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Reduction of salt in fermented sausages and bacon

Initial theoretical assessment of food safety of salt reduction in bacon

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Background

Reduction of the salt content in processed food including meat products has a high focus among health authorities, food producers and the consumers. Reduction of the salt content may impact food safety; however, it is possible to predict growth of many pathogenic bacteria by using predictive models. But if the salt concentration becomes very low, using predictive models can become difficult. Likewise, the models' content of preservative variables may be limited in relation to the industrial wishes for preservation profiles.

Objective

The objective of this report is to provide a theoretical assessment of food safety impacts when reducing salt in bacon. The assessment is based on predictive models for growth of pathogenic bacteria, results from previous studies at DMRI, and the scientific literature. The assessment will be used to pin-point knowledge gaps regarding food safety of salt reduced bacon that must be filled by challenge test with pathogenic bacteria.

Conclusion

Based on predictions from DMRIPredict and ComBase and data from former challenge test at DMRI, the following conclusions are made:

For products stored at 5°C (pH 6; 2.6-3.9% salt/water; shelf life 56 days, packed in 30% CO_2):

- The product is stabilised against growth of ***L. monocytogenes*** by combinations of:
  2.6% salt/water and
  - No nitrite, 1.7% L-lactate (2.1% Na-lactate); 0.04% acetate (0.05% Na-acetate) or
  - 60 ppm nitrite; 1.7% L-lactate (2.1% Na-lactate); no acetate or
  - 150 ppm nitrite; 1.5% L-lactate (1.9% Na-lactate), no acetate

  3.9% salt/water and
  - No nitrite, 1.7% L-lactate (2.1% Na-lactate); no acetate
  - 60 ppm nitrite; 1.6% L-lactate (2% Na-lactate); no acetate
  - 150 ppm nitrite; 1.4% L-lactate (1.8 % Na-lactate); no acetate

- No predictive model can document that ***Salmonella*** does not grow under conditions where the product is stabilised against growth of *L. monocytogenes,* and it has not been possible to find data from challenge studies that document this.

However, it does not seem likely that *Salmonella* will grow at 5°C (lower temperature limit for growth of *Salmonella*).

- *Clostridium botulinum* does not grow under conditions where the product is stabilised against growth of *L. monocytogenes.*

- Growth of *Yersinia enterocolitica* is inhibited in products containing 2.6% salt in water, when pH is ≤6.0, and nitrite is added. Organic acids seem to reduce growth, but more knowledge is needed.

- *For Bacillus cereus* it is assumed that conditions that inhibit growth of *Listeria monocytogenes*, will also not allow growth of *Bacillus cereus*. However, data from challenge studies seem inconclusive, hence more knowledge is needed.

For products stored at 7-8°C (pH 6; 2.6-3.9% salt/water; shelf life 56 days, packed in 30% CO_2):

2.6% salt/water and
  - No nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.17% acetate (0.23% Na-acetate)
  - 60 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.14% acetate (0.19% Na-acetate)
  - 150 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.06% acetate (0.08% Na-acetate)
  -

3.9% salt/water and
  - No nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.16% acetate (0.22% Na-acetate)
  - 60 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.12% acetate (0.17% Na-acetate)
  - 150 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.04% acetate (0.06% Na-acetate)

- *Salmonella* may not grow under conditions where the product is stabilised against growth of *L. monocytogenes*. Challenge studies are recommended.

- *Clostridium botulinum* does not grow under conditions where the product is stabilised against growth of *L. monocytogenes*.

- *Yersinia enterocolitica* may grow in products containing 1.6% salt/water, when pH is >5.6. If salt/water % is raised to 2.6%, growth is inhibited when pH is ≤6.0 and nitrite is added. Organic acids seem to reduce growth, but more knowledge is needed, hence challenge studies are recommended.

- For *Bacillus cereus* it is assumed that conditions that inhibit growth of *Listeria monocytogenes*, will also not allow growth of *Bacillus cereus* at 7°C. However, data from challenge studies seem inconclusive, hence more knowledge is needed.

Food safety assessment

Preservation and storage of bacon

The assessment is made for products containing the following hurdles:

- Salt % (%NaCl) in product: 1.5% and 2.2%
- Nitrite: 0, 60 or 150 ppm
- Na-lactate: 0-2.1%
- Na-acetate: 0-0.25%

All predictions are performed for products containing 57% water:

- Calculated salt/water%:
  Per volume: 2.6% and 3.9%
  Per weight: 2.6% and 3.7%

pH of bacon may vary from 5.5 to 6.5. The pH of pork belly is approx. 6, hence an average pH of 6 is chosen for the predictions.

Packaging conditions are either MAP (30% CO_2/70% N_2) or vacuum.

Storage temperature: 4-7°C *(predictions are made for 4-5°C and 7-8°C).*

Shelf life: 56 days.

Pathogenic bacteria

The raw meat for bacon production may in rare occasions be contaminated with low numbers of the pathogenic bacteria listed in Table 1. Contamination with *Listeria monocytogenes* and *Yersinia enterocolitica* may also occur during slicing.

The normal process of producing bacon (brine injected, smoked) does not eliminate bacteria. Therefore, the growth potential of all pathogenic bacteria in the product is assessed. In Table 1, the growth limits for these bacteria are indicated.

Growth conditions for pathogenic bacteria

Table 1. Growth limits for pathogenic bacteria (source: the Danish Veterinary and Food Administration, 2017)

Bacterium	Min. temperature	Max. salt in water phase (%)	Min. water activity (a_w)	Min. pH
Bacillus cereus	4°C	11-12%	0.92	4.5
Campylobacter	30°C	1.5%	0.99	4.9
Clostridium botulinum (proteolytic)	10-12°C	10%	0.94	4.6
Clostridium botulinum (non-proteolytic)	3-4°C	3-3.5%	0.97	5
Clostridium perfringens	10-12°C	7%	0.93	5.5
Listeria monocytogenes	0-1°C	10-12%	0.92	4.4
Salmonella	5°C	8%	0.94	4
Staphylococcus aureus	8°C	15%	0.83	4
Yersinia enterocolitica	0°C	7%	0.96	4.2
VT E. coli	7-8°C	6%	0.95	4.4

In the following predictions, only bacteria that can grow at temperatures ≤7°C are considered (highlighted in the table).

Bacon considered a raw meat product

At markets where bacon is considered a raw meat product, e.g., in Denmark, there are no legal requirements (anonymous, 2005) regarding the occurrence of *Listeria monocytogenes*. *Salmonella* must not be detectable in 10 g of processed meat (including bacon), which is consumed after heat treatment (food category 1.6; anonymous, 2005).

Bacon considered a ready-to-eat-product

At some markets, bacon is considered a ready-to-eat product.

If growth of *Listeria monocytogenes* within the desired shelf life period (56 days) is ≤0.5 log cfu/g, the product is considered stabilised against growth of *L. monocytogenes* (LM-stabilised). Meat products are not LM-stabilised if the predicted growth of *Listeria* is >0.5 log cfu/g during shelf life. For these products, the content of *Listeria* is assessed at the last day of sale. If the content is <2 log cfu/g, the product is acceptable.

In the following predictions, bacon will be considered a ready-to-eat product that is stabilised against growth of *Listeria monocytogenes* (food category 1.3), therefore predictions for other pathogenic bacteria are based on the hurdle combinations that ensure LM stabilisation.

Predictions for Listeria monocytogenes

For a shelf life of 56 days, the maximum growth rate (μ max) of *Listeria monocytogenes* should therefore not exceed:

$\frac{0.5 \log cfu/g}{56\ days}$ = 0.00089 log cfu/g/day = 0.00037 log cfu/g/hour

Based on the predictive model for *Listeria monocytogenes* at DMRIPredict, it is possible to obtain stabilisation against LM (<0.5 log cfu/g growth) for 56 days using the following combinations of hurdles (note: the model includes Na-lactate and Na-acetate as variables). The given values of L-lactate and acetate below are calculated from Na-lactate and Na-acetate. L-lactate = 0.8*Na-lactate; Acetate = 0.72*Na-acetate.

Bacon containing 2.2% NaCl-salt in the product (=3.9 % salt/water in a product containing 57% water), pH 6, 30% CO_2 in the packaging gas

Storage at 8°C:

- No nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.16% acetate (0.22% Na-acetate)
- 60 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.12% acetate (0.17% Na-acetate)
- 150 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.04% acetate (0.06% Na-acetate)

Storage at 5°C:

- No nitrite, 1.7% L-lactate (2.1% Na-lactate); no acetate
- 60 ppm nitrite; 1.6% L-lactate (2% Na-lactate); no acetate

- 150 ppm nitrite; 1.4% L-lactate (1.8 % Na-lactate); no acetate

Bacon containing 1.5% salt in the product (=2.6% salt/water in a product containing 57% water), pH 6, 30% CO_2 in the packaging gas

Storage at 8°C:

- No nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.17% acetate (0.23% Na-acetate)
- 60 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.14% acetate (0.19% Na-acetate)
- 150 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.06% acetate (0.08% Na-acetate)

Storage at 5°C:

- No nitrite, 1.7% L-lactate (2.1% Na-lactate); 0.04% acetate (0.05% Na-acetate)
- 60 ppm nitrite; 1.7% L-lactate (2.1% Na-lactate); no acetate
- 150 ppm nitrite; 1.5% L-lactate (1.9% Na-lactate), no acetate

Appendix 1 shows additional predictions of μ max and the time to reach 0.5 log cfu/g growth of *L. monocytogenes* at 4°C and 7°C, at pH 5.5-6.5 and 0-9-2.2% salt (NaCl) in a product containing 57% water.

Predictions above and in Appendix 1 are based on packaging conditions with 30% CO_2. Recent challenge studies at DMRI concluded that growth of *L. monocytogenes* in vacuum packs was similar or even slightly slower than in MA packs containing 30% CO_2 (Jacobsen & Koch, 2022); hence the predictions above are considered applicable for vacuum packs as well.

Clostridium botulinum

The model for *Clostridium botulinum* at DMRIPredict predicts the risks for growth of *C. botulinum* in MA packed meat (30% CO_2).

According to predictions, growth of *C. botulinum* is not likely in products stored at 4°C containing one of the above hurdle combinations that stabilises against growth of *Listeria monocytogenes*.

Examples of predictions under the "worst case-condition" (i.e., pH 6.4 (upper pH limit of the model), 1.5% salt in product (2.6% salt in water), at 8°C) are shown below.

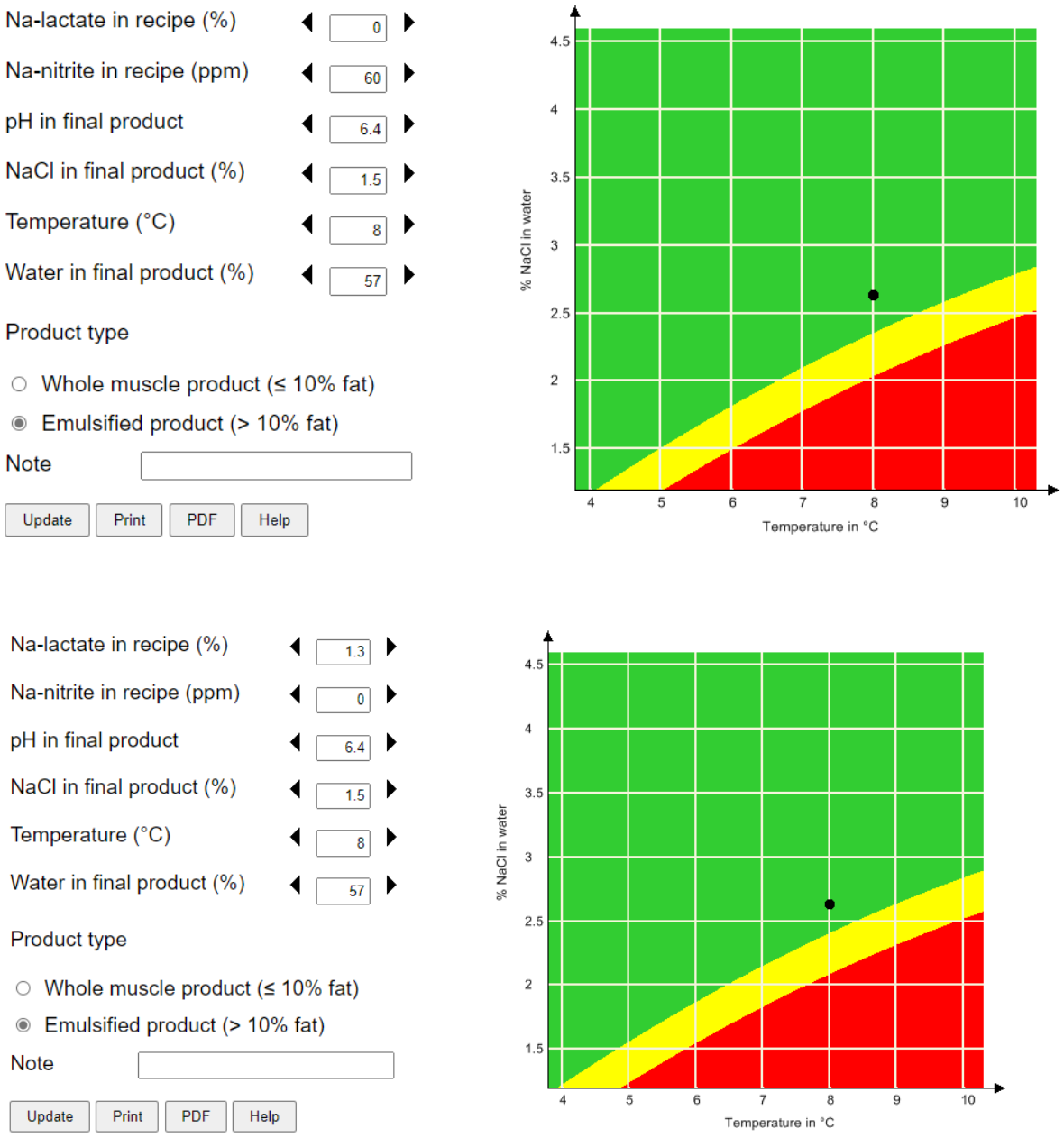

Figure 1. Predictions of the risk of growth of Clostridium botulinum (DMRIPredict).

Yersinia enterocolitica

For *Y. enterocolitica*, no predictive models are available that consider addition of both nitrite and organic acids. The model at DMRIPredict for *Yersinia enterocolitica* during curing of meat predicts growth or reduction during production/storage for 7 days at different salt, nitrite, and pH levels.

According to predictions, growth of *Yersinia* is inhibited in products containing 1.5% salt (2.6% salt in water) with 150 ppm nitrite added, pH ≤6, stored at max. 5°C or products with pH 5.5 with 150 ppm nitrite added, stored at max. 7°C.

For products containing 2.2% salt (3.9% salt in water), growth of *Yersinia* is inhibited in products stored at max. 5°C with 60 ppm nitrite added, pH ≤6, or 150 ppm

nitrite added. In products stored at max. 7°C, growth is inhibited in products with 150 ppm nitrite added, pH 5.5-6.4 or 60 ppm.

Table 2. Predicted growth rates (μ max) for *Yersinia enterocolitica* during curing of meat from DMRIPredict.

Temp. (°C)	Nitrite (ppm)	pH	μ max (log cfu/g /day)	
			Salt %	
			1.5	2.2
7	60	5.5	0.00	-0.05
		6	0.09	0.00
		6.4	0.23	0.08
	150	5.5	-0.04	-0.05
		6	0.00	-0.03
		6.4	0.05	-0.01
5	60	5.5	-0.03	-0.06
		6	0.03	-0.03
		6.4	0.12	0.02
	150	5.5	-0.04	-0.05
		6	-0.02	-0.04
		6.4	0.02	-0.02

Note: The model is only validated for 7 days.

Challenge studies have shown that growth of *Yersinia enterocolitica* is inhibited in fresh meat (pH 5.4-5.6) containing 0.8% salt in water and 1.3% lactate. The number of *Yersinia* is reduced if 0.8% salt in water, 0.6% lactate, and 0.12% malate and acetate are added to the meat (Gunvig, 2008).

Salmonella

According to the microbial criteria, *Salmonella* must not be detectable in meat that is consumed raw (none in 25 g, food category 1.4).

If the cooling chain is kept at ≤5°C, *Salmonella* cannot be propagated (cf. minimum growth temperature in Table 1).

According to predictions of growth of *Salmonella* from ComBase, *Salmonella* can grow in salt reduced bacon with nitrite added, when stored at ≥7°C (Table 3). It should be noted that predictions from ComBase do not consider the impact of background flora, which may impact growth of *Salmonella*. The calculated maximum growth rates (μ max values) from ComBase are comparable to μ max values for *Listeria monocytogenes* from DMRIPredict (60 or 150 ppm nitrite, pH 5.5-6.5) (Table 3). It is assumed that the same applies when lactate and acetate are added.

Table 3. Predicted growth rates for *Salmonella* and *Listeria monocytogenes* at 7°C from ComBase and DMRIPredict.

Nitrite (ppm)	pH	*Salmonella* µ max (log cfu/g /h) [a)]		*L. monocytogenes* µ max (log cfu/g /h) [b)]	
		Salt %		Salt %	
		1.5	2.2	1.5	2.2
60	6.5	0.01	0.008	0.012	0.011
	6	0.007	0.005	0.008	0.006
	5.5	0.005	0.004	0.003	0.002
150	6.5	0.007	0.006	0.009	0.008
	6	0.004	0.003	0.005	0.004
	5.5	0.002	0.001	0.001	0.001

a) Predictions from ComBase Broth Model; aerobic conditions.

b) Predictions from DMRIPredict Listeria Model. 30% CO_2 in packaging gas, >10% fat in product

In challenge studies at DMRI with back bacon pH~5.5 containing 3-5% salt in water, 60 or 150 ppm nitrite and vacuum packed, growth of *Salmonella* was not detected after 6 weeks of storage at 7°C or 10°C (Larsen, 1998). However, it has not been possible to find data from meat with pH >5.5.

Bacillus cereus

If temperatures are kept <10°C, *Bacillus cereus* does not produce the emetic toxin, cereulide (EFSA, 2005). However, if *Bacillus cereus* grows to high numbers in a product, it may still cause disease due to enterotoxin production in the gut (infection dose min. 100,000 cfu/g;(FVST, 2022)). Therefore, if a product is initially contaminated with 1 log cfu/g, the number of *Bacillus cereus* will reach the infection dose if 4-5 log cfu/g growth occurs during the shelf life of 56 days.

It should be noted that although the stated minimum growth temperature of *Bacillus cereus* is 4°C, strains of *Bacillus cereus* that grow at temperatures <7°C are only rarely occurring (EFSA, 2005).

The models for *Bacillus cereus* at ComBase do not include the possibility of predicting the impact of nitrite and organic acids. These variables have been tested in challenge studies at DMRI. However, due to variable results it is not possible to make clear conclusions of under which conditions meat products are stabilised against growth of *Bacillus cereus.*

Hurdle combinations that resulted in stabilisation against growth of *Bacillus cereus/weihenstephanensis* challenge are summarized below (from Koch, 2006):

At 5°C:

- pH 5.8-6.0 + 1.7-1.9 salt/water, vacuum (OTR 15 ml), no growth for 13 weeks.
- pH 6.3 + 2.2% salt/water + 2% Na-lactate, vacuum (OTR 40-60 ml), no growth for 8 weeks.
- pH 6.1-6.2 + 1.6-1.7% salt/water + 2.7% L-lactate/water, vacuum (OTR 15 ml), no growth at 5°C or 10°C for 13 weeks.
- pH 6.2; 1.9% salt/water; 30% CO_2; no growth for 4 weeks.
- pH 6.1; 1.1% salt/water, 60 ppm nitrite, 30% CO_2, no growth for 4 weeks.

At 8°C:

- pH 6.2; 2.1% salt/water; 20% CO_2, 0% O_2; no growth for 4 weeks.
- pH 6.1; 1.1% salt/water, 60 ppm nitrite, 30% CO_2; no growth for 4 weeks.
- pH 6.1; 1.9% salt/water, 1.9% L-lactate/water, 30% CO_2; no growth for 4 weeks.

The experiments have also shown that the *B. cereus* strains used can grow in a vacuum-packed meat product (minced meat with onions) with a pH of 6.1 and only 0.9% salt/water during storage at 5°C. In 3 weeks, the number increased from 4.5 log to 6 log cfu/g.

If, on the other hand, a little more salt is added (2.1% salt/water phase, pH 6.4), 1 log growth was found in an experiment in 7 weeks at 5°C (at 10°C there was 3 log growth in 1 week in this product). In another product with pH 6.3 and 2.1% salt/water added, the number of *B. cereus* increased from 4 log to 8 log during 3 weeks of storage at 5°C.

It is assumed that the conditions inhibit growth of *Listeria monocytogenes* in salt reduced bacon, i.e., addition of organic acids, will also not allow growth of *Bacillus cereus*, as *Bacillus cereus* is sensitive towards organic acids (Mols & Abee, 2011). However, data from previous challenge studies seem inconclusive, hence more knowledge is needed

Conclusions

Based on predictions from DMRIPredict and ComBase and data from former challenge test at DMRI, the following conclusions are made:

For products stored at 5°C (pH 6; 2.6-3.9% salt/water; shelf life 56 days, packed in 30% CO_2):

- The product is stabilised against growth of ***L. monocytogenes*** by combinations of:

  2.6% salt/water and
  - No nitrite, 1.7% L-lactate (2.1% Na-lactate); 0.04% acetate (0.05% Na-acetate) or
  - 60 ppm nitrite; 1.7% L-lactate (2.1% Na-lactate); no acetate or
  - 150 ppm nitrite; 1.5% L-lactate (1.9% Na-lactate), no acetate

  3.9% salt/water and
  - No nitrite, 1.7% L-lactate (2.1% Na-lactate); no acetate
  - 60 ppm nitrite; 1.6% L-lactate (2% Na-lactate); no acetate
  - 150 ppm nitrite; 1.4% L-lactate (1.8 % Na-lactate); no acetate

- No predictive model can document that ***Salmonella*** does not grow under conditions where the product is stabilised against growth of *L. monocytogenes,* and it has not been possible to find data from challenge studies that document this. However, it does not seem likely that *Salmonella* will grow at 5°C (lower temperature limit for growth of *Salmonella*).

- ***Clostridium botulinum*** does not grow under conditions where the product is stabilised against growth of *L. monocytogenes.*

- Growth of ***Yersinia enterocolitica*** is inhibited in products containing 2.6% salt in water, when pH is ≤6.0, and nitrite is added. Organic acids seem to reduce growth, but more knowledge is needed.

- *For* ***Bacillus cereus*** it is assumed that conditions that inhibit growth of *Listeria monocytogenes*, will also not allow growth of *Bacillus cereus*. However, data from challenge studies seem inconclusive, hence more knowledge is needed.

For products stored at 7-8°C (pH 6; 2.6-3.9% salt/water; shelf life 56 days, packed in 30% CO_2):

2.6% salt/water and
- No nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.17% acetate (0.23% Na-acetate)
- 60 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.14% acetate (0.19% Na-acetate)
- 150 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.06% acetate (0.08% Na-acetate)
-

3.9% salt/water and
- No nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.16% acetate (0.22% Na-acetate)
- 60 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.12% acetate (0.17% Na-acetate)
- 150 ppm nitrite, 1.7% L-lactate (2.1% Na-lactate), 0.04% acetate (0.06% Na-acetate)

- ***Salmonella*** may not grow under conditions where the product is stabilised against growth of *L. monocytogenes*. Challenge studies are recommended.

- ***Clostridium botulinum*** does not grow under conditions where the product is stabilised against growth of *L. monocytogenes*.

- ***Yersinia enterocolitica*** may grow in products containing 1.6% salt/water, when pH is >5.6. If salt/water % is raised to 2.6%, growth is inhibited when pH is ≤6.0 and nitrite is added. Organic acids seem to reduce growth, but more knowledge is needed, hence challenge studies are recommended.

- For ***Bacillus cereus*** it is assumed that conditions that inhibit growth of *Listeria monocytogenes*, will also not allow growth of *Bacillus cereus* at 7°C. However, data from challenge studies seem inconclusive, hence more knowledge is needed.

References

Anonymous, 2005. COMMISSION REGULATION (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuff.

FVST, 2022. Bakterier I fødevarer. Ministeriet for Fødevarer, Landbrug og Fiskeri.

EFSA, 2005. Opinion of the Scientific Panel on Biological Hazards on Bacillus cereus and other Bacillus spp. in foodstuffs. The EFSA Journal 175, 1-48.

Gunvig, A. 2008. Lagesammensætningens betydning for opformering af L. monocytogenes og Y. enterocolitica i marineret svinekød. DMRI report, project no. 18499

Jacobsen, T. & Koch, A. 2022. Ilttæthedens betydning for mikrobiel vækst Challengetest med cocktail af mulige fordærvere og patogener. DMRI report, project no. 2008771

Koch, A. G. 2006. Status for vækst af Bacillus cereus. Et sammendrag af resultater fra 4 projekter. DMRI report, project no. 18478

Larsen, A.G. 1998. Vækstmuligheder for Salmonella i back bacon ved temperaturbelastning, DMRI report.

Mols, M. & Abee, T. 2011. Bacillus cereus responses to acid stress. Environ Microbiol 3(11):2835-43.

Appendix 1

Predictions of growth of *Listeria monocytogenes* from DMRIPredict (whole muscle product; 30% CO_2 in packaging gas).

Temp. (°C)	Salt in product (%) [a]	Salt/ water %[b]	pH	Nitrite (ppm)	Na-lactate (%)[c]	Na-acetate (%)[d]	µ max (log cfu/g /h)	Time to 0.5 log cfu/g growth (days)
7	0.9	1.6	6.5	60	1.3	0.25	0.0018	11.75
				60	1.3	0.37	0.0001	> 56
				60	2.25	0.25	0.0003	> 56
				150	1.3	0.25	0.0009	22.67
				150	1.3	0.37	0	> 56
				150	2.25	0.25	0.0002	> 56
			6.0	60	1.3	0.25	0.0005	41.71
				60	1.3	0.37	0	> 56
				60	1.5	0.25	0.0002	> 56
				150	1.3	0.13	0.0007	31.54
				150	1.3	0.25	0.0002	> 56
			5.5	60	1.3	0	0.0006	32.38
				60	1.3	0.13	0.0003	> 56
				150	1.3	0	0.0004	29.18
				150	1.3	0.13	0.0002	> 56
	1.5	2.6	6.5	60	1.13	0.25	0.0016	7.81
				60	1.13	0.37	0.0001	> 56
				60	2.3	0.25	0.0002	> 56
				150	1.3	0.25	0.0008	24.67
				150	1.3	0.37	0	>56
				150	2.25	0.25	0.0002	> 56
			6.0	60	1.13	0.25	0.0005	> 44
				60	1.5	0.3	0.0002	> 56
				150	1.13	0.13	0.0002	33.46
				150	1.13	0.25	0.0006	> 56
			5.5	60	1.13	0.13	0.001	> 44
				60	1.13	0.25	0.0004	> 56
				150	1.13	0	0.0004	> 44
				150	1.13	0.13	0.0002	> 56
4	0.9	1.6	6.5	60	1.3	0.25	0.0005	43.96
				60	1.3	0.37	0	> 56
				60	2	0.25	0.0002	> 56
				150	1.3	0.13	0.0006	34.83
				150	1.3	0.25	0.0002	> 56
			6.0	60	1.3	0.13	0.0004	> 44
				60	1.3	0.25	0.0001	> 56
				150	1.3	0	0.0004	33.29
				150	1.3	0.13	0.0002	> 56
			5.5	60	0	0	0.0008	26
				60	1.3	0	0.0003	> 56
				150	0	0	0.0003	> 56
	1.5	2.6	6.5	60	1.3	0.25	0.0004	28.19
				60	1.13	0.37	0	> 56
				60	2.25	0.25	0.0001	> 56
				150	1.13	0.13	0.0006	36.63
				150	1.13	0.25	0.0002	> 56

Temp. (°C)	Salt in product (%) [a)]	Salt/ water %[b)]	pH	Nitrite (ppm)	Na-lactate (%)[c)]	Na-acetate (%)[d)]	µ max (log cfu/g /h)	Time to 0.5 log cfu/g growth (days)
			6.0	60	1.3	0.13	0.0004	> 44
				60	1.3	0.25	0.0001	> 56
				150	1.3	0	0.0004	> 44
				150	1.3	0.13	0.0002	> 56
			5.5	60	0	0	0.0006	32.33
				60	0.75	0	0.0003	> 56
				150	0	0	0.0002	> 56

a) 0.9% NaCl = 2.2% salt in the product based on Na-content from NaCl.
1.5% NaCl = 3.8% salt in the product based on Na-content from NaCl

b) Vol. percentage calculated in a product containing 57% water

c) Na-lactate added to the recipe; L-lactate in the water phase (incl. 0.3% naturally occurring lactate) 2.6-4.2%.

d) Na-acetate added to the recipe; acetate in the water phase

Bacon containing 2.2% salt in the product (=3.9 % salt/water in a product containing 57% water), pH 6, 30% CO_2 in packaging gas:

Storage at 7°C:

- 1% Na-lactate, 0.37% Na-acetate
- 60 ppm nitrite, 1.5% Na-lactate, 0.25% Na-acetate
- 60 ppm nitrite, 1% Na-lactate, 0.37% Na-acetate
- 150 ppm nitrite, 1.5% Na-lactate, 0.25% Na-acetate
- 150 ppm nitrite, 2.2% Na-lactate

Bacon containing 1.5% salt in the product (=2.6% salt/water in a product containing 57% water), pH 6, 30% CO_2 in packaging gas:

Storage at 7°C:

- 1.3% Na-lactate, 0.37% Na-acetate
- 60 ppm nitrite, 1.5% Na-lactate, 0.3% Na-acetate
- 150 ppm nitrite, 1.3% Na-lactate, 0.5% Na-acetate
- 150 ppm nitrite, 2.1% Na-lactate