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By H. Ritchie Chipman and Kenneth W. Mahen

The following experiments were carried out to determine the various relations between the temperature and duration of freezing, and the temperature and duration of glazing in the glazing of cod fillets.

The fresh fillets were cut into small pieces of a uniform thickness of about one inch, placed upon an iron plate well protected by oiled paper, and frozen in a small brine freezer. After remaining in the brine for a definite time the fillet was removed and immersed in the glazing bath for the required time. The fillet was removed from the glazing bath and cut across with a sharp knife, being pared so as to obtain a cross section with a plane surface at right angles to the sides. This exposed a thickness of glaze which was examined by means of a binocular microscope which had a scale in the objective. The thickness of the glaze and the extent of the defrosted area could thus be read directly from the scale. In these experiments the thickness of the glaze and the defrosted area is given in scale units only.

Four variable factors were used and the experiments may be divided into four sections giving the effect on the thickness of the glaze and defrosted area of the following:- the temperature of freezing: the length of time of freezing: the temperature of the glazing water: and the time of immersion.

The results which are given in Tables I, II, and III and Figure I. are averages of a suitable number of determinations.

Table I

Thickness of Glaze

	0°		10°	
Temperature of glazing	32	36	32°	36°
15 min. freezing				
30 secs. immersion	12	12	12	7
60 " "	22	16	17	13
120 " "	26	22	19	18
30 min. freezing				
30 secs. immersion	15	14	11	9
60 " "	18	17	16	12
120 " "	25	25	23	18
60 min. freezing				
30 secs. immersion	20	13	14	6
60 " "	23	17	22	16
120 " "	26	22	23	23

Table II

Thickness of Defrosted Area

	0°		10°	
Temperature of glazing	32°	36°	32°	36°
15 min. freezing				
30 secs. immersion	20	31	32	34
60 " "	28	40	49	38
120 " "	26	42	25	45
30 min. freezing				
30 secs. immersion	14	27	23	46
60 " "	22	37	--	37
120 " "	23	36	40	40
60 min. freezing				
30 secs. immersion	16	24	27	44
60 " "	25	32	34	41
120 " "	37	31	44	37

The Effect of the Temperature of Freezing

Experiments were carried on under similar conditions of time of freezing, temperature of glazing, and time of immersion in glazing water, with the fish frozen at 0° F. and 10°F.

It will be seen from Table I that there is a slight diminution in the thickness of the glaze when frozen at 10° compared to the thickness when frozen at 0°. This diminution appears to be slightly greater when the temperature of the glazing water is increased. If the piece of fish was large and was not kept in the brine freezer for a sufficient time for it to attain a uniform temperature, a slight diminution in the thickness of the glaze would be expected. In these experiments however, the piece of fish was quite small and even fifteen minutes freezing should be sufficient to ensure it being at a uniform temperature. The question of the effect of the temperature of the glazing water will be taken up in a later section.

The measurement of the thickness of the defrosted area presented experimental difficulties. It was very difficult to determine the boundaries of the defrosted portion, even though a needle, used as a prod, was employed. While the figures obtained show a great irregularity, it can be seen that there is a tendancy towards an increase in the extent of the defrosted area with an increase in the temperature of freezing. This is what might be expected, but it was a great surprise to find such a large extent of defrosting when the temperature of the glazing water was at the freezing point. To ensure constantcy in the results this temperature was very carefully maintained by keeping the glazing bath well stirred.

B
The Effect of the Duration of Freezing

From Table I it will be seen that, though there is a great irregularity in the results, there is a tendancy for the thickness of the glaze to increase with an increase in the duration of the freezing. As was mentioned before, it would not be expected that the duration of freezing would have an appreciable effect if there was sufficient time for the piece of fish to attain a uniform temperature. The variation in the figures is, however, so slight that it may be concluded that the duration of freezing does not effect the thickness of glaze.

When frozen at a temperature of 0°, an increase in the duration of freezing produces a decrease in the extent of the defrosted area: at 10° there is greater irregularity, and while it is not as exact, a tendancy towards a decrease in the extent of defrosting is quite apparant.

C

The Effect of the Temperature of the Glazing Bath

Table I shows that the thickness of glaze decreases with an increase in the temperature of the glazing bath, as would be expected. This fact is also shown in Table III where some figures giving the results at some higher temperatures are shown. The influence of the glazing temperature is intimately related to the effect of the duration of the glazing, and will be discussed more fully in that section.

It would be expected that there would be an increase in the extent of the defrosted area with an increase in the temperature of the glazing bath, and this is found to be the case. As before, there are many irregularities but a tendancy towards an increase may easily be seen. It is, however, very surprising that such a large extent of defrosted area was found with a temperature of 32° in the glazing bath.

D

The Effect of the Duration of Glazing

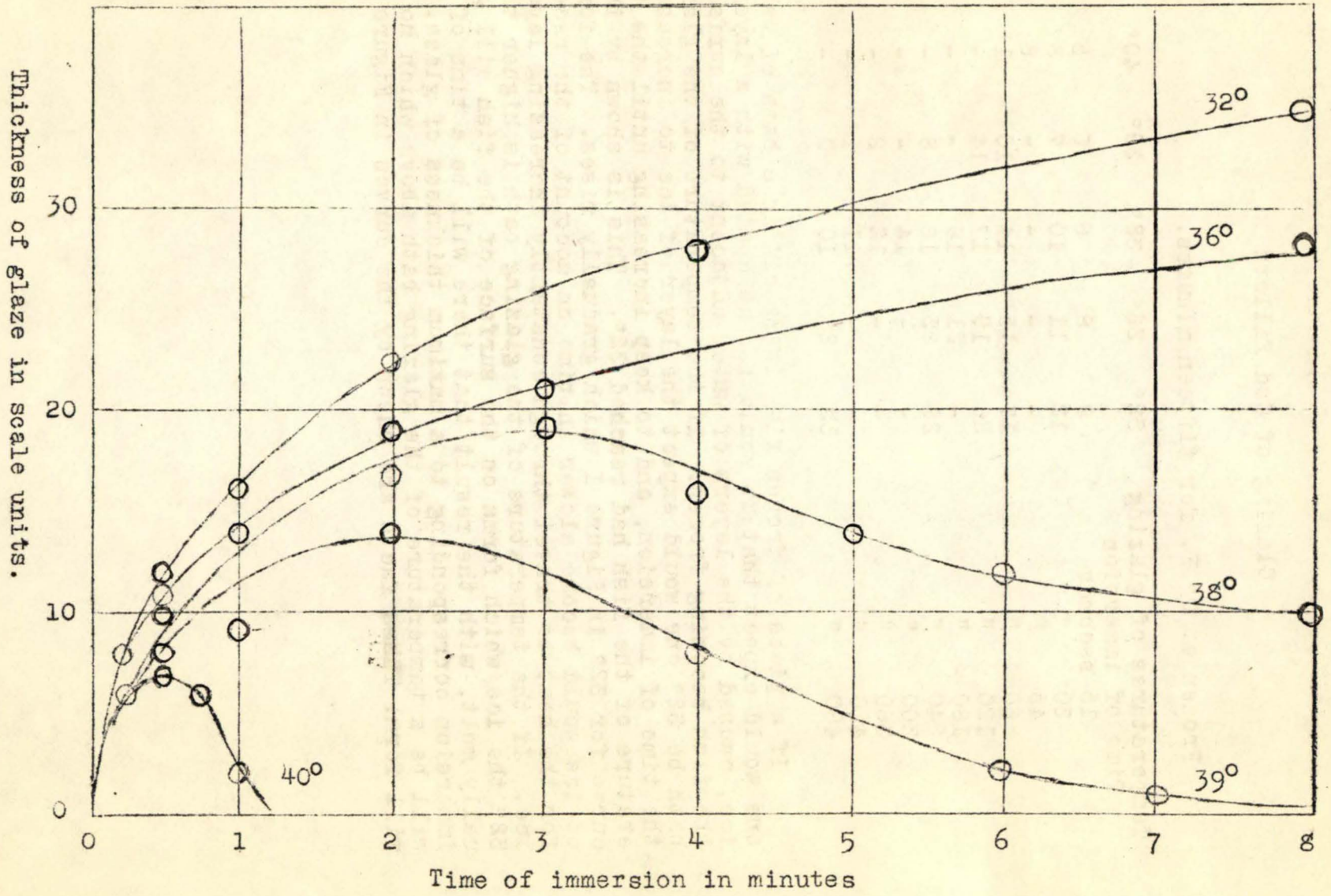
The length of time that the fish remained in the glazing bath appeared to have the greatest effect upon the thickness of the glaze, and the greater part of the experiments were conducted with that in mind. It was decided to carry out a series of experiments with fish frozen at 10° for fifteen minutes and glazed at different temperatures for various lengths of time. The results given in Table I show a very definite increase with an increase in the duration of glazing, and it was felt that some interesting results could be obtained if this was followed up. As the figures previously obtained for the thickness of the defrosted area were so uncertain, it was felt that nothing would be gained in attempting to record them, and it was found that at a temperature of glazing of 38° and higher the extent of defrosting soon increased to an amount greater than the capacity of the scale.

Table III shows the results of this series of experiments giving the thickness of the glaze in scale units for varying times of immersion and for different temperatures of the glazing bath. Figure I shows the results of plotting these figures with the thickness of glaze as ordinates and the time of immersion as absiscae, a separate curve being used for each temperature of the glazing bath.

Frozen at 0° F. for fifteen minutes.

Temperatures of glazing Time of immersion	32°	36°	38°	39°	40°
15 seconds	8	8	6	6	5
30 "	12	11	10	7	8
45 "	-	-	-	-	6
60 "	17	15	14	10	1
120 "	26	19	17	14	-
180 "	-	21	19	-	-
240 "	28	23	16	8	-
300 "	-	-	14	-	-
360 "	-	-	12	2	-
420 "	-	-	11	1	-
480 "	35	28	10	0	-

If a piece of frozen fish is placed in a bath of water, one would expect that it would become coated with a layer of ice, caused by the layers of water adjacent to the surface of the fish becoming frozen. If the temperature of the glazing bath be 32° one would expect the layer of ice to increase with the time of immersion, and to keep increasing until the temperature of the fish had reached 32°. This is shown by the curve for 32° in Figure I which gradually rises. The formation of ice would become slower in time on account of the necessity for the heat to travel through constantly increasing layers of ice. If the temperature of the glazing bath is higher than 32° the ice which forms on the surface of the fish will gradually melt, with the result that there will be a time of immersion corresponding to a maximum thickness of glaze. There will be a temperature of the glazing bath above which no glaze will form. These facts are shown by the curves in Figure I.


Thickness of glaze in scale units.
30
20
10
0
0
1
2
3
4
5
6
7
8
Time of immersion in minutes
32°
36°
38°
39°
40°