UNIVERSITI PUTRA MALAYSIA

FREEZING STUDIES ON A MODEL SYSTEM AND QUALITY CHANGES IN FROZEN MALAYSIAN FISH

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FREEZING STUDIES ON A MODEL SYSTEM AND QUALITY CHANGES IN FROZEN MALAYSIAN FISH

by

Mohd. Ismail Bin Abdullah

A thesis
submitted in partial fulfilment
of the requirements for the degree of
Doctor of Philosophy in the Department of Food Technology
in the Faculty of Food Science and Technology
Universiti Pertanian Malaysia

May 1985

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ABSTRACT

Variations in the definition of freezing time do not provide a universally accepted definition which adequately describe the freezing rate. A "volume average freezing time" was derived as an alternative definition of freezing time which gave a linear relationship with frozen depth. The majority of the experimental values was found to fall within 20% of the predicted figures using the derived formula.

Proximate analysis, objective and organoleptic tests were done on Chub Mackerel, Yellow-banded Trevally and Notched Threadfin Bream. Samples of gutted and ungutted fish were frozen fast and slow, and stored in the glazed and unglazed conditions at $-20^{o}C$ for 16 to 24 weeks. At intervals various chemical indices of deterioration were determined and taste-panel assessment performed. The data on lipid oxidation, protein denaturation and pH changes were related to textural, flavour, odour and general acceptability performances. The quality of canned frozen Chub Mackerel were also determined.

Malonaldehyde production in Threadfin Bream (0.8% fat content) was low and similar to that in Yellow-banded Trevally (9.7% fat content), whereas values for Chub Mackerel (2.1% fat content) was higher than both the former two species and were produced over a shorter storage period. These differences were also shown to conform to odour and flavour scores for all the three species. The protein solubility in Threadfin Bream (pH = 6.8) and Yellow-banded Trevally (pH = 6.15) remained low during the storage period which results in

a softer texture. In comparison, Chub Mackerel (pH = 6.15) had a firmer texture as protein solubility remained higher during the storage period. Threadfin Bream and Yellow-banded Trevally also gave higher general acceptability scores over that of Chub Mackerel at the same storage period, and the storage life of the two former species were longer than the latter.

TBA values of canned Chub Mackerel prepared from frozen fish increased during subsequent storage, and proportional to the length of frozen storage period before canning. The general acceptability scores decreased with increase in period of frozen storage before canning. The limit of frozen storage period for Chub Mackerel before canning is one month or less for an acceptable canned product to last for not more than three months. Generally fresh fish gave a better canned product than frozen fish.

ABSTRAK

Kepelbagaian dalam definasi tempoh menyejuk-beku telah tidak dapat memberi satu definasi yang boleh diterima secara keseluruhan bagi menerangkan kadar menyejuk-beku dengan memuaskan. Suatu tempoh menyejuk-beku purata isipadu diterbitkan sebagai definasi alternatif kepada tempoh menyejuk-beku yang dapat memberikan perhubungan linear dengan ketebalan beku. Dengan menggunakan formula terbitan, sebahagian besar daripada nilai-nilai percubaan didapati berada dalam 20% daripada angka-angka yang diramalkan.

Analisis proksimat, ujian objektif dan organoleptik telah dijalankan ke atas Ikan Kembung, Ikan Selar Kuning dan Ikan Kerisi. Sampel-sampel ikan ini yang berperut dan tanpa perut telah disejukbeku dengan kadar cepat dan perlahan dan disimpan dalam keadaan berselaput dan tanpa selaput pada suhu - 20°C selama 16 hingga 24 minggu. Pada selang masa tertentu, pelbagai indeks kimia berhubung dengan kemerosotan mutu serta penilaian panel ujirasa dijalankan. Data-data mengenai pengoksidanan lemak, penghasilan protein dan perubahan pH telah dikaitkan dengan perubahan-perubahan dari segi tekstur, rasa, bau dan penerimaan secara am. Kualiti ikan kembong sejukbeku yang ditinkan juga ditentukan.

Pengeluaran malonaldihaid dalam ikan kerisi yang mempunyai kandungan lemak rendah (0.8%) adalah rendah dan sama dengan ikan selar kuning yang mempunyai kandungan lemak tinggi (9.7%), manakala nilai untuk ikan kembung yang mempunyai kandungan lemak sederhana

(2.1%) adalah lebih tinggi daripada kedua-dua spesis tersebut dan dikeluarkan dalam jangkamasa simpanan yang lebih singkat. Perbezaan ini adalah bersesuaian dengan skor untuk bau dan citarasa untuk ketiga-tiga spesis tersebut. Kebolehlarutan protein dalam ikan kerisi (pH = 6.8) dan ikan selar (pH = 6.15) masih rendah semasa jangkamasa simpanan yang menghasilkan tekstur yang lebih lembut. Sebagai perbandingan ikan kembung (pH = 6.15) mempunyai tekstur yang lebih pejal di mana kebolehlarutan protein adalah tinggi sepanjang jangkamasa simpanan. Ikan kerisi dan ikan selar kuning juga memberikan skor yang tinggi untuk penerimaan secara keseluruhan berbanding dengan ikan kembung pada jangkamasa simpanan yang sama, dan tempoh simpanan kedua-dua spesis tersebut adalah lebih lama daripada ikan kembung.

Nilai TBA ikan kembung yang ditinkan dan disediakan daripada ikan yang telah disejukbeku meningkat semasa penyimpanan seterusnya dan berkadar sama kepada panjang tempoh masa simpanan sejukbeku sebelum pengetinan. Skor penerimaan keseluruhan menurun dengan peningkatan tempoh penyimpanan sejukbeku sebelum pengetinan. Tahap tempoh masa penyimpanan sejukbeku ikan kembung sebelum pengetinan ialah satu bulan atau kurang untuk hasil pengetinan yang masih boleh diterima dalam masa tidak lebih daripada tiga bulan. Secara am ikan segar memberikan hasil pengetinan yang lebih baik daripada ikan yang telah disejukbeku.

PART ONE : FREEZING STUDIES ON A MODEL SYSTEM

1. INTRODUCTION

The thermal centre as a reference point for the measurement of freezing time has become a standard measure, since it is the most convenient and also the point where slowest freezing occur. It should be noted that during the process of freezing, the freezing front has advanced two thirds of the way but the thermal centre is still above the freezing point.

When freezing is "complete", the product is made up of a frozen body with different "layers" due to different rates of freezing. In the evaluation of the quality of a frozen product, little importance has been placed on this phenomenon.

The time for the thermal centre to traverse over a temperature range of 0°C to - 10°C (International Institute of Refrigeration, 1972) is the main criterion for evaluating the effect of freezing time on the quality of a frozen product. However, as an index of quality determination it is inadequate as the product would then have layers of differences in quality within the frozen body. A "volume average freezing time" is suggested as an alternative.

This study was undertaken to determine whether the volume average freezing time can be used as an alternative method for the definition of freezing time in a spherical food model.

2. REVIEW OF LITERATURE

2.1 Definition of Freezing Rate

There is no universally accepted definition which adequately describes the rate at which freezing occurs. Commonly used terms were as "slow", "rapid" and "ultra-rapid" have been defined as 1 - 5°C/min., 5 - 20°C/min. and 100°C/min. respectively (Fennema and Powrie, 1964). These definitions are inadequate since they assume an average rate of temperature change throughout the entire freezing process. "Velocity of the ice front", used by Woodroof (1938) is a valid expression but is difficult to measure, and is the quantity of ice formed per unit weight of material per unit time. Luyet (1960) defined freezing rate as the time required to traverse the freezing plateau.

2.2 Definitions of Freezing Time

Mc Arthur (1945) reports the "Time required for complete freezing" of various foods. Kramer and Wani (1967) presented empirical equations for the period of "thermal arrest" but have not recorded the initial temperature of their samples prior to freezing, a temperature which will influence the duration of the thermal arrest period (Long, 1955).

Lentz and Van den Berg (1957) and Esselen et al., (1954) investigated the immersion freezing of poultry. The former reported the times, at various locations within the birds, for the temperature to fall from 0 to - 3.9°C while the latter recorded the total time to cool to - 9.4°C. Bratzler and Tucker (1963), Costello and Henrickson (1964) and Dunker and Hawkins (1953) have all investigated the freezing of parallelopipeds of meat. The first group reported the time to cool from 0°C to - 4.4°C from an unrecorded initial temperatures, the second gave the time to cool from an initial temperature of 1.7°C to certain subzero temperatures, while the last gave times to cool from 2.8°C to - 12.2°C and - 45.6°C. These definitions limit comparison of results.

Table 1 shows differences in the definition of freezing times measured by other workers. They do not define differences such as whether the temperature measured was a point or spatially arranged temperature and the location of the point of measurement.

The entries in Table 1 are set out in four groups. In the first, the initial temperature is a little above the freezing point of food and the final temperature is a few degrees below this. In the second group the initial temperature is again a little above the freezing point, but the final temperature is considerably lower. In the last two groups the freezing time is measured from the instant the food starts to be cooled in the freezer and is deemed to end at a temperature a little below the freezing point or when a much lower temperature.

TABLE 1

VARIATIONS IN THE DEFINITION ON FREEZING TIME

Group	Temp. at start of 'freezing time'°C	Temp. at end of 'freezing time' °C	Authors
I	+5	-5	Moran (1932); Finn (1933);Morris et al., (1948).
	0	-6	Prickett & Brown (1933); Lee et al., (1946).
	0	-5	Young (1934); Young (1935);Sair & Cook (1938);Banks (1947); Pearce (1948);Love (1956); Meyer et al., (1969); Bose (1969)
	0	-4.4	Bratzler & Tucker (1963).
	0	-4	Prickett & Brown (1933).
	0	-3.9	Smedley & Pratt(1951) Lentz & Van den Berg (1957).
	-1	-5	Reay (1934)
	-1	-2.5	Empey (1933)
	-1	-3	Cook et al.,(1926)
II	0	-15	Bounocore & Crivelli (1967); Bassi & Crivelli (1968)
III	Initial temp. of body	-3.9	Lentz & Van den Berg (1964)
IV	Initial temp. of body	-18	Lee et al., (1946); Kelly (1965); Crawford et al., (1969)
	Initial temp. of body	-15	Esselen et al.,(1954) Lorentzen (1964)
	Initial temp. of body	-10	Bengtsson (1967)