

ENERGETIC CALCULATION IN HEAT TREATMENT PROCESSES OF MEAT PRODUCTS

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Abstract: The energetic consideration in the heat treatment is important to follow the new energetic concepts of sustainable production and energy saving. Our numerical simulation showed that the involving the cooling phase into lethality calculation is promising saving possibility (7-10%). The heat absorbed by the product was not so different among the cans due to the high F_0 and filling weight. The best compromise among energy consumption, sensory quality and heat transfer intensity is 120°C ambient temperature and 200W/m²K heat transfer coefficient. The variable ambient temperature treatment have not so favourable energy savings potential due to larger cans and high F_0 .

Keywords: energy use, heat treatment, meat products

INTRODUCTION

The heat treatment is the one of the largest energy consuming process of the canned meat production. But the realisation of the principles of the environmental management and sustainable development, decreasing the energy use, remain a technological-unit operation question further on. This may be solved only by taking into account the food safety – food quality – and economic aspects together, increasing the competitiveness by decreasing the direct costs of the production. The energetic research in the food processing began in the sixties after the 1st report of the Rome Club. The first investigations dealt with the general energetics and heat loss of production buildings and equipments in the '70-ies (Rao et al. 1976, Rao et al. 1978, Singh 1978, Rao és Katz 1976, Unger 1973). In the 80-hties the ratio of the energy utilisation came in the foreground (Sielaff et al. 1982, Bhowmik et al. 1985) but these results showed only a definite parameter constellation and have not been investigated the thermal schedules. Singh (1986) evaluated the canning processes on the base of the heat taken up by the product. In the 90-thies the variable retort temperature researches showed some energy reduction (Almonacid-Merino et al. 1993). Ramaswamy and Grabowski (1999) found that the smaller characteristic length gives possibility for energy savings. Marcotte e tal. (2008) used the average temperature for estimating the heat taken up and observed an energy use decrease in case of increasing the thermal gradient (ambient temperature and $\Delta T = 20$ to 40°C) although this energy consumption was about the as in the CRT processes of 75°C ambient temperature. Recently Simpson et al. (2006) investigated the production programming in heat treatment units.

The literature above showed only a definite parameter constellations and no attempt was made for investigating the relation between the energy use and the variable initial and boundary conditions. In this way our aim was to investigate several energy saving possibilities such as constant and variable (two stage) ambient temperature heat treatment and the incorporation of the cooling phase into the heat treatment.

MATERIAL AND METHODS

Our calculations were carried out on canned meats with explicit finite difference method till reaching $F_0=9$ min to destroy the Bacilli and Clostridia, causing bombage, safely. The composition of canned meats was taken from the Hungarian Codex Alimentarius. On the base of these we calculate the thermal parameters according to

Riedel (1969) and Choi and Okos (1986). In case of constant ambient temperature schedules the ambient temperature was changed between 116 and 124°C. We assumed 15°C for the initial and cooling water temperature. The heat transfer coefficient was varied between 60-1000 W/m²K. The most frequently used cans were involved into the investigations. In case of variable ambient temperature the two stage process was investigated. The ambient temperature change was calculated according to Einser (1979). The heat absorbed by the cans was determined as the heat content difference between the initial and final (at the steam off time) state. We investigated the incorporation of the cooling phase at different cooling water temperature and surface heat transfer coefficient for different can size as well.

RESULTS

In case of constant ambient temperature the surface heat transfer coefficient influenced the heat absorption stronger compared to the ambient temperature at a given can mainly at higher ambient temperatures (Fig. 1-3). The size of the can was the main factor in the heat absorption. The involvement of the cooling resulted only several kJ heat absorption decrease in case of the same ambient conditions. The minimum heat absorption was happened in case of 60W/m²K heat transfer coefficient involving with cooling. After that the absorbed heat was increased till 400 W/m²K and then it is decreased till 1000 W/m²K. It can be explained that the temperature gradient increase could be compensated by the heat treatment time decrease (25%-40%) only after 400 W/m²K. This place of the maximum absorbed heat was at the same place (400 W/m²K) in all three cases. The differences between the 3 cans is not so high because the smaller diameter means higher heights or vice versa and the 3 cans has about the same filling weight of 400-450 g.

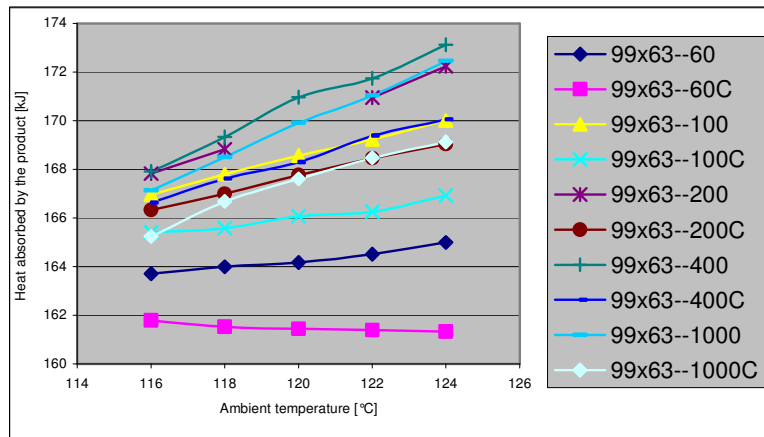


Fig 1. The heat absorbed by the product in dependence of the ambient temperature, heat transfer coefficient for 99x63 can (C=cooling)

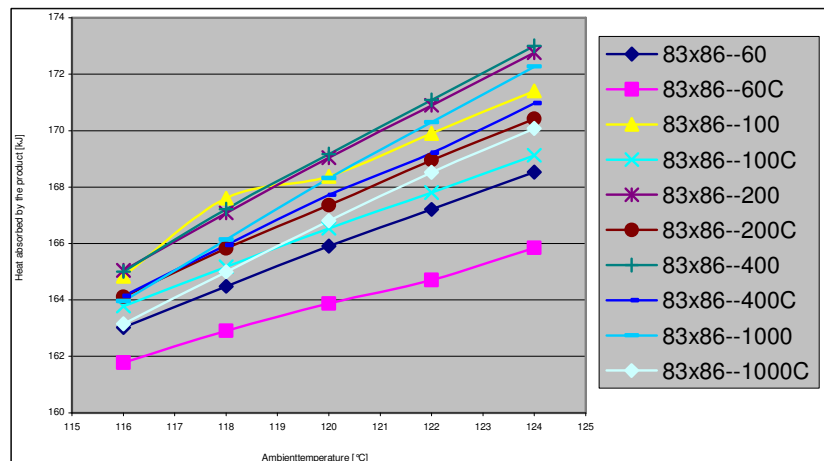


Fig 2. The heat absorbed by the product in dependence of the ambient temperature, heat transfer coefficient for 83x86 can (C=cooling)

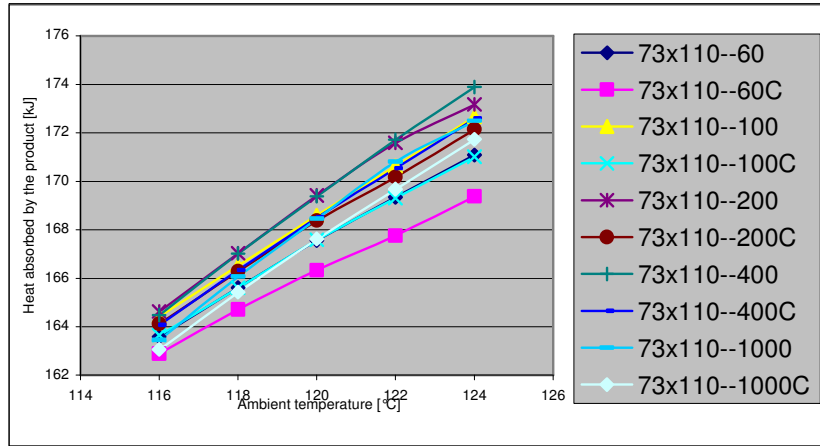


Fig 3. The heat absorbed by the product in dependence of the ambient temperature, heat transfer coefficient for 73x110 can (C=cooling)

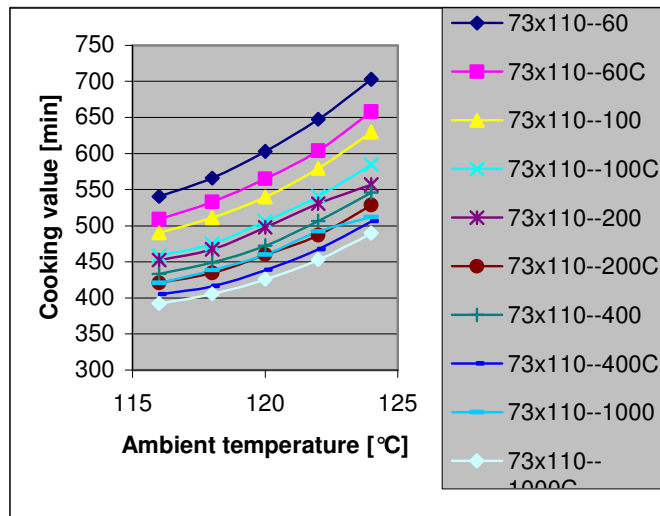


Fig 4. The cooking value development in dependence of the ambient temperature, heat transfer coefficient for 73x110 can (C=cooling)

The surface cooking values (Fig. 4), characterising the heat damage, showed a limiting picture. Till 118-120°C ambient temperature it could be experienced only a little increase in heat damage, which can not be differentiated in sensory properties. The increase in the heat transfer coefficient decreased the cooking values. The 99x63 and 83x86 cans showed the same trends but with about 40-50 min higher cooking values. It can be due to the larger diameter.

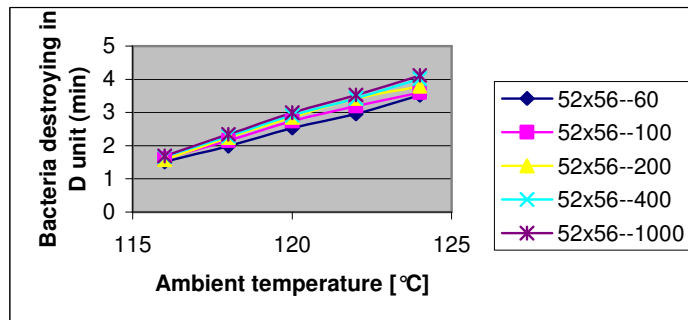


Fig 5. The bombage causing bacteria destroying during the cooling at different holding temperature and surface heat transfer coefficient during holding for 52x56 can (C=cooling)

The involvement of the cooling into the heat treatment can be handled as safety factor only for smallest cans under 120°C (Fig. 5). In this region only 10-100 bacteria can be destroyed. Above this the ratio of the cooling part in the total lethality may be 30-40%. In the case of the 99x63, 83x86 and 73x110 cans 3-4 D unit bombaging bacteria destroying can be reached. It means that about 10 minutes shortening in the can be reached in holding time shortening. This cause only little change in heat absorption by the products (Fig 1-3) but about 7-10% heat loss, 7-10% steam supply line heat loss, in water circulation autoclaves 7-10% electricity and steam generation cost decrease can be reached according to the size of the can surface heat transfer coefficient and ambient temperature.

Among the variable temperature heat treatments the two stage process the first stage ambient temperature would be at least 100°C because under this temperature the absorbed heat and the heat loss increased as the treatment time prolonged. This can be due to the large temperature lagging (7°C) as can be seen on Figure. The same trends and value was obtained for the 83x86 and 73x110 cans as well.

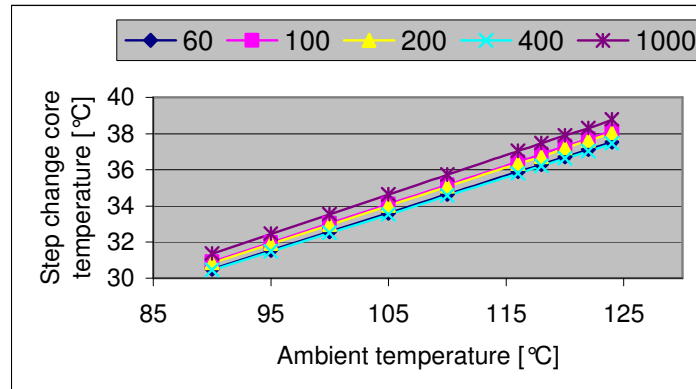


Fig. 6 The core temperature lagging in dependence on the heat transfer coefficient and ambient temperature for the 99x63 can.

The time of the end of the first stage was influenced mainly by the size of the can and a far less extent by the heat transfer coefficient. The heat transfer coefficient has only a minor role under $D < 50$ mm and if $D > 50$ mm the maximum value is 100-200 W/m²K from the energetic point of view. The ambient temperature has no role (rounding the time on minute) therefore it was not shown. (Fig. 6). In general 35 minute can be chosen for the first ambient temperature change. Because of the high F_0 value this is only about 1/4-1/5 part of the holding time so the holding time and heat saving is not so high and diminish as the time of the treatment extended.

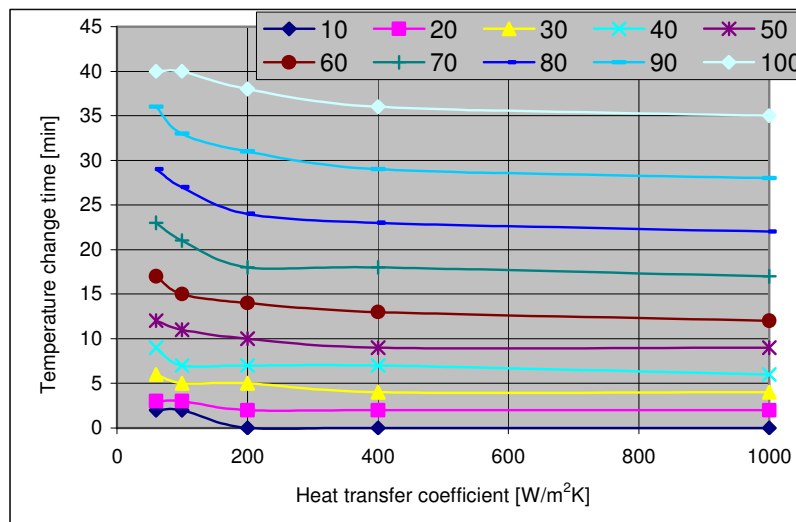


Fig 7. The Ambient temperature change time in dependence of the heat transfer coefficient and diameter

The total holding time was not so strongly decreased as in the literature mentioned (Almonacid-Merino et al. 1993, Ramaswamy and Grabowski 1999). It can be due to the greater sizes of the cans and much more higher

values. The applied only $F_0=2,52$ min heat equivalent unit (botulinum cook) and not $F_0=9$ min as we applied because of the destroying the bombage causing sulphite reductive Clostridium and Bacillus strains.

CONCLUSIONS

The heat absorbed by the product was not highly different among the investigated cans. It can be due to the high heat equivalent unit (F_0) and the about same filling weight. The most promising energy saving potential is in the involving the cooling phase lethality. It means 7-10% energy savings due the decrease in holding time. The best compromise among energy consumption, sensory quality and heat transfer intensity is about 120°C ambient temperature and about 200 W/m²K heat transfer coefficient. The variable ambient temperature treatment brought not so favourable energy saving potential as in the literature mentioned. It can be due to the larger cans and the high heat equivalents unit (incorporating the bombage causing microbe destroy).

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