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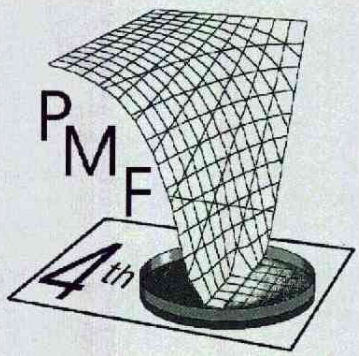
Predictive *modélisation* modelling *prévisionnelle* in foods *dans les aliments*

4th International Conference



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Development of a tool in order to simulate the behaviour of pathogens and evaluate the incidence of technological choices in ready-prepared fresh or pasteurised vegetable foodstuffs

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In-line process optimisation based on predictive models

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Modelling the surface growth of *Pseudomonas fluorescens* at elevated oxygen and carbon dioxide concentrations

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Optimisation of two-stage bacon tempering using mathematical modelling

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Influence of temperature and packaging method on the shelf life of sliced ham

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Prediction of food spoilage using microbiological, metabolic and enzymatic data

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Cooling of pig carcases

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Introduction

The fulfilling of the new food safety prescriptions is not an easy task because we had to reach the core temperature within 2 hours. Therefore new temperature programs have been offered recently. This are under –20°C. It is advantageous in the bacteriological point of view but the risk of the cold shortening and appearing ice crystals increase if we do not break this process in the right time. The resulting very high speed of cooling slow down the biochemical and rigor mortis processes, which is not good either for meat processing or meat trade as well.

Our aim was to investigate whether the new prescription of 7°C temperature in the carcass how can be achieved the new temperature programmes avoiding both the deterioration and cold shortening. in small scale slaughterhouses.

Material and methods

The cold shortening limit temperature was chosen to 12°C till 12 hours and the deterioration limit 20°C within 10 hours according to Rosset (1982). We used the equation for 1 dimensional body

$$\frac{T-T_a}{T_0-T_a}=\sum_{n=1}^{\infty}\frac{\sin(\beta_n)}{2\beta_n+\sin(2\beta_n)}e^{-\beta_n^2 Fo}\cos\left(\beta_n\frac{x}{X}\right) \quad (1)$$

where T = measured temperature at a point [°C]

Ta = ambient temperature [°C]
T0 = Initial temperature [°C]
ß = First root of the characteristic equation ßtg(ß)=Bi
Bi =α X/λ
α = Surface heat transfer coefficient [W/m^{2}K]
λ= Thermal conductivity of the carcass meat [W/mK]
X = characteristic length [m]
Fo =at/X/X

The calculation was made for leg.. The characteristic length are calculated by equation 4 (Prändtl 1988)

$$X=0{,}075\left(1+\frac{M}{100}\right) \quad (2)$$

where X = characteristic length [m]
M = carcass weight [kg]

The surface heat transfer coefficients were finite and assumed from 5 to 100 W/m^{2}K (from free convection to very strong convection at the blowing in) The initial temperature was 40°C. The bacteriological count was calculated by the method of Dantigny (1999) for E. coli. with an initial concentration of 10^4/cm^2

Results

First we investigated whether the one phase cooling can be applied for the new 7°Cwitin 24 hours prescription. Without deterioration and cold shortening.

Table 1: Time to reach 7°C in core and cooling temperature and surface heat transfer coefficient

Cooling temperature [°C]	Surface heat transfer coefficient [W/m^{2}K]	Cooling time [hours]
0	15-30	21-16,5
-5	10-20	20-16,5
-15	10	16,5

In the Table 1 we show only the parameters fulfilling the no deteoration and no cold shortening conditions. We can see that the surface heat transfer coefficient has to be lowered to avoid cold shortening if we lower the cooling temperature. About 10 W/m2K surface heat transfer coefficient change is equal to a change caused by 5°C cooling temperature change relating to the cooling time. The lowering of the cooling temperature affect the surface temperature and the bacterial count on the surface as well (Figure 1).

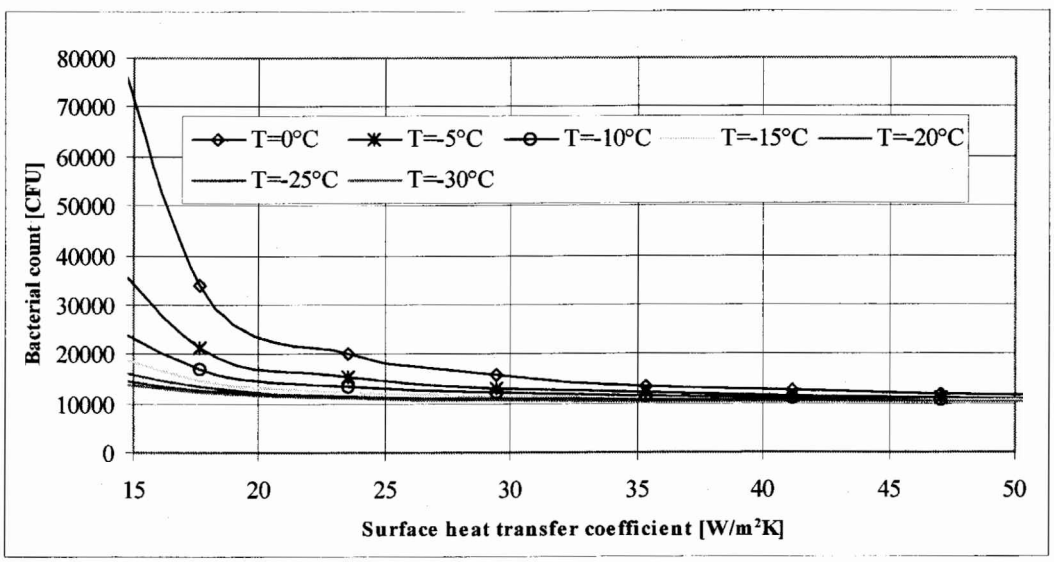

Figure 1: Bacterial count development at the surface at different surface heat transfer coefficient and cooling temperature

From figure 1 we can see that the surface bacterial count can be lowered significantly if we change the ambient temperature from –0°C to –10 centigrade. After that the differences became lower and lower between the cooling temperatures and seems to be a maximum useful surface heat transfer coefficients of 40W/m^{2}K. If we would have chosen lower initial CFU count we could have the same picture but lower CFU of course.

If we consider a two phase cooling as proposed by Klettner (1996) we have to investigate when we reach the 0°C because we do not want to freeze the carcass.(Figure 2). We can see from the figure 2 that the freezing region can be achieved more quickly if we apply lower temperature but it is not worthy to go under –15°C because we win only very few amount of time. An another aspect of this figure that the exposition time at the lowest temperature is so short that only the surface temperature lowered but the cooling time is not significantly less and will be very similar to the one phase cooling with a temperature of 0÷-5°C.

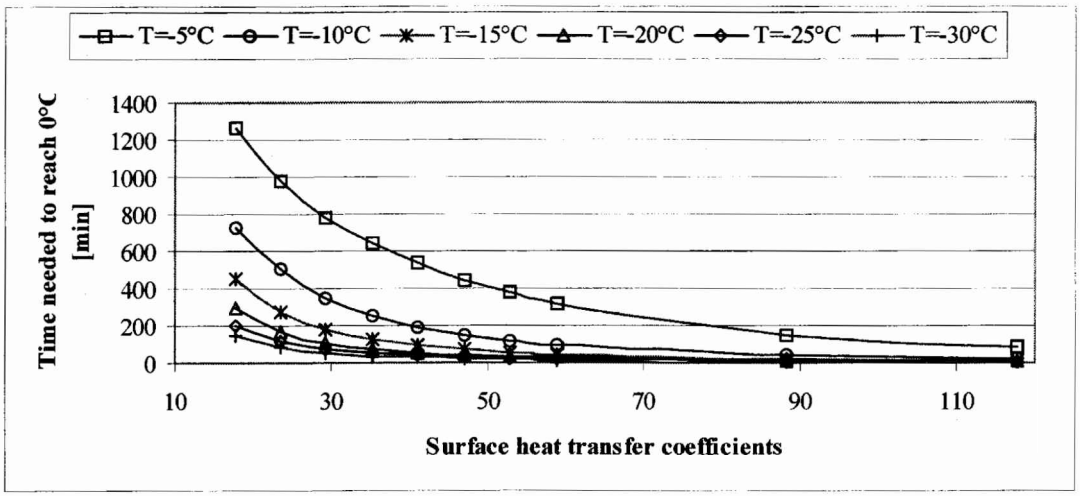

Figure 2: Time to reach 0°C in the surface [min]

Conclusions

The small plants can use the older cooling system if they have enough reserve in it because we do not need to lower the cooling temperature under –15°C (preferably –10°C). Under this temperature we get no advantage both in cooling time and in bacterial count.

In case of very low cooling temperature there is a very short effective time for cooling at low temperature and we approximate the in the second part of cooling the constant temperature cooling of 0÷-5°C.

The limit surface heat transfer coefficient is about 30-40W/m^{2}K, which means not more than 5 m/s in air velocity. In the practice the problem is that this 5-10m/s can be measured only at blowing in area meanwhile a little distance from it can be measured 0,5-2 m/s. It means that if we would like to have a 4-5m/s among the carcasses we need to blow in the air with a velocity more than 10m/s.

This is not usual in the mechanical engineering recommendations for closed spaces because of the high pressure drop and increase of the ventilator power consumption. We recommend therefore an air manifold system directing their blow out openings on to the leg of the carcasses. It would mean a 7.2 m^3/h in case of 40 mm diameter and pro carcasses.

Acknowledgements

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