Advantages of Liquid Nitrogen Freezing of *Penaeus monodon* Over Conventional Plate Freezing

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Liquid nitrogen frozen products are biochemically and organoleptically superior to conventional plate frozen products; but beneficial effect of liquid nitrogen freezing over conventional plate freezing can exist only upto 59 days at a commercial storage temperature of -18°C.

Freezing is one of the commercial methods for preservation of food, particularly prawn, which is very susceptable to spoilage. Processing of prawn is one of the established industries in India and the amount of foreign exchange earning through it has already exceeded Rs. 300 crores (MPEDA, 1983).

Liquid nitrogen frozen prawn has several advantages over conventional plate frozen prawn. The main advantage of the liquid nitrogen freezing is that the additional 6–15% of meat, which is at present used in conventional plate freezing to compensate the loss during freezing and thawing will not be reqired. This will save about 10% of our foreign exchange (Rs. 31 crores) and in addition quality is much superior to the conventionally frozen products. Effort has therefore been made in this communication to judge the quality of the liquid nitrogen frozen product through biochemical indices and to study storage life of liquid nitrogen frozen prawn under commercial storage condition in our country (–18°C).

Materials and Methods

Freshly caught *Penaeus monodon* (30 to 40 whole prawn per kg) was brought to the laboratory under ice. Dressed prawns were washed, wrapped in polythene film and subsequently frozen in contact plate freezer (–40°C). Another lot, packed in mylar pouches, was frozen by spraying type liquid nitrogen freezer. The average cooling rate in the latter was 5°C/min from + 1°C to –40°C and it was 10°C/min upto –60°C. Both the plate frozen and liquid nitrogen frozen products were stored at –18°C in a freezing factory situated nearby.

Organoleptic analysis of thawed samples was carried out and the result was scored as overall quality on a nine point hedonic scale (Little, 1958; Hill & Giew, 1973) using a score of 5 as the limit of acceptability. Drip loss was measured as percentage of loss of weight of initial weight on thawing.

Salt soluble protein was extracted by the method of Ironside & Love (1958) and the protein content was measured by Folin & Lawry method. Total volatile base nitrogen and trimethyl amino nitrogen were measured by Conway microdiffusion method (1947). Alpha amino nitrogen was measured by the method of Block & Balling (1951). Adenosine monophosphate (AMP) and inosine monophosphate (IMP) content in thawed muscle were measured by the method of Spinelli & Kemp (1956).

Results and Discussion

Table 1 shows that drip loss of liquid nitrogen frozen sample is considerably less

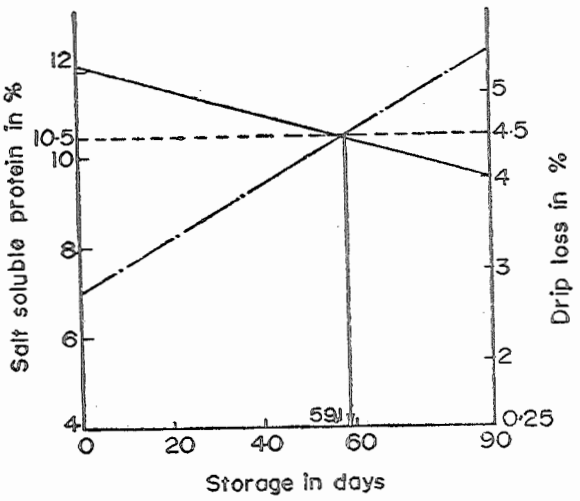
Table 1. *Changes during freezing of prawn*

Sample	Organo-leptic score	% drip loss by weight	Moisture content %	Salt soluble protein %	AMP μ mole/g
Plate freezing:					
Before freezing	9	—	80.2	12.1	0.84
After freezing	8	4.5	77.5	10.5	0.45
Liquid nitrogen freezing:					
Before freezing	9	—	80.2	12.1	0.84
After freezing	8.5	2.8	80.1	11.7	0.63

than that of plate frozen. Electron micrograph plates (Love, 1968) of slow frozen cod muscle shows that the ice can be seen as large round columns for more extensive than extracellular spaces with several layers of compressed and dehydrated cells. Electron micrograph (Love, 1968) of the cross section of the outer margin of a single frog muscle cell which had been plunged into isopentane (–150°C) shows myofilaments are regularly spaced as in unfrozen muscle and there is no evidence of displacement by ice. Modification to either the protein surface or to the interaction between protein molecules during freezing can result changes in water holding capacity of gel network of actin and myosin in muscle, thus drip will also result on thawing(Connell,1968) Table 1 also shows that salt soluble protein of liquid nitrogen frozen product is more than that of plate frozen product. This shows more of denaturation of protein during plate freezing. The reduction in total extractable protein (salt soluble protein) was due to the increase in insolubility of myosin because of chemical changes, physical changes and salting out in hypertonic solution (>5% NaCl) formed by the partial freezing, that is, below eutectic point -55 to -65°C of tissue water. Love *et al.* (1958) observed that the freezing at various temperature e.g. -78°C, -60°C etc. and immediate thawing reduced salt soluable nitrogen content from 96% to about 87%.

Table 1 also shows that the retention of moisture and AMP in liquid nitrogen frozen product was more than that in plate frozen product. This confirms that the damage to prawn muscle in liquid nitrogen freezing is comparatively lesser than that to plate frozen product.

Both the liquid nitrogen frozen product and plate frozen product were stored at-18°C. Fig. 1 shows that the drip loss increases and salt soluble protein content (in thawed muscle) decreases during frozen storage. Both the parameters of liquid nitrogen frozen product touch the respective value of plate frozen sample (immediately thawed after freezing) in 59 days. It is further evident from Fig. 2 that the rate of decrease in AMP and moisture content (in thawed muscle) of liquid nitrogen frozen meat was noticed during frozen storage, but both the values were more than



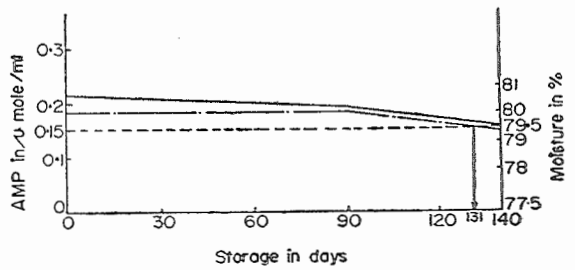
---- Plate frozen (thawed immediately after freezing)
—·—· Drip loss of liquid nitrogen frozen
——— Salt soluble protein in liquid nitrogen frozen

Fig. 1. Changes in drip loss and salt soluble protein on frozen storage

Table 2. *Changes in liquid nitrogen frozen product (in thawed muscle) during storage*

	Fresh sample	Immediate after freezing	90 days
TMAN mg%	5.15	5.11	5.12
TVBN mg%	13.86	13.33	15.90
Alpha amino nitrogen mg%	263.4	213.89	191.72
IMP μ mole/ml of elute	0.82	0.84	0.88
Organoleptic overall quality	9	8.50	8.00

the respective values of plate frozen prawn (thawed immediately after freezing) during 120 days of frozen storage storage. Thus Figs. 1 and 2 indicate that the quality of liquid nitrogen frozen prawn even after storage at -18°C for 59 days was comparable to the quality of plate frozen sample thawed immediately after freezing. Increase in drip loss in liquid nitrogen frozen product during storage is due to (1) imigratory recrystallisation resulting in formation of big crystals (2) desiccation causing damaging effect on myosin due to removal of critically located water molecules (3) salt denaturation of muscle protein.



- - - - Plate frozen (thawed immediately after freezing)
—·—· AMP content in LN frozen (in thawed muscle)
——— Moisture content in LN frozen (in thawed muscle)

Fig. 2. Changes in AMP and moisture content on frozen storage

Table 2 shows that except alpha amino nitrogen content other parameters are almost constant during frozen storage. The decrease in alpha amino nitrogen content is probably due to increase in drip loss. The retarded growth of cold resistant microbes and decreasing trend of proteolytic enzymatic activity with lowering temperature (Fennema *et al.* 1973) cause little increasing trend or almost constant in alpha amino nitrogen content; but damage to cell during freezing and frozen storage gives rise to drip which carries degradation products of protein. Thus net balance effect is the slight decreasing trend of alpha amino nitrogen content in thawed muscle with the increase of drip loss.

The above results indicate that the beneficial effect of liquid nitrogen freezing over conventional plate freezing can exist upto 59 days only at a commercial storage temperature of -18°C.

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