:25 # Water holding capacity (WHC) of meat - a possible parameter in heat process calculations?

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Introduction

In order to determine the necessary heating time (t) for a certain meat product (we considered only the pasteurized canned meat products) to reach at the coldest poing (geometrical center) the required temperature (T) we use the equation:

$$t = f \cdot \log \cdot j(T_1 - T_o) \; / \; (T_1 - T)$$

Where T_1 is the temperature of heating medium, T_o - the initial temperature of the product, j - the referent point on the asymptote of the log time-temperature curve on the temperature (Y) axis at the time $t = 0$, f - the factor of temperature respons, which shows that on the log time-temperature curve the ordinate changes ten times in a defined period of time. This time is designated by f. Physically, f is the time required to reduce the difference between the heating medium temperature and the temperature at defined point (geometrical center) of the product to one-tenth its value at the beginning of the time interval.

By using the equation:

$$T = T_1 - j(T_1 - T_o) \cdot 10^{-t/f}$$

we can calculate the temperature T after t minutes of heating of the defined point of the product.

It should be pointed out that f does not vary both with the position of the point in the subject and distribution of the initial temperature, but varies with the thermal diffusivity.

f is also dependant on thermal diffusivity (a) of the product. This relation is gived by the equation:

$$af = \frac{\text{thermal conductivity}}{\text{(specific heat) (density)}}$$

Those equations have shown that f, disregarding the way it was calculated or obtained, is a very important varyable for calculating heat processes.

Our previous experiments and literature data have suggested that the heating rate of meat (or meat mixtures with curing ingredients), expressed as f, are influenced by the WHC. Our aim was to examine how some of those factors important for the WHC of meat do affect the heating rate expessed as f value.

Materials and Methods

Schedule of the experiments along with ingredients added to meat mixtures are given in table 1.

Heat processing was carried out in a thermostatic water bath at 75 or 80°C untill 70°C was reached in the geometrical center of cylindrical cans (diameter73, height 74 milimeters).

Temperature of the geometrical center was recorded by ELLAB Thermocouple at 5 minutes intervals.

Grau and Hamm (1972) filter paper press method was used for WHC determinations.

pH-meter Model 29 (Radiometer Copenhagen) with combined electrode was used for the pH determinations.

f values were calculated according to Ball and Olson (1957). Time-temperature curves were plotted on semilogarithmic paper as described by Ball and Olson (1957). Those curves were used for f value calculations. f values (times) are given in minutes.

All muscles were completely trimmed off from visible fatty and conective tissues.

Mixing of minced muscles with curing ingredients and different amounts of added water was carried out in experimental baker mixing machine.

pH of mixtutes was adjusted by adding HCl of NaOH diluted solutions.

DFD (dark, firm, dry) muscles were used provided their pH_{24} value was equal to or higher than 6.34 (Wirth, 1978). As DFD muscles of hogs which were intraperitoneally injected with 10 ml of 0.001 per cent adrenalin solution prior to slaughter and having the pH_{24} value equal to or higher than 6.30, were also used.

PSE (pale, soft, exudative) muscles were taken from hog sides having pH_1 value equal to or lower than 5.80 (Wirth, 1978).

All experiments were repeated three times. Taking into consideration that there were no significant differences among repeatings, the results were presented as mean values.

Table 1.

Experiment	Muscle	Per cent of added ingredients NaCl	Tari P 22	H_2O	Time post mortem of mixing	Time post mortem of heating	Temperature of heating °C
1	beef semitendinosus, minced through 3 mm holes 3 hours post mortem	-	-	-		3	75
	chilled for 48 hours	-	-	-		48	75
2	same as in 1st experiment chilled for 24 hours	4	-	-	3	27	75
		4	-	5			
		4	-	15			
		4	-	25			
3	"	4	-	-	24	48	75
		4	-	5			
		4	-	15			
		4	-	25			
4	"	4	·5	-	24	48	75
		4	·5	5			
		4	·5	15			
		4	·5	25			
5	beef semitendinosus and semimembranosus 48 hours chilled pH adjusted to 4.0 up to 10.0	4	-	15	48	72	80
6	pork semitendinosus and semimembranosus $pH_{24} \geqslant 6.34$ minced through 8 mm holes	4	·5	-	24	48	80
		4	·5	15			
		4	·5	30			
7	same as in 6th experiment but virtually provoked DFD characteristics	4	·5	-	24	48	80
		4	·5	15			
		4	·5	30			
8	pork semitendinosus and semimembranosus $pH_1 \leqslant 5.8$ minced through 8 mm holes	4	·5	-	24	48	80
		4	·5	15			
		4	·5	30			

Results

The experiments have shown that hot meat (3 hours post mortem) minced and heated immediately thereafter had the f value of 60 minutes. The same meat but chilled for 48 hours at 4°C had the f value of 54.5 minutes. Hot (3 hours post mortem) minced and salt-added (4 per cent) beef, mixed with different amounts of added water (0, 5, 15, 25 per cent) 24 hours later conducts the heat faster as the amount of added water to the mixture is increased. Each per cent of added water caused a decrease of f value for 0.23 minutes. This effec showed nearly linear pattern. Mixtures without water had the f values ranging between 57.95 and 58.125 minutes, those mixtures containing 25 per cent of added water had f values of only 52.625 or 52.08 minutes

Chilled (24 hours at 4°C), minced and salted (4 per cent) beef mixed with different amounts of added water (0, 5, 15, 25 per cent) and chilled for following 24 hours, conducted the heat faster as the amount of added water was increased. Each per cent of added water caused a decrease of f value for 0.165 minutes. Mixtures without added water had the f values ranging between 55.58 and 56.85 minutes, mixtures containing 25 per cent of added water had the f values of 52.2 and 51.18 minutes.

Addition of water (0, 5, 15, 25 per cent) to minced beef mixtures with common salt (4 per cent) and polyphosphate preparation (0.5 per cent of Tari P 22) promoted heat conduction. Each per cent of added water decreased the f values for 0.112 minutes. Mixtures without added water had the f values between 56.43 and 56.68 minutes. Mixtures containing 25 per cent of added water had the f values between 53.88 and 53.31 minutes.

Minced beef mixtures with adjusted pH values showed slower heat conduction with the rise of pH. Mixtures having pH 4.0 showed the f value of 42.94 minutes, those mixtures having pH 9.51 had the f value of 53.85 minutes. However, in the range of pH between 5.1 and 7.60, the f value remained practically unchanged (approximately 50 minutes).

Mixtures of DFD pork containing common salt (4 per cent) and polyphosphate preparation and different amounts of added water (0, 15, 30 per cent) showed decrease of the f values with the increase of added water amounts. Each per cent of added water decreased the f value for 0.2 minutes. Mixtures without added water had the f value of 59.15 minutes, those mixtures containing 30 per cent of added water showed 53.15 minutes of f value.

Identical results were obtained with mixtures of pork originating from hogs being injected with adrenalin solution to provoke DFD characteristics.

Mixtures of PSE pork containing the same ingredients as DFD ones showed considerably shorter f values (faster heat conduction) in comparison with the DFD or with normal meat mixtures. The pheno-

menon of decreasing the *f* values by the increase of added water amounts in this experiment was not observed (mixture without added water had *f* value of 47.84, those containing 15 per cent of added water - 49.23, and mixtures with 30 per cent of added water had *f* value of 46.85 minutes).

Discussion

Exact determination of the *f*-parameter has a multifarious significance. As evident from the quoted equations the *f* value could serve to determine the duration of heat treatment or those temperatures which are to be reached after certain time in the geometrical center of the content, as to render the product not to be "undercooked" nor "overcooked".

Nowadays the temperature in the geometrical center of the product is frequently monitored, in every or almost every sterilization or pasteurization unit just in order to avoid "overcookedness" or "undercookedness", that is to avoid deviations from parameters set forth. Anyhow, even such a procedure does not give a total control of thermal process. In our opinion it is possible to secure a satisfactory heat treatment control provided the *f* value is corrected by the factors for WHC or percentage of added water, PSE or DFD meat properties.

The results referred to, just as the previously made examinations (Hill, 1967, Šuvakov, 1980) have shown that the *f* values are in negativ correlation with the WHC (dependant muscle homogenate composition). The fact according to which homogenates with more immobilized water have shorter *f* values, can be above all, explained by the phenomenon according to which larger quantities of immobilized water as related to compression, are released by heating due to the thermal coagulation of proteins so that the water released in such a way contributes to the faster heating of the product by forming microconvectional streamings. Anyhow, the fact that the hot meat (3 hours post mortem, without additions) has the most prolonged *f* value, as compared with the same meat that was chilled, shows that the meat with better WHC - conducts heat slower. Accordingly, the paradox is false and arises only due to the method applied to determine the WHC.

From all what was said we can conclude that the effect of WHC on the *f* value in heat process calculations has to be considered. Anyhow, since the determination of WHC by the method described requires a lot of time, even if performed by well skilled staff, we thought it would be much simpler to take into consideration the amounts of added water, what induced us to present the results we obtained in such form.

By our experiments we intended to call the attentions of scientists to a very important detail related to the calculation and determination of heat processes. It is quite natural that we shall have to do much more experimental and theoretical work in order to clarify all the correction factors of the *f* value dependant on WHC or amounts of added water.

The results clearly indicate that the changes within the *f* values are significant particularly if bearing in mind that the experiments were carried out with small size cans (diameter 73, height 74 mm) and that the cooking was performed at pasteurization temperatures. IT is quite probable to suppose that the significance of the factors examined would be more apparent if the monitored changes were extrapolated on large, 14 lbs oblong cooked hams.

References

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