

INFLUENCE OF LOW-FREQUENCY VIBRATIONS ON FREEZING

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The methods accelerating the process of crystallization may intensify the process of freezing. These may be physical methods, for example, supply of vibrations to the product being treated. This approach can, to a large extent, accelerate the processes of heat exchange between the environment and the product, improve quality and reduce meat weight losses without significant increase in energy consumption [1, 2].

The conditions of refrigeration treatment were simulated at 243 K by nitrogen gas in experimental vibration chamber. The object of the investigations was *M. longissimus dorsi* of fresh beef of 1st grade of quality, the samples having the form of slab with the size 24 x 40 x 70 mm.

The experiments were run in three series. The first one - freezing with preliminary spraying by liquid nitrogen during 60 sec with simultaneous vibration effect to 265 K in the centre of the sample (experiment 1). The second one - freezing to 265 K in the centre of the sample supplemented by vibration oscillations without liquid nitrogen spraying (experiment 2). Third - one stage freezing without vibrations (control). The length of time as required for temperature reduction in geometrical centre of the investigated sample to the final one equal to 265 K, was considered as the duration of freezing. Due to the fact that vibrations parameters were chosen having considering its possible utilization in commercial production of frozen foods, the main series of experiments was carried out at the amplitude of vibration action 3 mm and fixed frequencies 6, 10, 16, 25, 40 Hz.

Processing of experimental data has shown that vibration action on the process of crystal formation was very significant. The data of investigations are summarized in Table 1, the thermograms of the process are shown in Fig. 1.

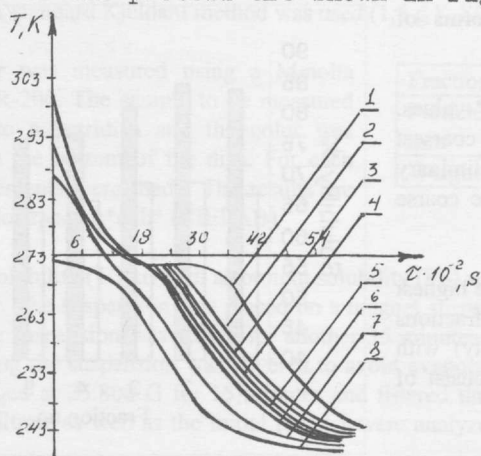


Fig. 1. Thermogram of small pieces of meat freezing:

1-6 temperature in the centre of sample

7-8 temperature on the surface of sample

1 = 0; 2 = 6 Hz;

3 = 10 Hz; 4 = 16 Hz;

5 = 25 Hz; 6 = 40 Hz;

7 = 0 Hz; 8 = 6+40 Hz

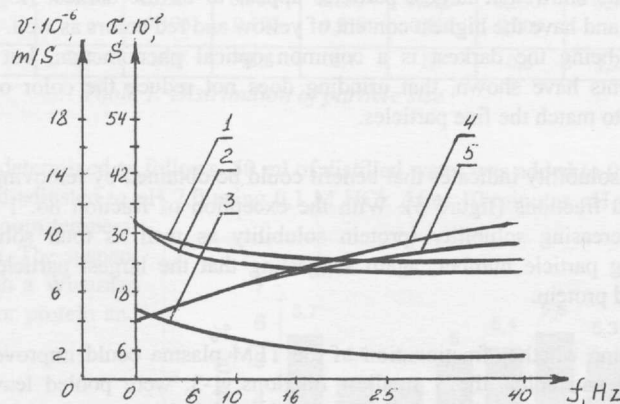


Fig. 2. Dependence of length of crystal formation and freezing of small pieces of meat on vibration frequency:

1-length of freezing (experiment 1)

2-length of freezing (experiment 2)

3-length of crystal formation

4-average freezing rate (experiment 2)

5-average freezing rate (experiment 1)

Table 1

Frequency, Hz	Freezing time, s		Time of crystals formation, s		Average freezing rate, m/s · 10 ⁵	
	spraying	no spraying	liquid spraying	nitrogen no spraying	spraying	no spraying
0	-	4620	-	2100	-	0.571
6	3720	4020	1500	1500	0.800	0.800
10	3600	3900	1320	1380	0.909	0.870
16	3480	3780	1080	1200	1.11	1.00
25	3300	3660	1020	1080	1.177	1.11
40	3120	3540	840	900	1.423	1.333

Thermographic analysis has shown that frequency of vibration with one and the same amplitude has a great influence on acceleration of freezing process: with frequency increase the process of crystals formation in the product decreased on the average by 43%. Dependence of crystals formation time and freezing rate on frequency of oscillations is shown in Fig. 2. Analysis of data has shown that vibration action on meat during its freezing causes intensive nucleation of ice crystals, due to which a coefficient of heat conductivity increases. This leads to reduction of total freezing time by 20%.

The pattern of freezing curves, i.e. lowering of temperature from cryoscopic one (271.5 K) to 265 K doesn't change for control and experimental samples, although the angle of inclination of control curves is to some extent less than of the experimental ones, which can also be explained by some increase of coefficient of heat transfer from the product to environment. One of possible reasons of acceleration of crystallization process during meat freezing is the disturbance of the front of crystal formation with simultaneous acceleration of volumetric crystallization when the pressure wave was passing, induced by vibration action. The influence of vibration action on quality attributes of meat raw materials during freezing was followed by the change of their structural mechanical (rheological) characteristics (Table 2). From Table 2 it can be seen that with the increase in vibrations frequency, the shear stress falls, and the degree of penetration increases, and thus the tenderness of meat increases as well. It can be supposed that in this case we observe a tenderizing effect of vibration on the meat, regardless of its ageing process.

Table 2

Samples	Average freezing rate, W.10 ⁻⁶ , m/s	Vibration parameters		Shear stress, Pa x 10 ⁻⁵		Degree of penetration	
		Frequency Hz	amplitude mm	$\bar{X}$	S	$\bar{X}$	S
Control	5.71	-	-	4.00	1.35	220	1.88
Experiment 1	8.06	6	3	3.75	1.94	273	1.94
Experiment 2	9.10	10	3	3.50	1.54	300	2.13
Experiment 3	11.11	16	3	3.20	1.80	320	2.26
Experiment 4	11.17	25	3	3.00	1.71	330	2.09
Experiment 5	14.28	40	3	3.00	1.97	340	2.16

Based on the investigations carried out and the results obtained it was found, that usage of vibration action during freezing promotes acceleration of this process.

References

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