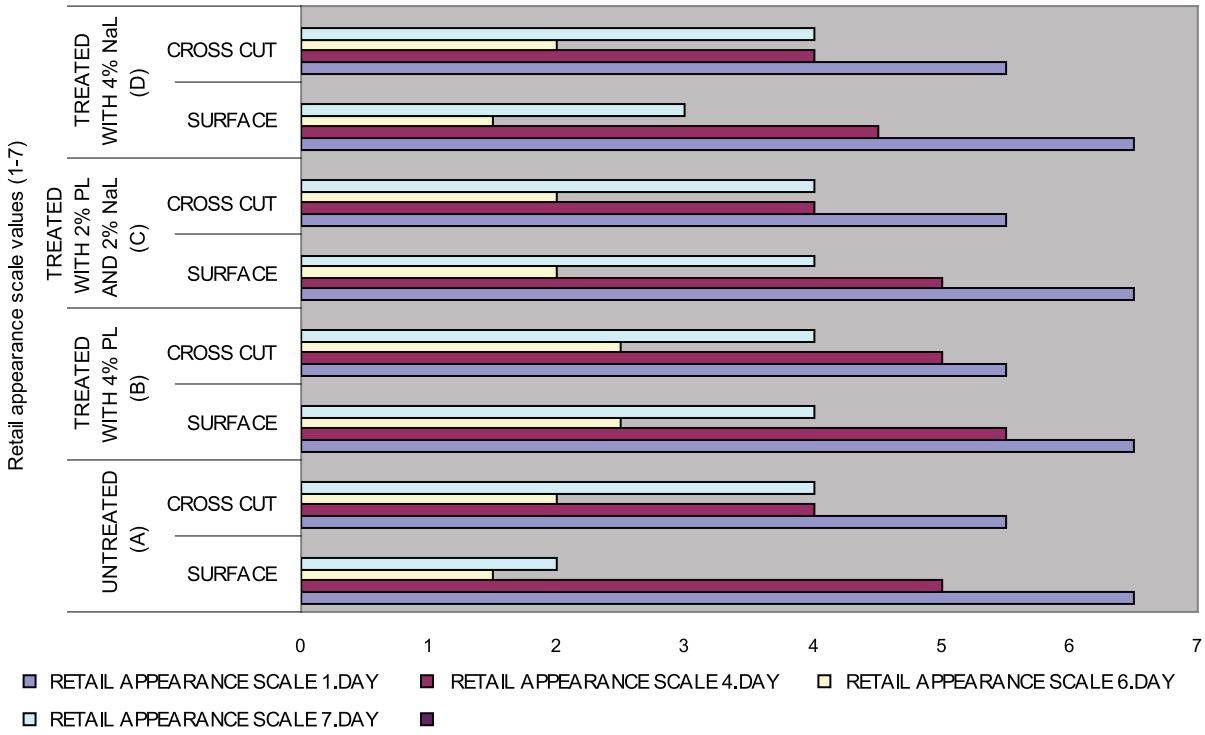
Figure 5. Discoloration scale values for samples stored at 2ºC



	UNTREATED (A)		TREATED WITH 4% PL (B)		TREATED WITH 2% PL AND 2% NaL (C)		TREATED WITH 4% NaL (D)	
	SURFACE	CROSS CUT	SURFACE	CROSS CUT	SURFACE	CROSS CUT	SURFACE	CROSS CUT
DISCOLORATION SCALE 1.DAY	1	3	1	2	1	4	1	4
DISCOLORATION SCALE 4.DAY	2	2	1	2	1	2	1	3
DISCOLORATION SCALE 6.DAY	2,5	3	3,5	3	3,5	3	3,5	3
DISCOLORATION SCALE 7.DAY	3	4	2	2,5	3	3	3	3

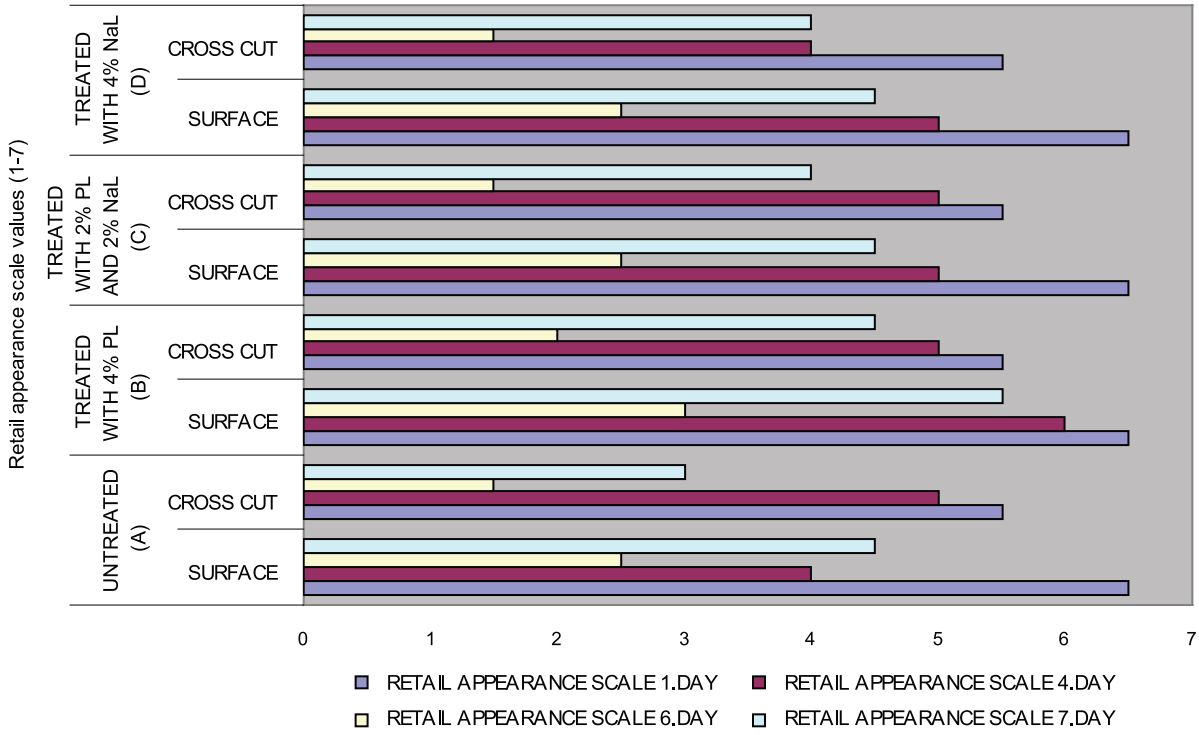
Value explanation: 1=no discoloration, 2=1-10% discoloration, 3=11-25% discoloration, 4=26-50% discoloration, 5=51-75% discoloration, 6=76-99% discoloration, 7=completely discolored (100%)
* Treated: B = treated with 4% P-lactate; C = treated with 2% P- lactate and 2% Na- lactate; D= treated with 4% Na-lactate

Figure 6. Overview of average values on retail appearance scale for untreated sample and samples treated with different combinations of lactate, stored at 8ºC



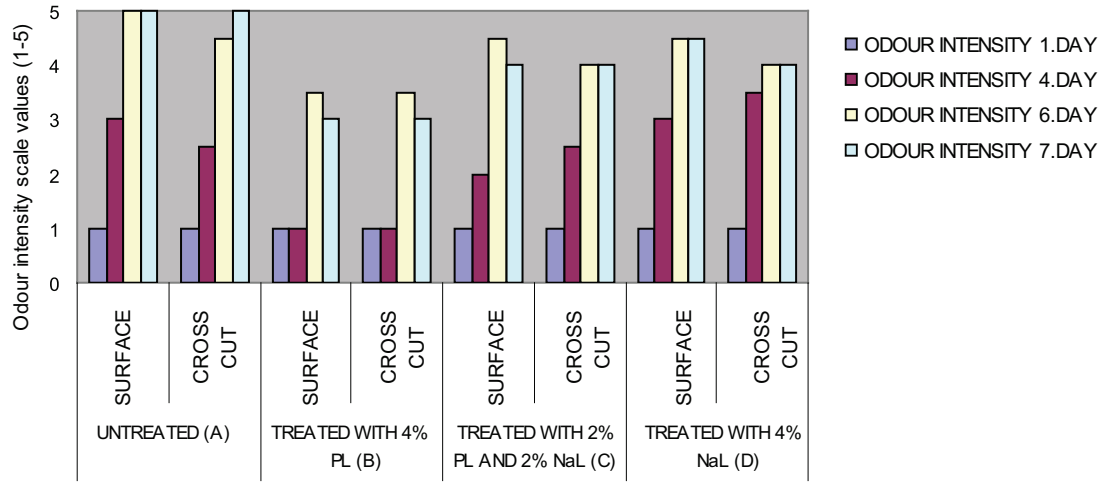
Value explanation: 1=very undesirable, 2=undesirable, 3=slightly undesirable, 4=neither undesirable nor desirable, 5=slightly desirable, 6=desirable, 7=very desirable
* Treated: B = treated with 4% P-lactate; C = treated with 2% P- lactate and 2% Na- lactate; D= treated with 4% Na-lactate

Figure 7. Overview of average values on retail appearance scale for untreated sample and samples treated with different combinations of lactate, stored at 2ºC



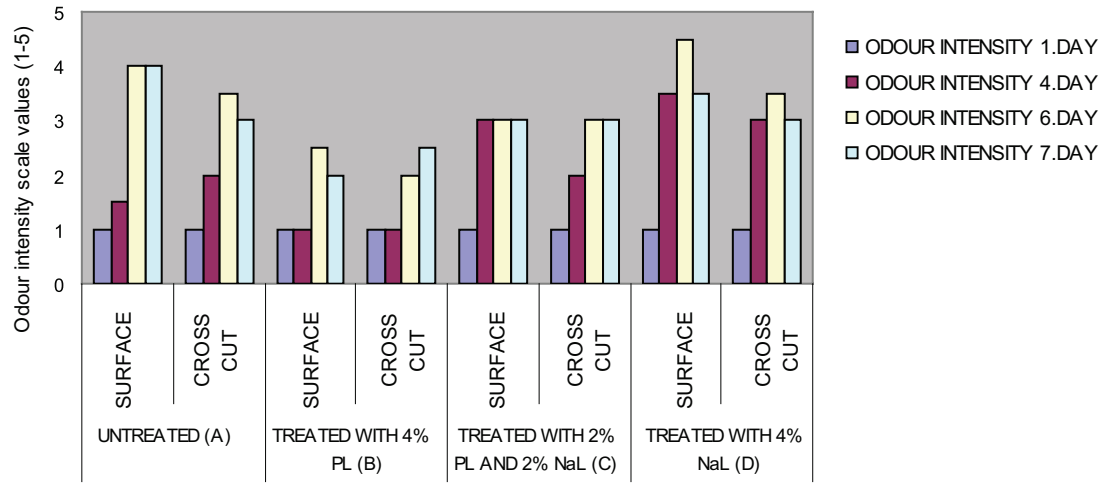
Value explanation: 1=very undesirable, 2=undesirable, 3=slightly undesirable, 4=neither undesirable nor desirable, 5=slightly desirable, 6=desirable, 7=very desirable
* Treated: B = treated with 4% P-lactate; C = treated with 2% P- lactate and 2% Na- lactate; D= treated with 4% Na-lactate

Figure 8. Overview of average values on off-odor intensity scale for untreated sample and samples treated with different combinations of lactate, stored at 8ºC



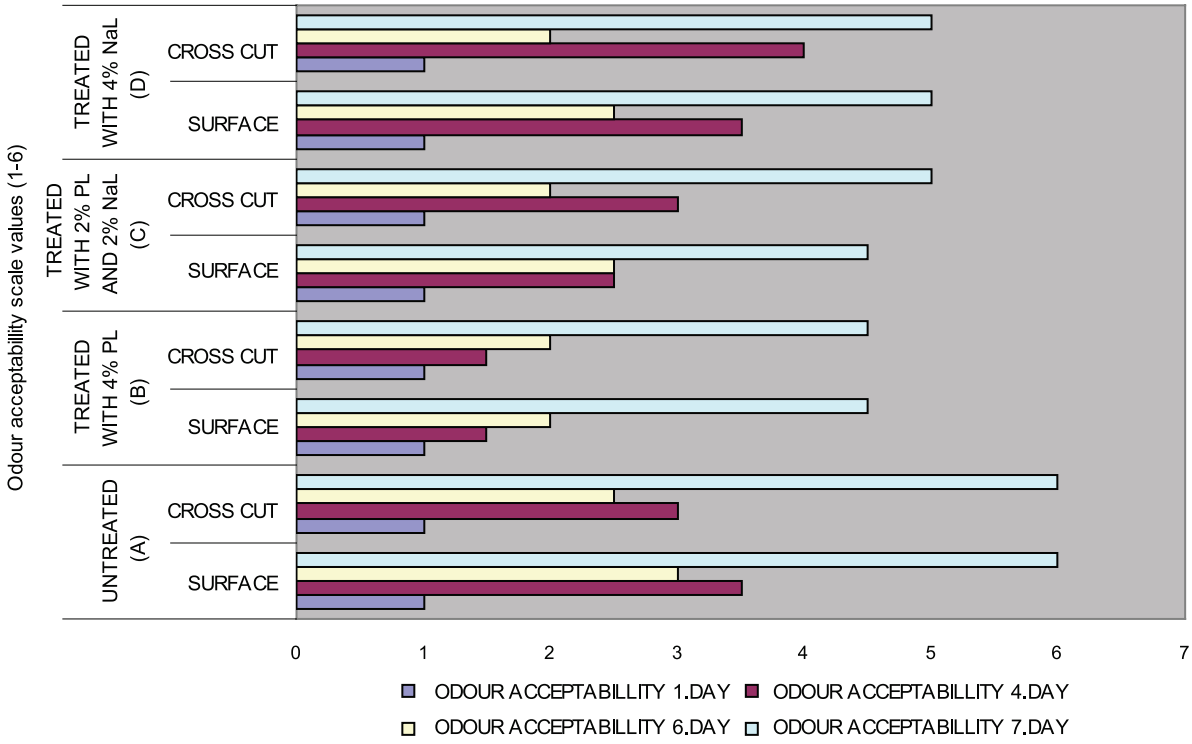
Value explanation: 1=no off-odor, 2=slight off-odor, 3=moderate off-odor, 4=strong off-odor, 5=very strong off-odor
* Treated: B = treated with 4% K-lactate; C = treated with 2% K- lactate and 2% Na- lactate; D= treated with 4% Na-lactate

Figure 9. Overview of average values on off-odor intensity scale for untreated sample and samples treated with different combinations of lactate, stored at 2ºC



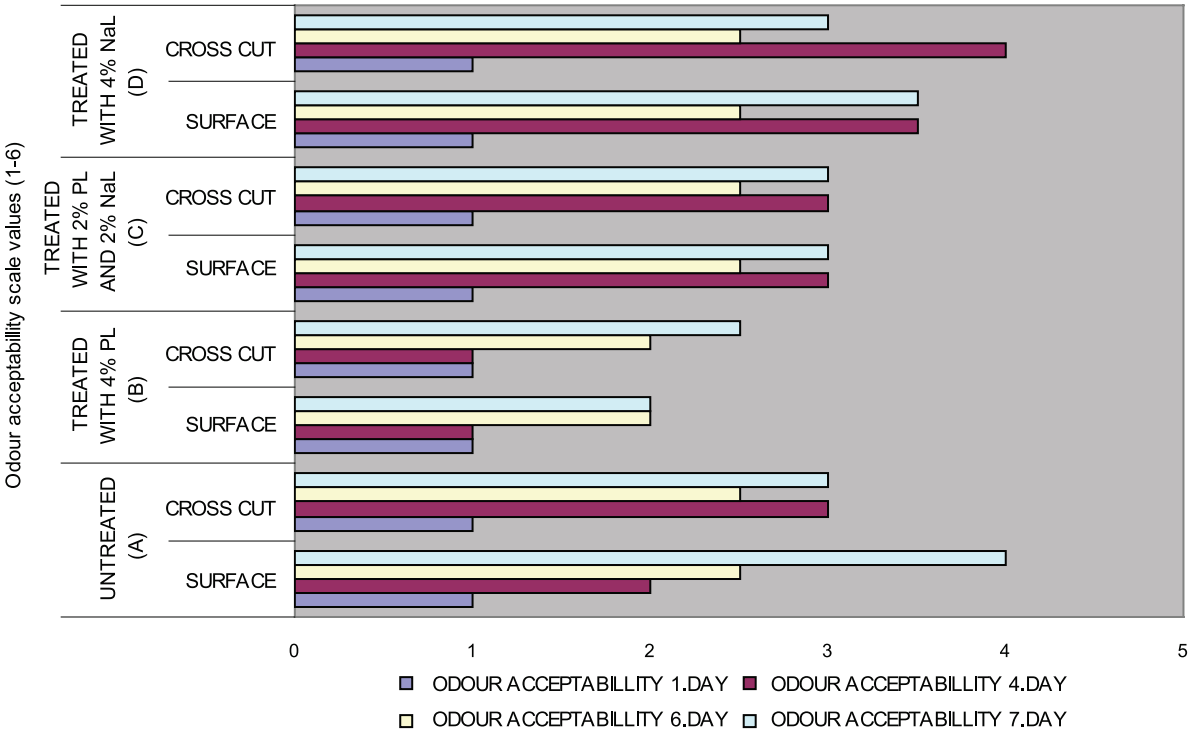
Value explanation: 1=no off-odor, 2=slight off-odor, 3=moderate off-odor, 4=strong off-odor, 5=very strong off-odor
* Treated: B = treated with 4% P-lactate; C = treated with 2% P- lactate and 2% Na- lactate; D= treated with 4% Na-lactate

Figure 10. Overview of average values on odor acceptability scale for untreated sample and samples treated with different combinations of lactate, stored at 8ºC



Value explanation: 1=acceptable, 2=slightly acceptable, 3=neither acceptable nor unacceptable, 4=slightly unacceptable, 5= unacceptable, 6=very unacceptable
* Treated: B = treated with 4% P-lactate; C = treated with 2% P- lactate and 2% Na- lactate; D= treated with 4% Na-lactate

Figure 11. Overview of average values on odor acceptability scale for untreated sample and samples treated with different combinations of lactate, stored at 2ºC



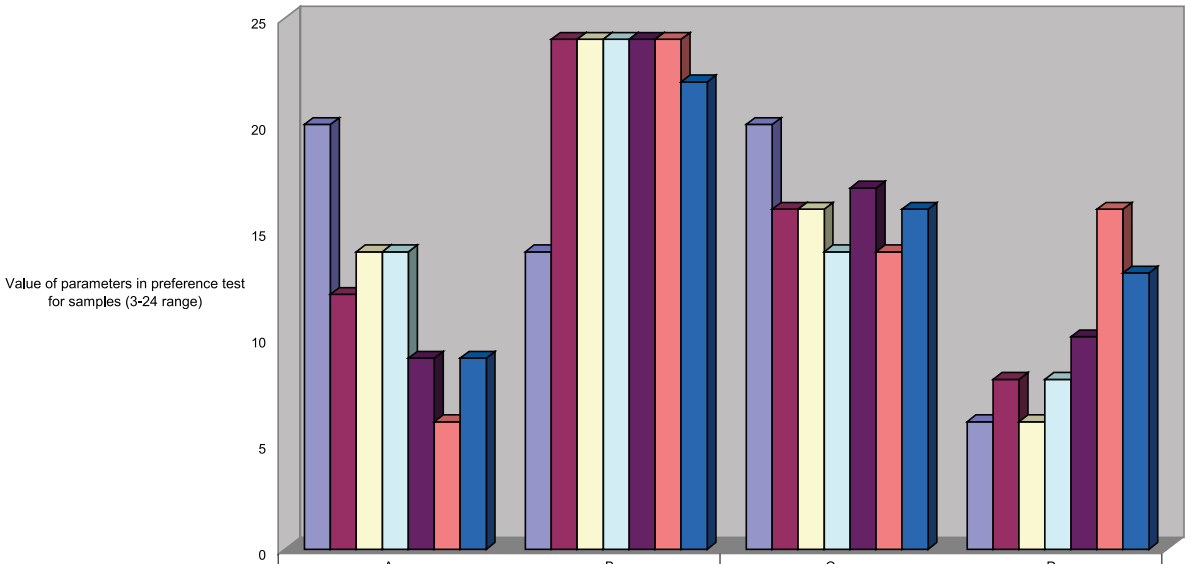
Value explanation: 1=acceptable, 2=slightly acceptable, 3=neither acceptable nor unacceptable, 4=slightly unacceptable, 5= unacceptable, 6=very unacceptable
* Treated: B = treated with 4% P-lactate; C = treated with 2% P- lactate and 2% Na- lactate; D= treated with 4% Na-lactate

the samples stored at 8ºC do not comply with organoleptic and microbiological parameters. The results obtained by performing a preference test (Figure 12) are in accordance with those obtained at evaluation of individual characteristics. The sample treated with 4% PL gained maximum values in the grade through all days (except for the first one) and in all storing conditions. That superiority is prominent and visible immediately. In checking according to the kind of the treated sample it can be seen that the sample C (sample treated with 2% of PL and 2% of NaL) has shown the most homogenous values. In the sample A (the untreated sample) the value has been falling during storage, whereas the value for the sample D (sample treated with 4% of NaL) has been increasing correspondingly. Figure 13 vividly shows the difference between the treated fresh sample of minced beef meat and the untreated samples stored for seven days at 8ºC (the best and the worst graded samples in the analysis).

CONCLUSIONS

The improvement of microbiological picture and organoleptic grade of the samples in relation to the control untreated samples is visible by adding lactates in all combinations. In an overview of the microbiological analysis' results there is an interesting appearance of the number of microorganisms with the series of samples treated with sodium lactate on the fourth day of storage in relation to the initial samples, which appears with both temperatures of storing. After that there follows the growth with storage at 8ºC with the series of samples treated with sodium lactate, and on the seventh day the value of the samples treated with potassium lactate is exceeded. The influence of increasing temperature manifests in isolation of exudates, an appearance of a brownish nuance in a visual appearance of the sample and the appearance of unacceptable odors for fresh meat. The listed appearances become more intense with the prolongation of storage. The smell of samples treated with sodium lactate both on the surface and cross cut reminded on rancidness, which would be a basic obstacle to a commercial use (it should be combined with some of the antioxidative mediums allowed for fresh minced meat). They showed the most equal and the most wanted values as microbiologically so organoleptically during the research of the series of sam-

Figure 12. Overview of values in preference test for untreated sample and samples treated with different combinations of lactate (outlook, odor and crosscut outlook were parameters in the test) during 7 days of storage



	A	B	C	D
1. DAY	20	14	20	6
4. DAY, STORAGE AT 2ºC	12	24	16	8
4. DAY, STORAGE AT 8ºC	14	24	16	6
6. DAY, STORAGE AT 2ºC	14	24	14	8
6. DAY, STORAGE AT 8ºC	9	24	17	10
7. DAY, STORAGE AT 2ºC	6	24	14	16
7. DAY, STORAGE AT 8ºC	9	22	16	13

ples treated with potassium lactate. Further researches should determine the optimal quantity of salt, as well as different combinations with other salts, the length of storage and variations of conditions, different times of excepting samples, and researches on a molecule level in order to realize the real mechanism of activity of certain salts which would explain the appearances noticed during the microbiological and organoleptic analysis of the treated samples.

Figure 13. Samples of beef minced meat after 7 days of storage at 8ºC: sample treated with 4% potassium lactate (left) and untreated sample (right)

A=untreated sample * Treated: B = treated with 4% P-lactate; C = treated with 2% P- lactate and 2% Na-lactate; D= treated with 4% Na- lactate

ZUSAMMENFASSUNG

DIE WIRKUNG VON KALI- UND NATRIUMLAKTATE AUF DIE ERHALTUNG DES RINDFLEISCHES UNTER VERSCHIEDENEN LAGERBEDINGUNGEN

Frisches Rindfleisch wurde mit Kaliumlaktat (KL) und Natriumlaktat (NaL) behandelt, in der Menge von 4 % als sie einzeln zugefügt wurden, und jedes zu 2 % als sie kombiniert waren; das Fleisch wurde in eine modifizierte Atmosphäre zusammengesetzt von O_2 und CO_2 im Verhältnis 80 % : 20 % verpackt und bei 2° und 8° C 7 Tage gelagert. Die Muster wurden am ersten,vierten, sechsten und siebten Tag analysiert. Die Prüfungsresultate haben gezeigt, dass der Einfluss von KL und NaL auf die Zahl der aeroben mesophylen Bakterien ungefähr gleich war, so sind die Muster gelagert bei 2° C in allen Kombinationen innerhalb der kontrollierten Grenzen während der ganzen Lagerzeit geblieben. Bei der Lagerung auf 8° C haben die nicht behandelten Muster Kontrollmuster) schon am vierten Lagertag den Grenzwert für log10 cfu