Quasi adiabatic compression heating of selected foods

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Introduction

The application of high pressure for food sterilisation (so called pressure assisted sterilisation) in industrial conditions can be expected in near future. The main problems here are the resistance of spores and temperature non-uniformity of packed products in the chamber of high pressure unit. The basic tool for evaluating the uniformity of temperature of foods in the chamber is the numerical modelling of thermal behaviour of the chamber content. This numerical model needs to input reliable physical properties of processed foods, also the adiabatic compression temperature increase.

In spite of the fact of existence of some data, the ΔT values are not broadly known for foods and food components of ready to eat dishes that have greatest potential to be sterilised by HP assisted process. The aim of this paper is contributing to fill this gap selecting those food materials with high potential of application.

Due to non-linear character of the effect we will present directly ΔT vs. T_0 for given pressure level.

Material and methods

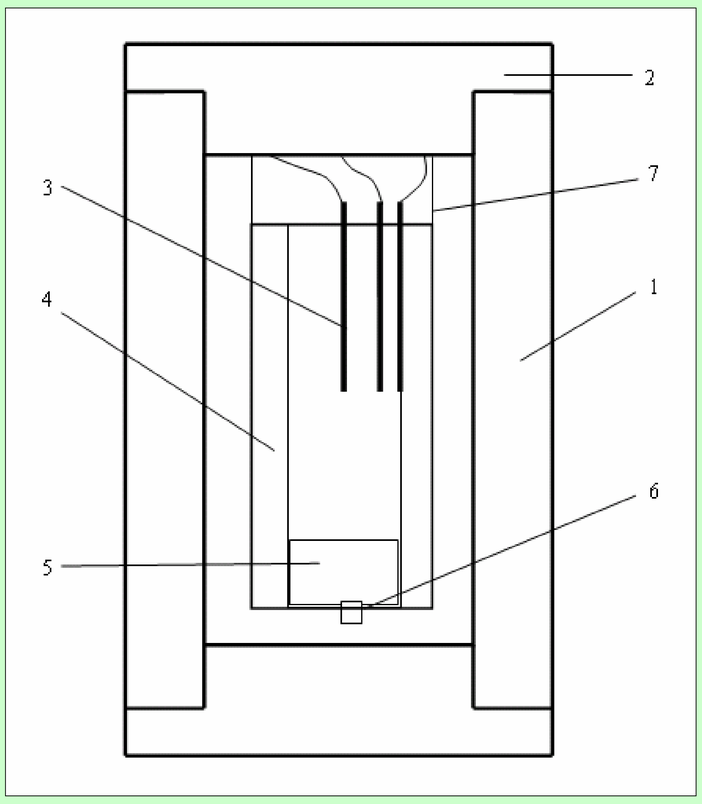
Food samples: Water with added 2 % Hamulsion BDG powder
Fresh meat mixture for Swedish meat balls
Pork meat pate
Tomato purée

Equipment: HP iso-static press CYX 6/0103 (Zdas j.s. co., Czech Republic)
volume of chamber: 2 litres (320 mm height a 90 mm diameter).
pressure: 0 -500 MPa

Methods:

Schema of experimental set-up is given in the schema of the experimental set-up. There is the cylindrical cup made from POM (polyoxymethylene) material placed in the chamber of the isostatic press. Outer diameter of the cup was 67 mm, length 250 mm and inner diameter 40 mm. There were three T-thermocouples introduced shielded by the stainless steel tube of outer diameter of 1.5 mm. One thermocouple was placed in the axis, second thermocouple was placed 12 mm from the wall and third thermocouple was placed in contact with the cup wall. For every food sample we have made measurement for nominal pressure 400 and 500 MPa and for three initial temperatures at range about 40 - 80°C. The sample was placed in the cup and covered by movable piston. The entrapped air was removed by the air-outlet valve. After that we tempered it on the required initial temperature. The pressure chamber was always tempered to 40°C. For calculation of adiabatic compression heating we used temperature course measured in the axis of the sample. We assume that this temperature is not affected by heat transfer in radial direction and by the wall temperature during short period of pressure-up time (verification by thermocouples 2 a 3).

We have made three pressure cycles for one filling of cup with given food, see three points in the figures. Due to non-linear character of the effect we will present directly ΔT vs. T_0 for given pressure level and use the correlation methodology to predict best fitting mathematical relation.



Scheme of the experimental set-up
1 - HP chamber with heating jacket
2 – lid of the chamber
3 – thermocouples
4 – POM cup with sample
5 - movable piston
6 – air-outlet valve
7 – holder of the cup

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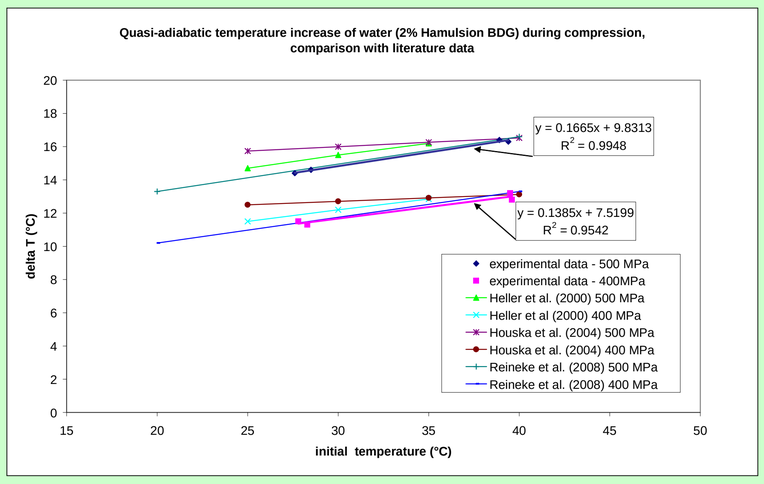
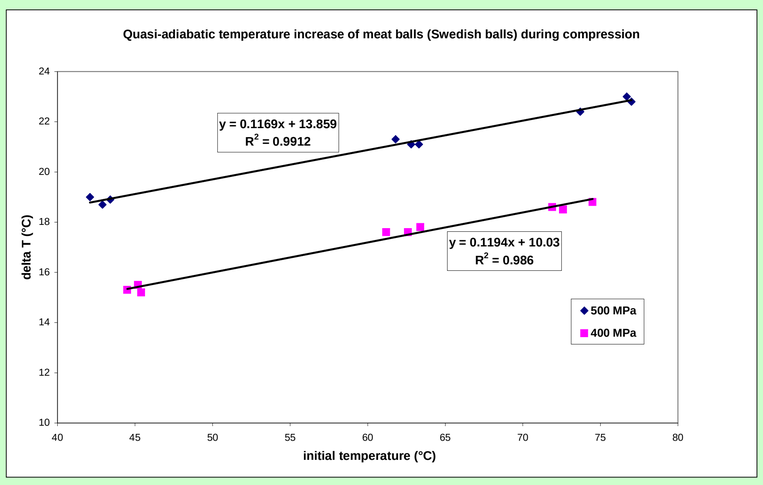
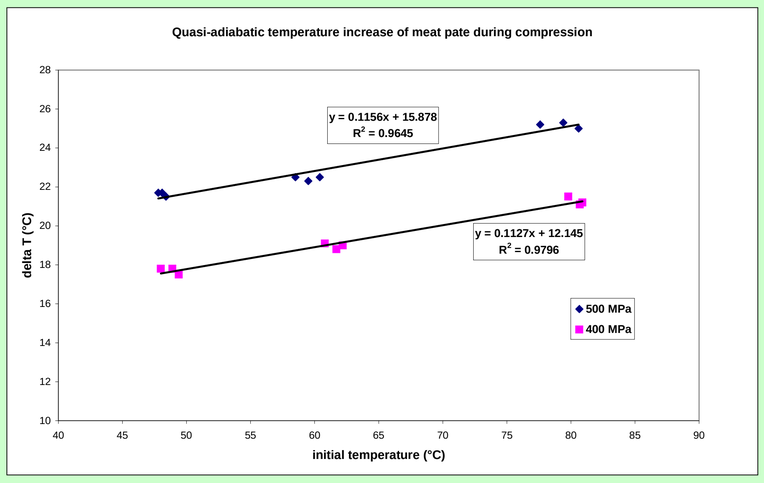
Results

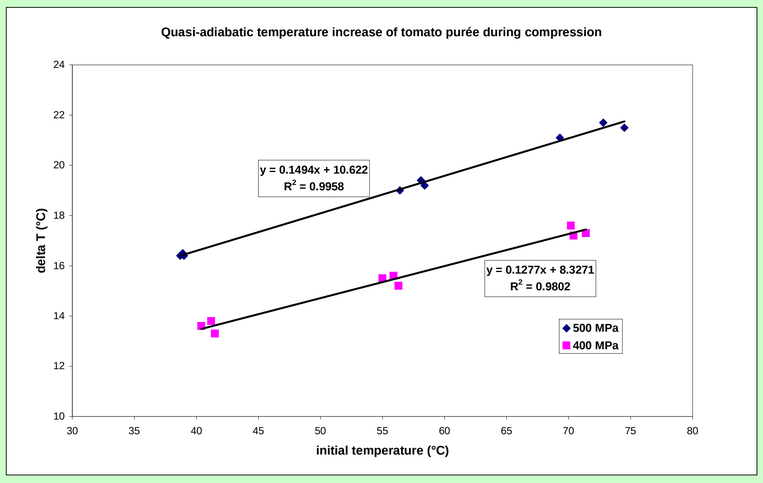
Tab.1 Resulting relations of quasi-adiabatic temperature increase vs. initial temperature of studied samples

sample	nominal pressure (MPa)	Equation for ΔT (°C)	T_0 range (°C)	R^2 (-)	SEE (°C)
Water-2 % Hamulsion	400	$\Delta T = 0.139 \cdot T_0 + 7.520$	27.8 – 39.6	0.954	0.247
Water-2 % Hamulsion	500	$\Delta T = 0.167 \cdot T_0 + 9.831$	27.6 - 38.9	0.995	0.095
meat balls	400	$\Delta T = 0.119 \cdot T_0 + 10.030$	44.5 – 74.5	0.986	0.187
meat balls	500	$\Delta T = 0.117 \cdot T_0 + 13.859$	42.1 – 77.0	0.991	0.170
meat pate	400	$\Delta T = 0.113 \cdot T_0 + 12.145$	48.0 – 81.0	0.978	0.240
meat pate	500	$\Delta T = 0.116 \cdot T_0 + 15.878$	47.8 – 80.6	0.965	0.324
tomato purée	400	$\Delta T = 0.128 \cdot T_0 + 8.327$	40.4 – 71.4	0.980	0.249
tomato purée	500	$\Delta T = 0.149 \cdot T_0 + 10.622$	38.7 – 74.5	0.996	0.151









Conclusions

We have tested our methodology of measuring quasi-adiabatic temperature increase using thickened water. The reasonable agreement between our and literature data valid for water was found.

We have predicted that quasi-adiabatic temperature increase of meat balls, pork meat pate and tomato purée is linearly dependent on initial temperature T_0. The quasi-adiabatic temperature increase raised with increasing pressure level for all foods studied.

The highest values of quasi-adiabatic temperature increase were found for pork meat pate due to the highest content of the fat. Tomato purée exhibited similar quasi-adiabatic temperature increase values as water thickened with 2 % of Hamulsion.

Received equations can be used in future for mathematical modelling their thermal behaviour during the HP assisted pasteurisation or sterilisation processes.