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Heating Rate of Muscle Homogenates

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Introduction:
The heating rate of meat batters during heat treatment, as well as other meat foods, can be presented in many different manners. One of them is estimating of the f values. The f value is also a particularly important parameter in heat process calculations, i.e.in predicting temperatures after defined time of heat treatment or in calculating the time necessary to reach desired temperature in the coldest point of a canned product.
A well known fact is that the heating rate of meat batters depends, among many other factors, on their composition. The amount of added water, water holding capacity and pH of meat substrates do influence their heating rate (Suvakov et al. 1978, Panin et al. 1979, Suvakov et al. 1984). Part of emulsification in heat stability of meat batters was studied by Shut (1976). Our aim was to investigate the heating rates of meat homogenates containing various amounts of meat, fatty tissue and water.

Materials and Methods:
Meat. Semitendinosus and semimembranosus muscles of a young steer (24 months of age) were used for the experiments. Hind quarters have been previously kept frozen (-25°C) for three months. After thawing the quarters (48 hours at +12°C), muscles were excised and completely trimmed off from fatty and connective tissues. Thaw-drip (about 3%) was discarded. The so prepared meat was minced through 4 mm diameter holes (Helly-Jolly pilot-plant mincer). The chemical composition was the following (%): water 73.75, protein 23.15, fat 2.25, ash 0.85, estimated according to AOAC procedures (1975). In further text this raw material is MT denoted.
Fatty Tissue (FT). Pork fatty tissue (from the back region), chilled for 48 hours at +4°C, minced through 4 mm diameter holes (the same mincer as previously) was used for homogenate preparation. The chemical composition of pork fatty tissue was (%): water 6.80, protein (connective tissue proteins) 1.83, fat 89.60, ash 1.77.
Ice (W). Ice was produced from tap-water, having a temperature of -6°C.
Salt (NaCl). Common salt was used for the preparation of homogenates. All homogenates contained 2% of salt.
Polyphosphate Preparation. Tari K 2, in amount of 50 grams was added to 10 kilograms of raw materials used for homogenate preparation (p.ph).
Three basic homogenates were prepared in a bowl chopper (helly-Jolly pilot plant chopper, bowl capacity 20 liters), by applying low speed for both bowl rotation and knives.

Table 1 - Raw Material Composition of Basic Homogenates

Homogenate	Amount of components (grams)				
	MT	W	FT	NaCl	p.ph.
I	5800	2000	2000	200	50
II	-	8000	1800	200	50
III	-	1800	8000	200	50

Final homogenization was carried out in a laboratory homogenizer (Iskra-Kranj), applying high speed (about 10 000 rpm) during 2 x 45 seconds.
Varying the amounts of the three basic homogenates in final homogenate preparation, 13 different homogenates were produced.

Table 2 - Basic Raw Material Composition of Homogenates

Component %	Denotation of homogenates												
	1	2	3	4	5	6	7	8	9	10	11	12	13
MT	58.00	38.66	38.66	38.66	29.00	29.00	29.00	14.50	14.50	15.46	9.66	9.66	9.66
W	20.00	30.00	19.33	29.66	50.00	19.00	34.50	65.00	18.50	41.26	70.00	18.33	44.16
FT	20.00	19.33	40.00	29.66	19.00	50.00	34.50	18.50	65.00	41.26	18.33	70.00	44.16

Table 3 - Assumed Chemical Composition of Final Homogenates

%	Denotation of homogenates				
	1	2	5	8	11
Water	64.13	69.83	72.67	76.95	78.37
MT proteins	13.42	10.95	6.71	3.35	2.23
CN proteins*	0.36	0.35	0.34	0.33	0.33
Fat	19.22	18.19	17.67	16.90	16.64
NaCl	2.00	2.00	2.00	2.00	2.00
p.ph.	0.50	0.50	0.50	0.50	0.50

Table 4 - Assumed Chemical Composition of Final Homogenates

%	Denotation of homogenates 1	4	7	10	13
Water	64.13	60.19	58.23	55.47	54.29
MT proteins	13.42	10.95	6.71	3.58	2,23
CN proteins*	0.36	0.53	0.63	0.75	0.80
Fat	19.22	27.44	31.56	37,32	39.78
NaCl	2.00	2.00	2.00	2.00	2.00
p.ph.	0.50	0.50	0.50	0.50	0,50

Table 5 - Assumed Chemical Composition of Final Homogenates

%	Denotation of homogenates 1	3	6	9	12
Water	64.13	50.56	43.78	33.61	30.22
MT proteins	13.42	10.95	6.71	3.35	2.23
CN proteins*	0.36	0.73	0.91	1.18	1.28
Fat	19.22	36.70	45.45	58.56	62.93
NaCl	2.00	2.00	2.00	2.00	2.00
p.ph.	0.50	0.50	0.50	0.50	0.50

*CN = connective tissue proteins from the fatty tissue

Temperatures of homogenates after final homogenization ranged between 6 and 14°C. Final homogenates were stuffed into cylindrical cans (73 mm in diameter, 70 mm in height) by hand operated stuffer. Sealed cans with fixed thermocouples on the lid (inserted to record the temperature in the geometrical center) were kept for 10 hours in a refrigerator (at +3°C) to equalize temperature of the homogenates throughout the can content. Three cans for each homogenate were used for heat penetration tests.

Heat Treatment was carried out in a thermostatically regulated water bath at 80°C, until 70°C was reached (69.7 - 70.6) in the geometrical center of a can. Temperatures were recorded by the ELLAB thermocouple. Readings were done in 3 minute intervals.

Immediately after 70°C was reached in the geometrical center of a can, the can was removed from the water bath and opened to pour the cooked-out juice into the graduated cylinder. When the cooked-out fat was solidified the volumes of the water and fat were recorded.

Determination of Heating Rate. First of all, the temperature differences between consecutive temperature readings (3 minute intervals) were plotted (Y axis) against time (X axis) on a cross-section paper to find the period of fast heating for each homogenate (Fig. 1). Having estimated the heating period during which the heat penetration rate is high (most often from 9th to 21st minute of heat treatment) a time-temperature curve was plotted on the semilogarithmic paper inversely divided (Fig. 2). Temperature denoted "u" presents the quotient

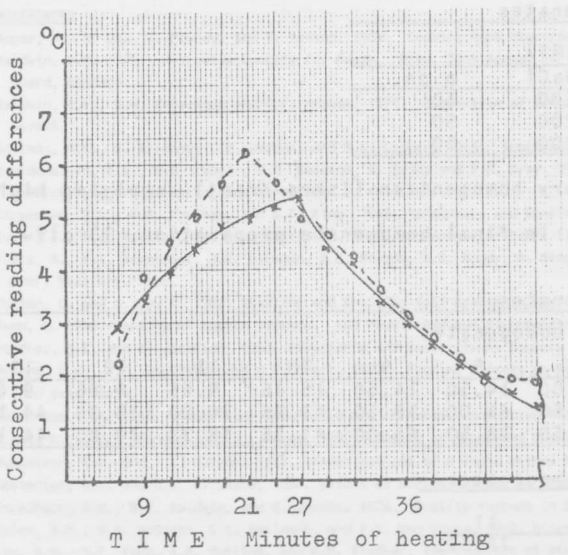

Fig. 1 - Consecutive reading (3 minutes) differences (°C).

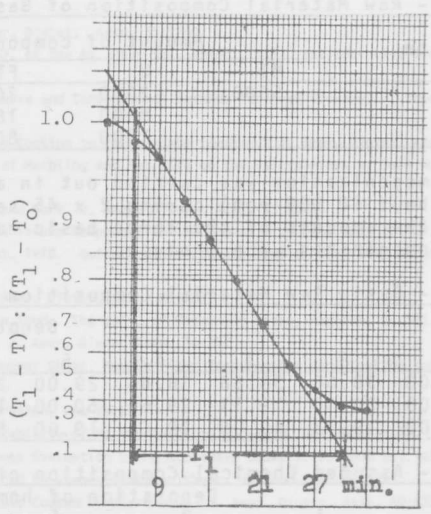

Fig. 2 - Time-temperature curve plotted on semilogarithmic paper (inverse division) used for f_1 estimation.

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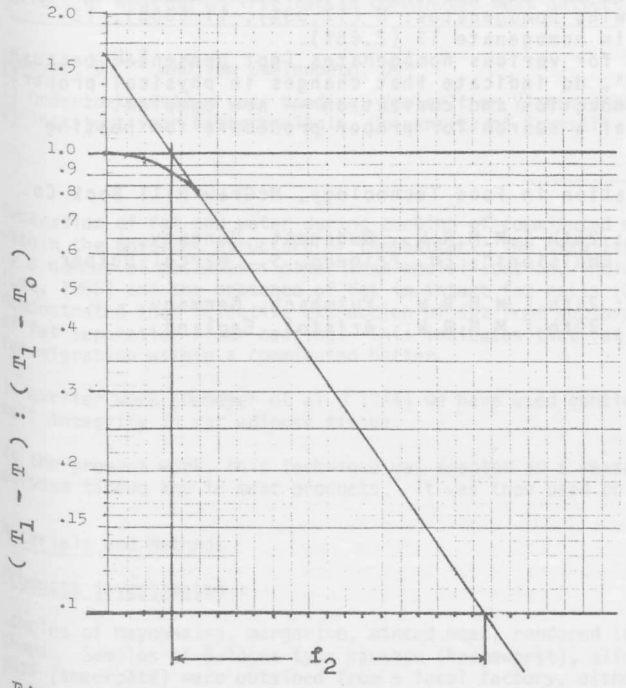

Fig. 3 - Time-temperature curve plotted on semilogarithmic paper used for f_2 estimation. (Original size sevefold reduced)

of temperature differences (T_1 - T) and (T_1 - To). T_1 is the temperature of heating medium, T_o is the initial temperature of homogenate, and T the temperature of homogenate at the time t. This temperature scale always shaws unity at the beginning of a heating period, and zero represents the temperature of the heating medium. Asymptote of that kind of time-temperature curve traversing one logarithmic cycle gives the f_1 value.
The second time-temperature curve, according to Ball and Olson (1957), was plotted on the semilogarithmic paper (Fig. 3) for the same homogenate, (but not having an inverse logarithmic division). Asymptote of this time-temperature curve corresponded to the period of a lower heating rate of a homogenate and was used for calculating f_2 values (time necessary to traverse one logarithmic cycle). Both geometrical and computational procedures were used for obtaining f_1 and f_2 values.

Results and Discussion:

The results show (table 6) that homogenates containing more water have lower heating rates, although those differences in heating rates are not significant. But it should be considered that f values are valid for homogenates heated in small size cans. However, with a certain amount of added water in excess, the heating rate became higher (shorter f value times). This limit is about 65% of added water for homogenates having predominant amounts of water added (homogenates 8 and 11). Increasing amounts of added fatty tissue to homogenates resulted as lower heating rates (homogenates 3, 6, 9 and 12), until a certain limit (65 - 70%) of added fatty tissue is not exceded. Beyond that limit the heating rate turns to higher values (homogenate 12).
Group of homogenates (4, 7, 10 and 13), having the ratio of added fatty tissue and water 1:1 (or nearly that value), shows lower heating rates as the amount of those raw materials is higher. This group of homogenates was heated faster in comparison to those homogenates containing predominant amounts of added fatty tissue, however slower then homogenates containing high amounts of water if we compare homogenates containing equal amounts of muscle tissue.
Taking into consideration the composition of homogenates we were experimenting with, the importance of the amounts of muscle tissue added is in providing strong enough or not strong enough protein matrix. That means to provide thermo-stability of homogenates. With those homogenates having very low percentage of muscle tissue (8, 9, 10, 11, 12 and 13) water and/or fat separation occurred, promoting microconvectional streamings, bringing irregularities in heating rates (table 6), i.e. accelerating the heating. Exception was the homogenate (12) containing extremely high (70%) amount of added fatty tissue, in which considerable amount of water was separated after heat treatment, although lower heating rate was estimated than expected.

Table 6 - Heating Rates (f_1 and f_2) of Homogenates

(A)	Denotation of homogenates				
	1	2	5	8	11
f_1	29'0"	29'06"	26'30"	32'57"	29'58"
time:min.*	9 - 21	9 - 21	6 - 21	9 - 27	9 - 21
f_2	50'30"	51'06"	51'20"	49'42"	45'34"
time:min.*	21- 54	21- 54	21- 54	27- 60	21- 51
(B)		4	7	10	13
f_1		30'00"	30'00"	31'12"	34'20"
time:min.*		9 - 24	9 - 27	9 - 33	9 - 36
f_2		51'37"	52'07"	54'14"	54'25"
time:min.*		24- 54	27- 57	33-60	36- 63
(C)		3	6	9	12
f_1		34'12"	35'18"	41'47"	46'30"
time:min.*		9 - 24	9 - 27	9 - 33	9 - 36
f_2		53'53"	60'39"	66'20"	54'09"
time:min.*		24- 57	27- 66	33- 69	36- 66

* - Periods of heating determined from the consecutive reading of differences in time-temperature curves.

In discussing the obtained results it should be pointed out that significant amounts of water were separated during heat treatment by following homogenates: 8 (17.33%), 11 (30%), 12 (17.33%) and 13 (6%). Fat was separated only in homogenate 13 (2.66%).
Different patterns of time-temperature curves for various homogenates (not presented because of space shortage) as well as "irregularities", do indicate that changes in physical properties of muscle homogenates -- relevant for heat conduction and convection -- are complex.
The results presented are only the beginning of a search for proper procedure for heating rate estimation appliable on meat batters.

Refferences:

1. Ball, C.O., Olson, F.C.W. (1957): Sterilization in Food Technology, McGraw Hill Book Co. Inc., New York.
2. Panin, J., Šuvakov, M., Radetić, P. (1979): 25th E.M.M.R.W., Budapest, Hungary.
3. Shut, J., (1976): Meat Emulsions in: "Food Emulsions". Ed. Friberg, S., Marcel Dekber, Ing., New York.
4. Šuvakov, M., Panin, J., Radetic, P. (1978): 24th E.M.M.R.W., Kulmbach, Germany.
5. Šuvakov, M., Radetić, P., Panin, J. (1984). 30th E.M.M.R.W., Bristol, England.