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THE INFLUENCE OF TIME OF CURING POST MORTEM ON THE DIFFUSION OF BRINE AND CORRESPONDING CHANGES IN M. LONG.DORSI OF PIGS

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Bate-Smith quotes that muscle immidiately post mortem, i.e. when in "closed" structure, besides high pH and high water holding capacity /WHC/ has the property that brine diffuses slowly in it. The author explains that the slower diffusion of brine in muscle in "closed" structure is due to the swelling of muscle fibres which is slowering the penetration of brine salts through them. Afterwards, post mortem, when pH is lowered and WHC decreased i.e. when muscle is changed into an "open" structure the brine will quicker penetrate in it.

However, Mullins et al., as quoted by Arganosa and Henrickson /1/, found in 1958. that brine penetrates unsignificantly quicker in muscles when in "closed" than in "open" structure. Arganosa and Henrickson /1/ obtained more interesting results. They investigated in 1969. rate of brine diffusion in meat puting the peaces of muscle in glass tubes with one end dipped in brine. The muscles were dipped in brine 1 and 24 hours post mortem and kept in it for 24 hours. It was found that in lower layers of muscles dipped 1 hour post mortem there was less NaCl than in those dipped 24 hours post mortem. The finding was quite contary in the upper layer. However, nitrosomyoglobin /NOMb/ was found in larger quantity in muscles dipped in the brine 1 hour post mortem than in those dipped 24 hours. According to this finding it was concluded that brine penetrates quicker in muscels when dipped in brine 1 than 24 hours post mortem. Poor and Henrickson /7/ found that pigment is converted in NOMb more quicker in "hot" muscle when cured with hot brine, and that it is more stable.

The possibility of curing "hot" pork in order, to shorten the canned hams production, has been investigated before the mentioned results were published by Arganosa and Henrickson. Henrickson /5/ established that if hot muscle is cured than it will better bound the water, but it will be tougher than that cured after chilling. Weiner et al. detected that muscle releases less water in the course of backnig it has been hot cured and it has been found to be more tender than those cured after chilling. Mandigo and Henrickson /6/ found that when hot muscles are cured the canned hams will be more tender.

Many authors /3,4,8,9,1o/ have been invectigated the influence of hot meat curing on canned hams quality and found that there is no significant differences between those and hams produced by curing the chilled pork.

Estimating the problem of brine diffusion in the meat at different time post mortem as important from theoretical and practical point of view we decided in the middle of 1969. to investigate how does the time of curing post mortem influence the rate of salts diffusion in the muscles.

M a t e r i a l a n d m e t h o d s

Material. M. long.dorsi of white, fleshy commercial pigs, from 6 to 8 mounths old and 1oo to 11o kg weight have been used. Muscles were taken off from the 4th to 12th thoracal vertebra and cut into 4, or 5 pieces, weighing from 15o to 25o g.

Pieces of muscles have heen dipped in the brine 45 min, 5 and 24 hours post mortem /brine comp.: water 1 l; NaCl o,138 kg; sugar 7 g; $NaNO_3$ 1,2 g and $NaNO_2$ o,7 g/ in relation meat-brine as 1-2. Muscles have been cured in pots of plastic material with covers, and kept at 4°C.

Investigation has been divided into two experiments. In the first one /A/ muscles were cured for 72 hours and examined 6, 24, 48 and 72 hours after dipping, and in the second one /B/ they were cured for 15 days, and examined 1, 3, 6, 1o and 15 days after dipping. One piece of the every m. long.dorsi has been examined at every time of examination /muscles were cut into 4 and 5 pieces, respectively/.

Three samples have been examined for each curing time in every experiment.

Brines used have been examined at the same time as muscles.

In the first experiment /A/ there have been determined the content /a/ of NaCl on the surface, in the center and between these two points in the sample and in the center of sample as well as the /f/ changes of the weight, /g/ firmness, and /h/ pH of samples. In the brine there have been determined the content /i/ of NaCl, /j/ proteins as well as /j/ the colour. The same experiments have been done in the second experiment /B/, except determination of the firmness.

Methods. Content of NaCl in muscles has been determined by "Salztester", Radiometer, type CDM 21a, directly in the tissue. "Salztester" has been proved in 5% saline solution before every usage. Measurements have been done by inserting the needle of apparatus for o,5 cm in the muscle, at determined spots.

The content of NaCl in the brine has been determined by Mohre method.

The content of $NaNO_2$ in muscles has been determined by Grau and Mirna method.

The content of TP and NOMb have been measured by Hornsey method, modified by Möhler.

The brightness of muscles has been determined with attachment for reflectance of spectrophotometer Baush-Lomb, Spectronic 2o, at 525 mu.

Changes in the weight of samples during the curing have been measured in order to determine the quantity of retained water. Samples were weighted before immersing in the brine and at the end of curing and after draining.

Firmness has been measured by Hoeppler consistometer determining the depth of needle penetration in the muscle, loaded with 25o g for 3o sec.

The content of total proteins in the brine has been determined by Kjeldahle method.

Colour of the brine has been measured as extinction of filtrated brine, using Carl Zeiss spectrophotometer, type MK 6/6, at 64o mu.

Results and discussion

Found content of NaCl at determined spots in m. long. dorsi dipped in the brine at different time post mortem are given in Fig. 1. A and 1. B. The results obtained with measurement in muscles cured for 72 hours, are in the first one and in the second those from cured for 15 days.

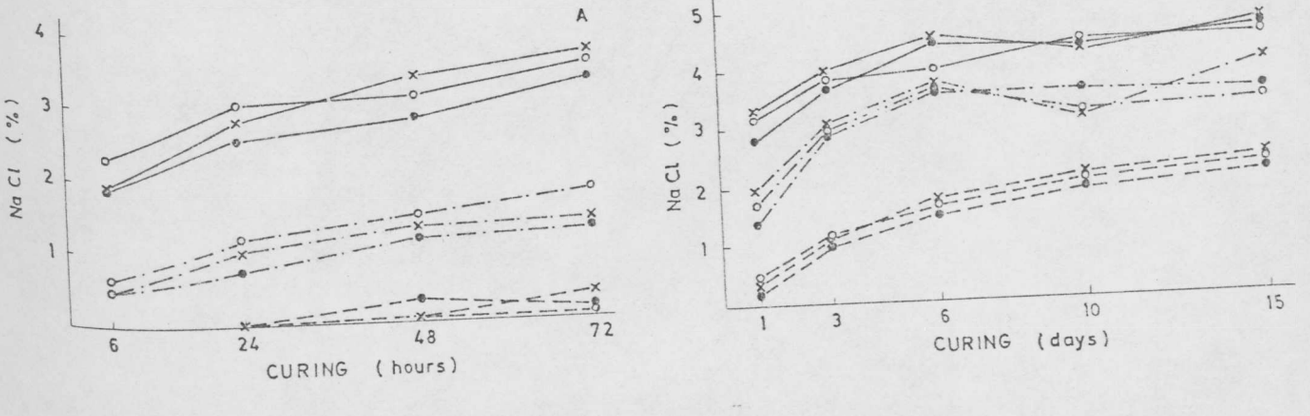

Fig. 1. A. and 1. B.: The changes of NaCl content in different parts of m. long. dorsi of pig cured by dipping in brine at different times post mortem. Spot for NaCl determination: ——— samples surface-·-·-middle between the centre and sample's surface----sample's centre. Time of dipping in brine post mortem: •45 min ∘5 h ×24 h.

From these results one can see that NaCl diffuses, in general, at continuously accelerated rate until 6th day of curing. After that time the diffusion has been slowered. NaCl has been diffusing in the center of samples still upto 15th day. The concentration of NaCl has been at the surface about 4,5%, in the middle about 3,5% and in the center about 2,5% after 15 days of curing. Statistically no significant differences have been found in the rate of salt diffusion in the muscles dipped in the brine at different time post mortem.

Rate of penetration of $NaNO_2$ on the surface and in the center of muscles dipped in the brine at the different time post mortem is presented in Fig. 2.A. and 2.B. From these data one can see that about o,25 mg% of $NaNO_2$ has been found at the surface of samples 6 hours after dipping in the brine. Concentration of $NaNO_2$ has been continuously increasing in superficial layers of muscle until 6th day of curing when the concentration amounted to reach about o,4o mg%. Later on the concentration doesn't increase. The concentration of $NaNO_2$ is increasing in the center of samples until 15th day of curing when amounts to about o,33 mg%. As with NaCl, no statistically significant differences have been found in the rate of penetration of $NaNO_2$ in muscles dipped in the brine at different time post mortem.

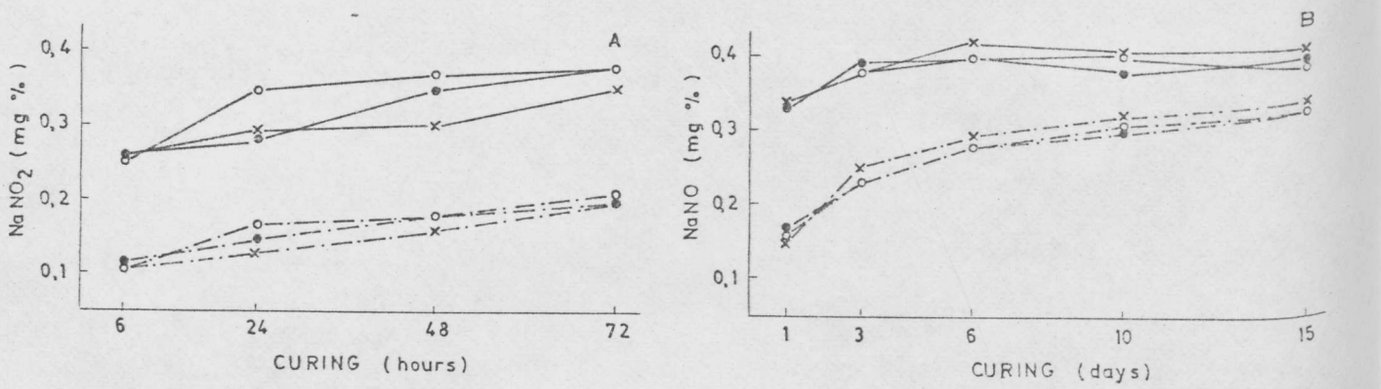

Fig. 2. A. and 2. B.: The changes of $NaNO_2$ content in different parts of m.long. dorsi of pig cured by dipping in brine at different times post mortem. Spot for $NaNO_2$ determination: ——sample's surface– · –·–sample's centre. Time of dipping in brine post mortem: • 45 min ∘ 5 h × 24 h.

Relation between the rate of penetration of NaCl and $NaNO_2$ in the muscles dipped in the brine at different time post mortem has been significantly high /$P < o,o1$/ /in samples dipped in brine 45 min post mortem o,97; 5 hours post mortem o,78, and 24 hours post mortem o,91/. Correlations between the values determined in the superficial layers have been somewhat lower /45 min post mortem o,61; 5 hours post mortem o,65, and 24 hours post mortem o,79; $P < o,o1$/.

These results are not conformable to the quotation about the influence of structure of muscle post mortem /"closed" and "open"/ on rate of brine diffusion in muscle, as well as with the findings by Mullins et al. Arganosa and Henrickson /1/ and Poor and Henrickson /7/. However, the obtained results are confirmed by findings of authors who found that there is no difference in quality between canned hams produced by pork cured pre- and post-chilling.

Findings of TP content in samples dipped in brine at different time post mortem and cured for 72 hours are presented in Fig. 3.A. and those cured for 15 days in Fig. 3. B. It has been found that the content of TP is decreasing in the course of curing. This decrease has been higher in the superficial layers then in the depth of muscle, and after 15 days of curing the content of TP has been lowered from about 5o ppm at 2o in the superficial layers and at about

35 ppm in the center of muscle.

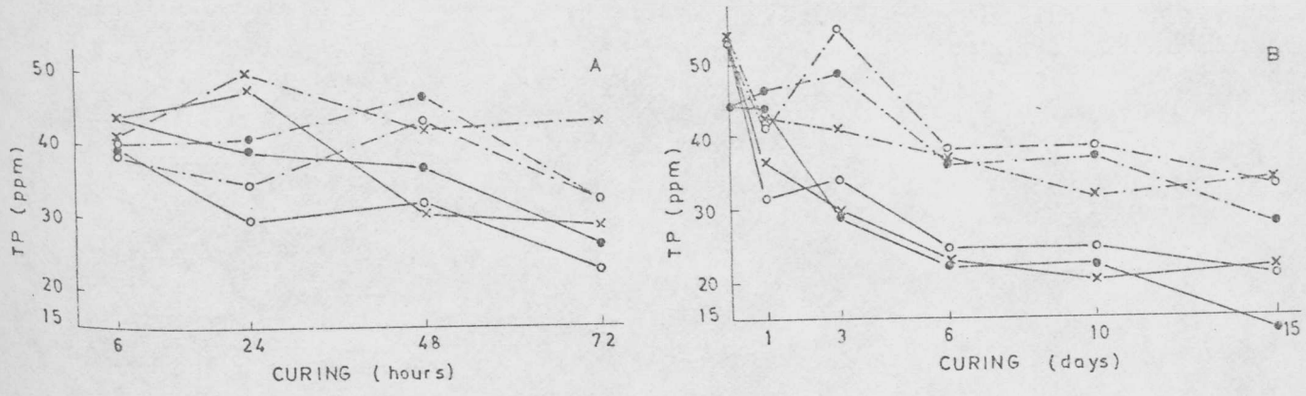

Fig. 3. A. and 3. B.: The changes of total pigments in different spots of m. long. dorsi of pigs cured at different time p. mortem. /Legend the same as at Fig. 2. A. and 2. B./

This decrease of the content of TP is a result of dissolution and rinsing of the pigments by the brine. But, besides this, it can be supposed that the ingredients of brine influence on myoglobin, and maybe, in two ways: to decompose this protein and denature it and so to aggravate its extraction.

The amounts of NOMb detected in muscles dipped in brine at different time post mortem are given in Fig. 4. A. and 4. B. Results abtained in the course of curing for 72 hours are presented in the first one and those obtained in the course of curing for 15 days in the second one. It is interesting that after 6 hours of curing there has been found already 8 to lo ppm of NOMb and in the course of subsequent curing the amount has not been increased, in general. No significant difference has been found in the amount of NOMb in muscles dipped in the brine at different time post mortem.

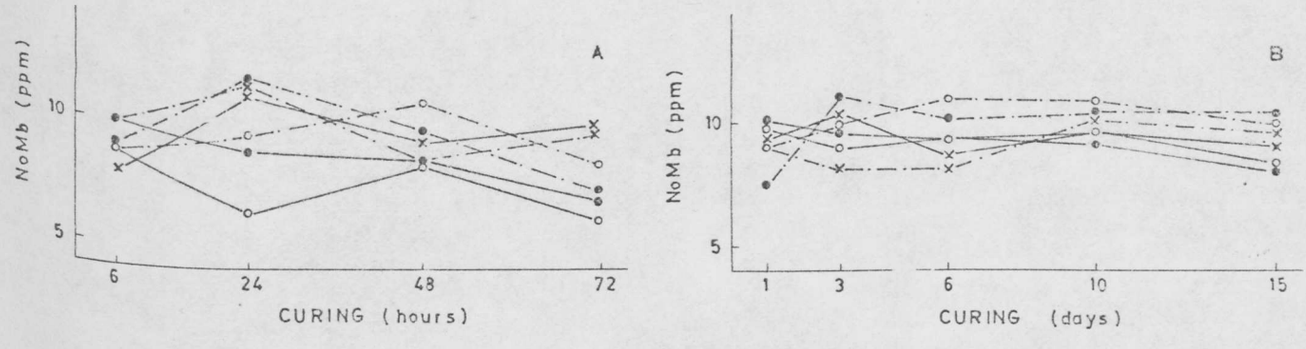

Fig. 4. A. and 4. B.: The changes of NOMb in different spots of m. long. dorsi of pigs cured at different time post mortem. /Legend the same as at Fig. 2. A. and 2. B./

This finding is in accordance with the results obtained by Rahelić and Skenderović /11/, who found that convertion of Mb to NOMb is completed 8 hours after injection of brine in the hams. However, it could be supposed that NOMb is converting in the course of curing even though the content doesn't change. Namely, it was already mentioned that the pigments are rinsed from muscle in the course of curing. But, if the amount of NOMb is at the same

level during the whole curing it should be supposed that equal amount is converted as it is washed out.

By determining the influence of the amount of $NaNO_2$ on formation of NOMb a poorly expressed correlation was found between these two compounds. The highest correlation in superficial layers has been o,17, and in the center of sample o,22. Significant correlation between TP and NOMb was established in the samples dipped in the brine 45 min and 5 hours post mortem - in the superficial layers there were o,59 /$P < o,ol$/ and o,38, and in the center o,35 and o,4o /$P < o,o5$/. In the samples dipped 24 hours post mortem the correlation was very low.

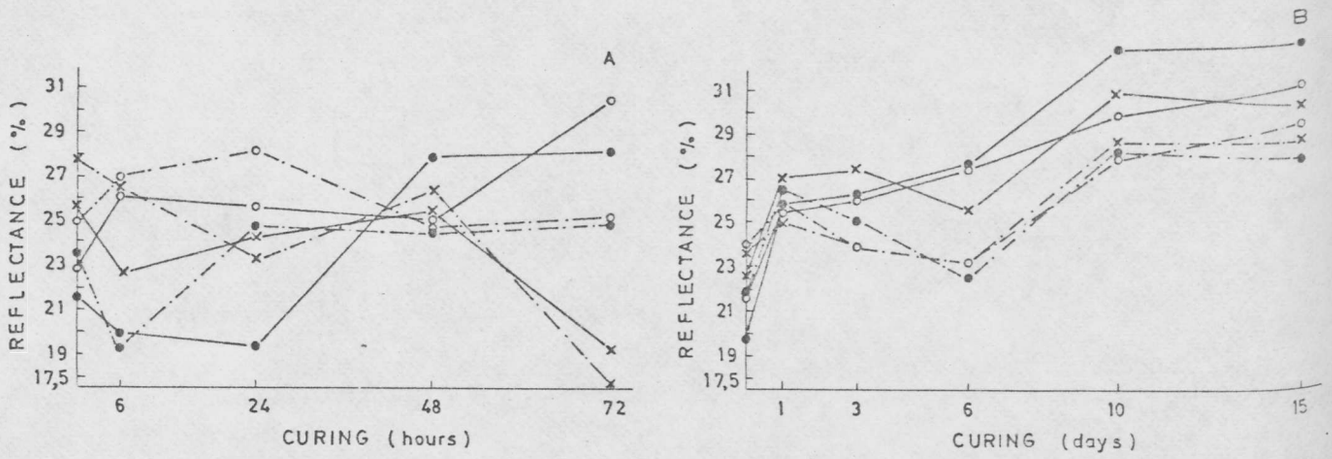

Fig. 5. A. and 5. B.: Changes in reflectance on the surface and in the center of samples at m. long. dorsi of pigs cured at different time post mortem / 64o mu/. /Legend the same as at Fig. 2. A. and 2. B./

Results of cured samples brightness determination are given in Fig. 5. A. and 5. B. From data in Fig. 5. A. one can see that the brightness of samples cured for 72 hours varied very much in the course of examination, and those variations were very high. Different results have been obtained by examination the samples cured for 15 days. These results showed that the samples grown up paler even the first day of curing, then from the first to 6th day the colour has not been notably changed. From 6th to loth day of curing it was growing up more paler and from this time until the end of curing it was, in general, unchanged. The next characteristic of those findings is that the muscles were constantly growing more and more paler the lowest quantity of reflected light has been from 2o to 28%/, and mostly at the surface of samples. Such a finding should be the result of washing out the pigments from the muscles in the course of curing, which were rinsed more at the surface. It can be supposed that muscles were also growing paler, due to the water diffused in the tissue. It was found that muscles gained in weight in the course of curing /Tabl. 1./ and the fibres while swelling are reflecting larger quantity of light.

Besides mentioned characteristics there have examined pH, change of the weight and firmness of samples on the course of 72 hours of curing /Tabl. 1./ From obtained data it is shown that pH decreases for 24 hours post mortem, and then is increasing in samples dipped at all time post mortem. However, the lowest pH has been detected at the end of examination the samples dipped in brine 24 hours post mortem. While the pH have been higher in samples dipped in the brine 45 min and 5 hours, maybe, it is a consequence of effect of penetrated NaCl in the samples /Fig. 1. A. and 1. B./.

Data presented in Table 1. are showing that the weight of all samples dipped in brine at all three times post mortem is permanently increasing. This increase, i.e. swelling it was found to be in significant correlation with the content of penetrated NaCl, but only in samples dipped in the brine 45 min post mortem /r = o,62; P $<$ o,ol/, and for samples dipped in the brine 24 hours post mortem /r = o,64; P $<$ o,ol/, but not for those dipped 5 hours post mortem /r = o,o9; P $<$ o,ol/.

The firmness of the samples has been increased on the course of curing. However, significant correlation has been found only between the firmness and the amount of NaCl penetrated in muscles dipped in the brine 45 min post mortem /r = o,6l; P $<$ o,ol/. The increase in the firmness is, probably, provoked by water penetrated in muscles.

Changes of pH, weight and firmness of m. long. dorsi of pig samples cured by dipping in brine at different time post mortem

Table 1.

Investigated characteristics	Time of dipping post mortem	Curing duration /h/ 0	6	24	48	72
pH	45'	6,73	5,87	5,53	5,87	5,83
	5 h	6,oo	5,68	5,72	6,oo	5,8o
	24 h	5,73	5,47	5,77	5,6o	5,6o
Weight /%/	45'	-	2,41 ±o,37	1,87 ±o,82	4,85 ±1,79	8,19 ±3,2
	5 h	-	o,68 ±o,45	2,54 ±o,99	5,56 ±1,66	5,28 ± 2,33
	24 h	-	2,84 ±o,77	2,76 ±o,79	4,14 ±9,84	5,93 ±o,61
Firmness /kg/cm^3/	45'	o,681 ±o,248	o,867 ±o,235	1,o22 ±o,362	1,332 ±o,6o5	1,372 ±o,1o5
	5 h	o,775 ±o,177	1,oo9 ±o,391	o,8o4 ±o,178	1,1o1 ±o,439	1,117 ±1,125
	24 h	o,88o ±o,1o9	o,878 ±o,298	1,153 ±o,298	1,3o8 ±o,25	1,4o9 ±o,621

The percentage of NaCl and proteins in the brine during the 72 hours and 15 days curing are presented in Tables 2. A. and 2. B. These data show that the content of NaCl has been decreasing and this of total proteins increasing in the brine in the course of curing. The amount of pigments has been found to be increasing during the curing.

Changes of content of NaCl and proteins as well as the colour of brine used for curing m. long. dorsi of pig at different time post mortem

Table 2. A.

Investigated characteristics	Time of dipping post mortem	Curing duration /h/ 6	24	48	72
NaCl /%/	45'	12,18	11,62	11,o8	1o,68
	5 h	13,o7	12,12	11,47	11,32
	24 h	12,63	11,76	11,28	1o,63
Total proteins /%/	45'	o,297 ±o,o25	o,4291o ±o,o33	o,566 ±o,o44	o,678 ±o,o58
	5 h	o,237 ±o,o33	o,427 ±o,o22	o,569 ±o,o14	o,634 ±o,o39
	24 h	o,392 ±o,o34	o,565 ±o,12o	o,74o ±o,168	o,876 ±o,319
Brine colour as $/E_{64o}/$	45'	o,o14 ±o,olo	o,oo8 ±o,o	o,o12 ±o,oo1	o,o15 ±o,oo2
	5 h	o,oo5 ±o,o	o,oo5 ±o,oo1	o,oo8 ±o,oo2	o,o11 ±o,o
	24 h	o,oo4 ±o,oo1	o,o11 ±o,oo4	o,o17 ±o,oo5	o,o22 ±o,oo6

Changes of content of NaCl and proteins as well as the colour of brine used for curing m. long. dorsi of pigs at different time post mortem

Table 2. B.

Investigated characteristics	Time of dipping post mortem	Curing duration /days/ 1	3	6	1o	15
NaCl /%/	45'	12,24 ±o,72	11,92 ±o,74	11,o5 ±1,13	11,67 ±o,54	11,88 ±o,71
	5 h	11,68 ±o,39	11,4o ±o,3	1o,81 ±1,36	1o,89 ±o,84	1o,94 ±o,68
	24 h	12,37 ±o,71	11,82 ±o,68	1o,9o ±o,1	1o,9o ±o,1	1o,96 ±o,87
Total proteins /%/	45'	o,442 ±o,o19	o,6o2 ±o,o84	o,748 ±o,o82	1,o24 ±o,o45	1,129 ±o,77
	5 h	o,427 ±o,o46	o,666 ±o,1o3	o,825 ±o,162	1,o66 ±1,123	o,972 ±o,124
	24 h	o,483 ±o,o74	o,632 ±o,129	o,889 ±o,o87	1,196 ±o,o43	1,o99o ±o,333
Brine colour as $/E_{64o}/$	45'	o,o13 ±o,ooo3	o,o18 ±o,oo3	o,o24 ±o,oo4	o,o31 ±o,oo5	o,o32 ±o,oo5
	5 h	o,oo8 ±o,oo1	o,o17 ±o,oo3	o,o29 ±o,o12	o,o34 ±o,oo9	o,o37 ±o,oo7
	24 h	o,o13 ±o,oo4	o,o23 ±o,oo9	o,o23 ±o,oo9	o,o36 ±o,olo	-

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