STORAGE CHARACTERISTICS OF FROZEN PRAWNS IN RELATION TO QUALITY ASSESSMENT

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INTRODUCTION

THE problem of evaluating the quality of frozen prawn has been the subject for detailed investigation in many countries. Standard specifications have been laid down by some of these countries for specific items of frozen prawn products. These, however, are based mainly on physical and organoleptic characteristics of the products and are, therefore, subject to a wide degree of error, especially in their application. As a means to overcome these limitations many objective methods have been advocated for assessing the quality using bacteriological, chemical or biochemical methods.

Studies on the changes in pH, trimethylamine nitrogen, picric acid turbidity tests etc. (Kurtzman and Snyder, 1960; Bethea and Ambrose, 1962) conducted on raw headless brown prawn during ice storage have shown that definite pH values could be assigned for different degrees of quality of prawn. The picric acid turbidity test also gave indications of loss of quality several days before the taste panel could detect any off-flavours. Chemical indices to determine the extent of spoilage of fish primarily depend upon the measurement of the amounts of intermediate and end products of fish tissue decomposition such as trimethylamine (Fieger and Friloux, 1954), ammonia, volatile acids (Fieger and Friloux, 1954), indole and skatole (Duggan and Strausburger, 1946) and other compounds (Alford and Fieger, 1952; Bailey, Fieger and Novak, 1956). However, all these methods have specific limitations. There is evidence to show that the microbiological conditions of the product, when interpreted correctly, can help to determine the degree of freshness of the material with a fair amount of accuracy. But the processes of freezing, frozen storage or thawing are capable of altering the microbial population at rates that depend on the organisms, the product, the rate of cooling or thawing and storage temperatures. The nature of the raw material from which the product is prepared, the pre- and post-process treatment of the material, the sanitary conditions of the factories, etc., will

materially affect the quality of the final product. All these factors will have to be considered when assessing the quality of the finished product. Although the effects of freezing and of low temperature storage in flesh foods, particularly fish, have been intensively investigated in various countries during the past forty years, a single test for the rapid evaluation of quality of raw material or frozen product has not yet been proposed. Again, though the bacterial activity is the predominating factor affecting quality at normal and chilling temperatures, other biochemical, physical and chemical reactions also take place and once bacterial activity has been inhibited by cold storage, these secondary reactions become of major importance.

Freezing and storage at very low temperatures may bring about a considerable retardation of bacterial activity, although the frozen product may yet contain sufficient moisture to sustain microbial activity (Shewan, 1961). Stewart (1934) experimenting with fish muscle found bacterial growth several months after storage at -6° C. although a gradual reduction was noticed during storage. Kiser and Beckwick (1942) have found that in mackerel freezing destroys 60–90% of the bacterial population. Fieger (1950) examined fresh and frozen prawn and considered spoilage of this product to be largely due to biochemical changes induced by the microbial population and to a lesser degree to enzymes and chemical compounds inherent in the prawn. Prawn frozen as late as 9th and 10th day of iced storage showed a minor reduction in count through freezing and a gradual decline in the following twelve months (Green, 1949). Pivnick (1949) found that apart from the fall in the numbers of bacteria occurring during freezing there is an exponential fall during the initial period of frozen storage followed by a more gradual decline. Another important problem which consequently arises is the question of when to take a sample of a frozen product for bacteriological examination. It was considered of value in the present study, therefore, to find out the changes in the chemical and bacteriological characteristics of prawns kept for varying intervals of time in ice and the changes if any, occurring in these characteristics due to freezing and prolonged frozen storage.

EXPERIMENTAL

Materials and Methods

Prawns used in this study were *Penaeus indicus* in the headless condition, obtained from one of the processing factories in Cochin. They were of medium size, 44–55 pieces per kg. The physical, chemical and bacteriological characteristics of the prawns were determined in the fresh condition and a five-pound block from this lot was frozen immediately in the Jackstone

Froster. The remaining prawns were well iced and kept in a chill storage for 15 days. Samples were removed at random from ice storage at intervals of 2, 5, 7, 12 and 14 days and five-pound blocks were frozen after the initial examination of the raw material. The frozen samples were reglazed according to commercial practice and stored at −18°C. Samples were taken at intervals of one month in the beginning and bimonthly afterwards and examined in detail. The frozen blocks were tested bacteriologically immediately after freezing. All analyses were conducted during a ten-month period so that the samples of prawn analysed at the end of the study were in frozen storage ten months longer than were those analysed at the beginning of the study.

Methods of Testing:

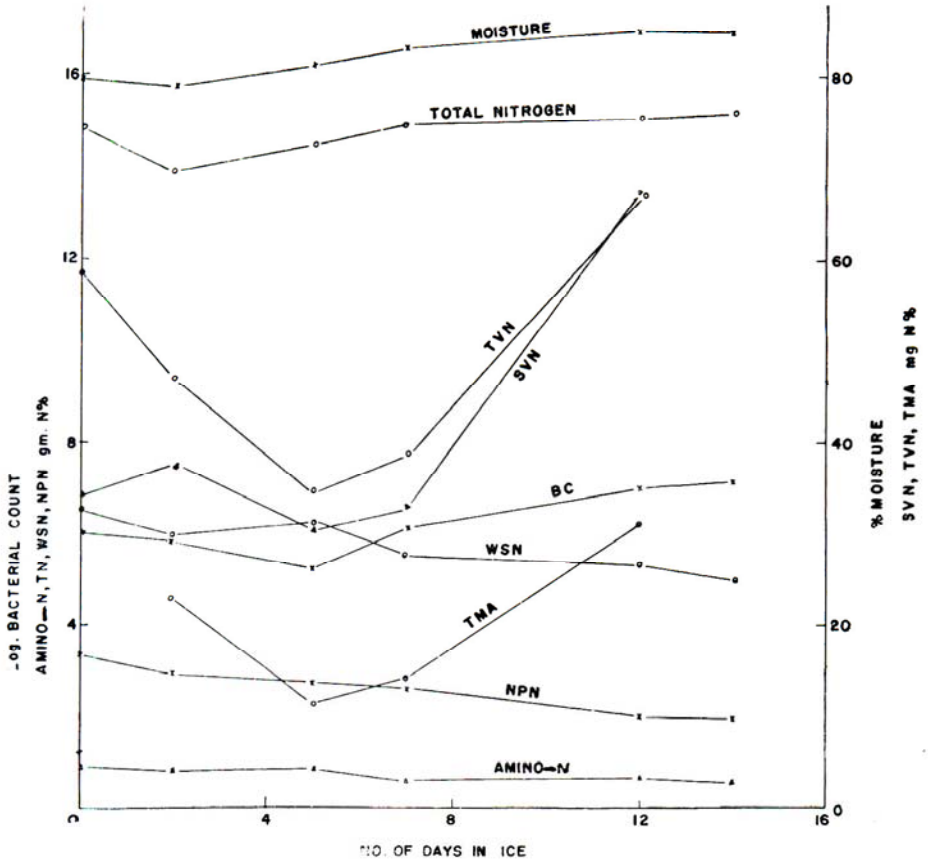

FIG. 1. Changes in the chemical characteristics of prawn during ice storage.

Standard plate count.—Ten gm. of prawn muscle were used in each sample tested. This was blended under aseptic conditions with 90 ml. of

sterile aged sea-water. Tenfold serial dilutions were plated in duplicate on sea-water agar. The plates were incubated at 30° C. and those plates containing between 30 and 300 colonies were counted after 48 hr.

Examination of prawn muscle.—In the case of the raw material, after examination for visual spoilage 20–25 numbers were peeled, deveined and macerated in a waring blendor. Samples from this homogenate were used for chemical examination. In the case of the frozen prawn, the frozen block was allowed to thaw at room temperature for 2 hours, after the complete removal of glaze. The separated pieces were tested for visual characteristics and then the same procedure was followed for chemical examination as that used for the raw material.

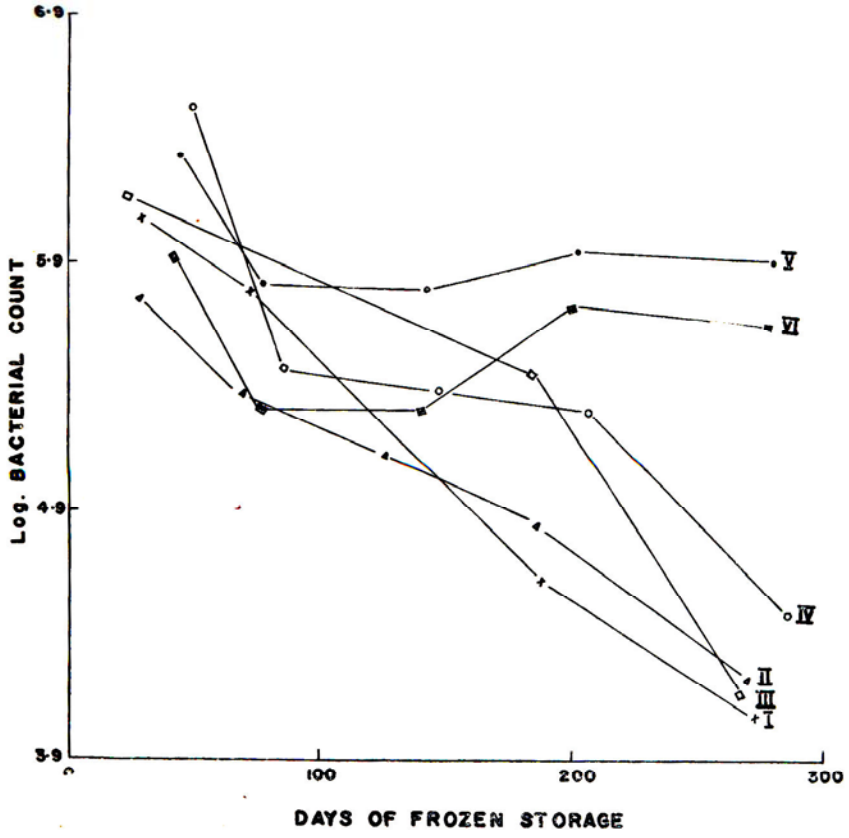

FIG. 2. Changes in total bacterial plate count in frozen prawn during storage.

Determination of chemical indices.—Ten gm. samples were dried at 105° C. for 6 hr. and the moisture content determined. Trimethylamine and total volatile nitrogen were estimated in an alcoholic extract of the muscle

homogenate, the former by Conway's micro-diffusion method and the latter by micro-distillation in flowing steam. Total nitrogen, non-protein nitrogen and water-soluble nitrogen were determined by micro-Kjeldahl method and amino nitrogen by the method of Pope and Stevens (1933).

Results and Discussion

The changes in the visual characteristics of the raw material during ice storage are summarised in Table I. Changes in chemical characteristics, standard plate count, moisture, etc., are represented in Fig. 1.

TABLE I

Changes in visual characteristics of headless prawn during ice storage

No. of days of storage in ice	Pieces showing black discoloration %	Pieces giving off odour %	Remarks
0	Nil	Nil	Meat hard and white
2	40·48	15·10	Tail region black
5	62·85	22·86	Tail discolouration in all pieces
7	21·05	26·31	Tail black in all pieces
12	..	43·90	Tail black in all pieces
14	..	52·50	Shell colour bleached, tail black in 52·5%

The changes in bacterial count, moisture, trimethylamine, total volatile nitrogen, non-protein nitrogen, water-soluble nitrogen and amino-nitrogen of the six frozen blocks during frozen storage are represented in Figs. 2 to 8.

During storage of prawns in ice, the moisture content of the prawn muscle shows a steady increase. Bacterial count, T.V.N. and T.M.A. follow the same pattern of change. After an initial drop up to 4–6 days in ice, there is a sudden rise and the values go on increasing thereafter. The former may be due to an initial retardation of bacterial growth and the leaching effect of melting ice. Water-soluble nitrogen, non-protein nitrogen and amino-nitrogen show a gradual fall throughout the entire period of storage in ice.

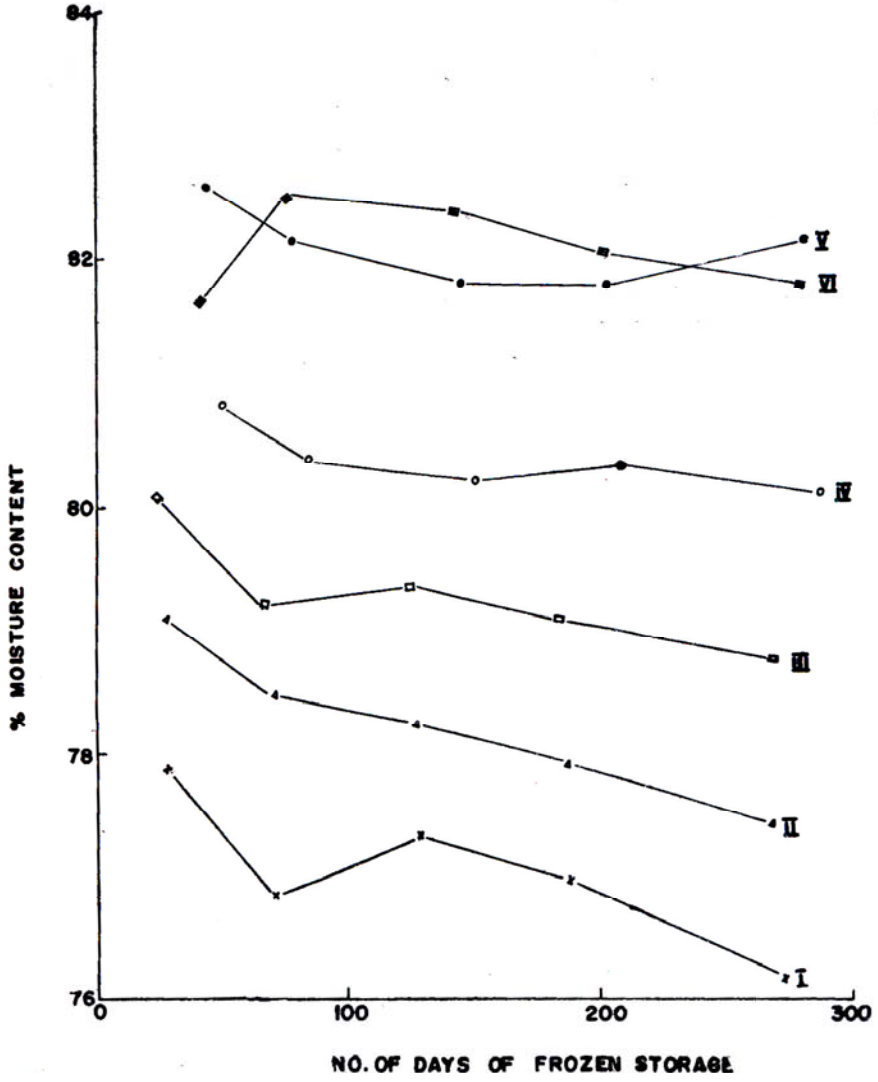

FIG. 3. Changes in moisture content of frozen prawn during storage.

The slow increase in the bacterial count after the initial fall, in spite of the continuous leaching effect shows that the material undergoes a slow but steady deterioration in quality during continuous ice storage. This is reflected in the values of T.V.N. and T.M.A. also. It can, therefore, be seen that the material used for the freezing experiments although from the same initial stock, are different in quality. From Table I it is seen that the same trend is noticed for the visual characteristics of the raw material. A

progressive increase in the number of discoloured and spoiled pieces is observed as the number of days of storage in ice increases.

Figure 3 shows the variation in the moisture content of thawed muscle, in the case of all the six frozen blocks after different periods of storage. It may be seen that immediately after freezing the moisture content drops by 1–2 units from that of the corresponding raw materials, when estimated after thawing. This loss may be due to the effect of drip during thawing. In the first four blocks prepared from raw materials stored for 0, 2, 5 and 7 days respectively in ice, the moisture content shows a steady fall during continued frozen storage, although the range of such variation decreases in the order of blocks I, II, III and IV (as the ice storage period of the raw material

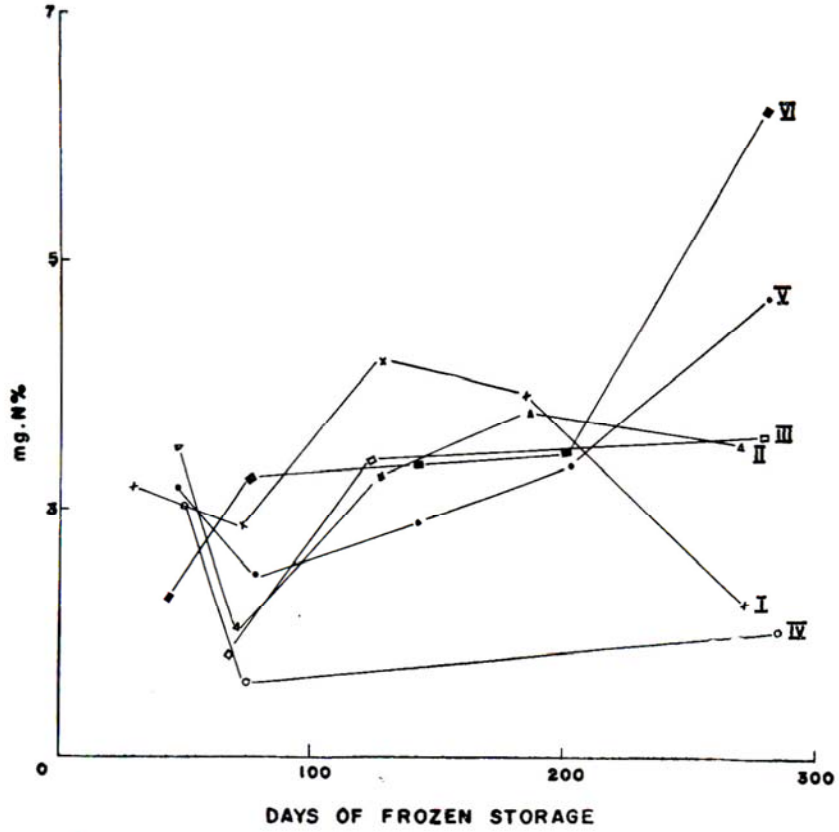

FIG. 4. Changes in trimethylamine in frozen prawn during storage.

increases). This is further substantiated by the fact that the decrease in the moisture content in blocks V and VI, the raw material of which had been kept in ice for 12 and 14 days respectively, is not very significant. The

levels of moisture content maintained by each block is so distinctly different from one another that it has to be assumed that a material kept longer in ice will always show a higher moisture content after freezing. This observation may indirectly help in the inspection of frozen fishery products, where the history of the raw materials will have to be traced back from the results obtained from the finished product alone for a proper grading.

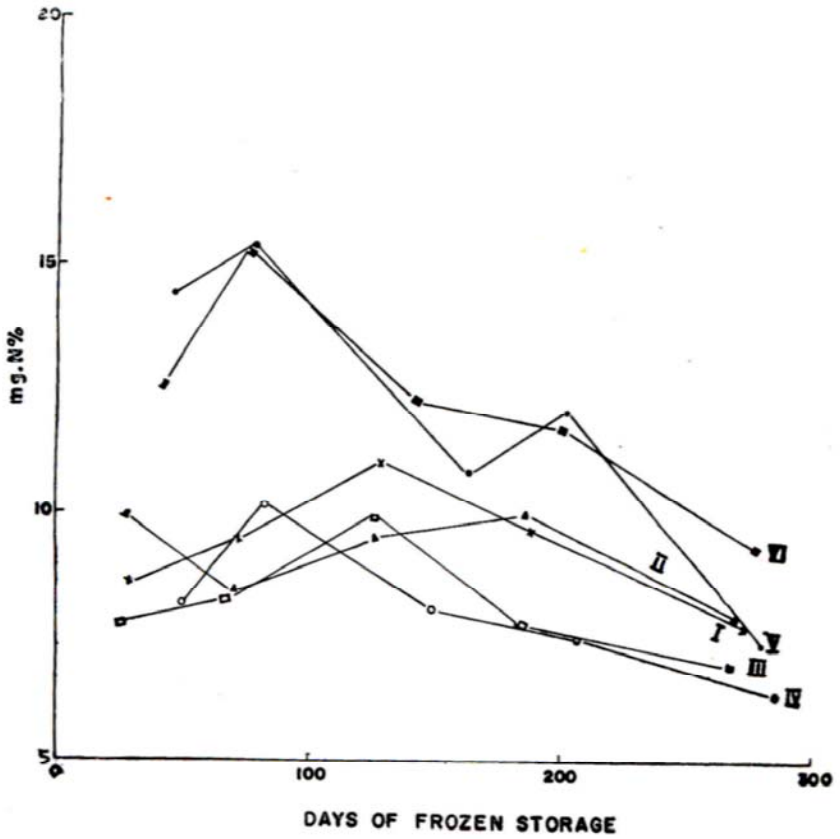

FIG. 5. Changes in the total volatile nitrogen in frozen prawn during storage.

Figure 2 shows the changes in the bacterial load (S.P.C.) of the frozen blocks during storage. In the case of the first three blocks there is a progressive fall in the bacterial count and more than 90% of the bacteria are destroyed during a period of approximately 300 days. In the case of Block IV, there is an initial drop up to the first 90 days followed by a period when the decrease is very little, while after about 200 days there is again a decrease. The total destruction of bacteria during 300 days of storage is above 80% of the initial count of the frozen block. In Blocks V and VI the decrease is

very little and the percentage reduction at the end of 280 days is around 30% of the initial bacterial count. It is obvious from these results that the longer the period of ice storage of the raw material the lesser is the destruction of bacteria during freezing and continued frozen storage. When the prawns are preserved longer in ice, the typical mesophilic organisms slowly die out while the surviving species develop a resistance to cold temperatures and multiply normally. This may be primarily responsible for the lesser rate of destruction of bacteria in the blocks prepared from material stored longer in ice, during frozen storage. With the rapidly changing pattern of the

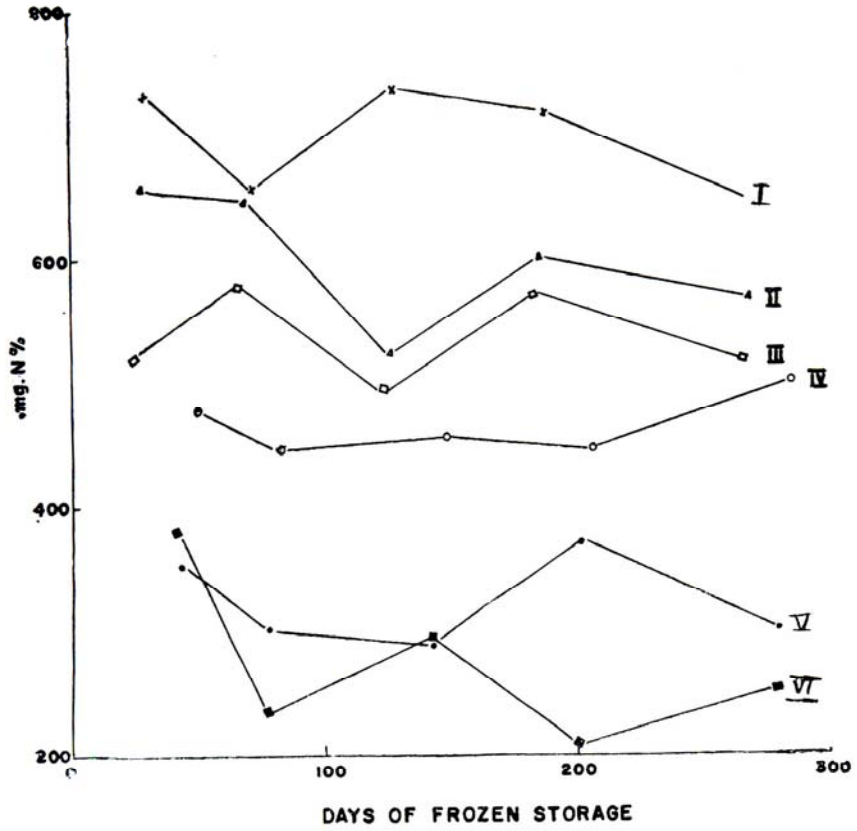

FIG. 6. Changes in non-protein nitrogen in frozen prawn during storage.

bacterial load of the frozen product during storage noticed in the case of the first three blocks, the question arises as to when a frozen block is to be sampled for bacteriological examination, so that the results may be representative of the material from which the product is prepared. As under commercial conditions raw materials are not usually stored in ice for more than

three days, the answer to the above question is that sampling will have to be done as early as possible after freezing. This aspect, however, is being studied in greater detail and will be dealt with further in a separate communication.

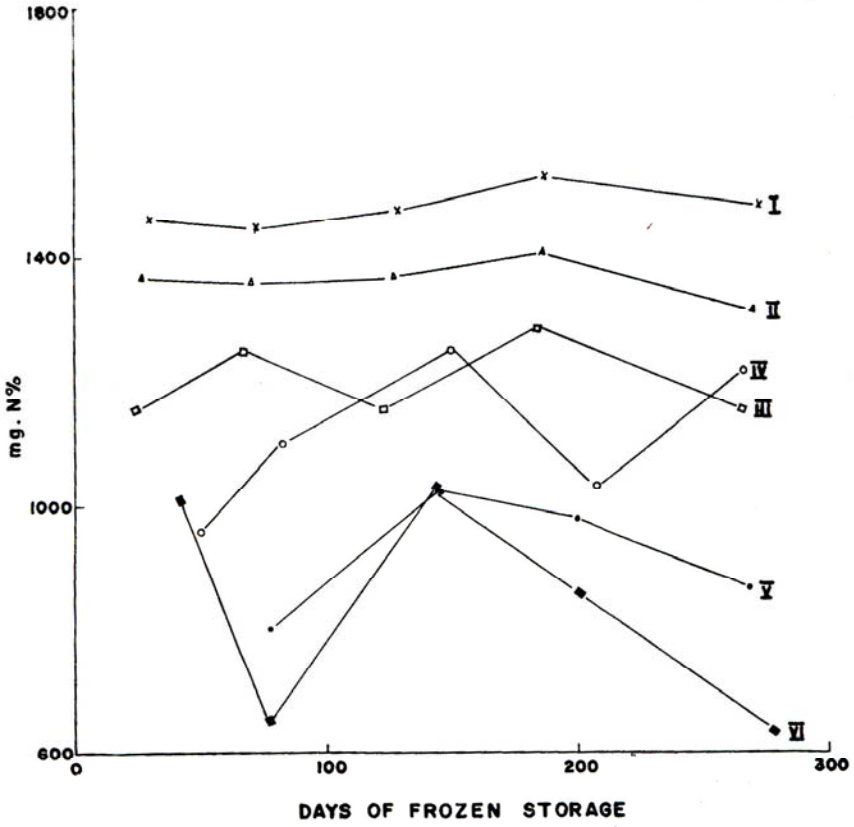

FIG. 7. Changes in water-soluble nitrogen in frozen prawn during storage.

Figures 4 and 5 respectively show the changes in the trimethylamine and total volatile nitrogen contents of the material in the different frozen blocks during storage. Except for minor fluctuations in the values, which may be due to sampling error, there is no significant changes in the T.M.A. and T.V.N. in the first four blocks. This can probably mean that there is no significant bacterial growth or biochemical changes in these blocks during storage. In the case of Blocks V and VI, however, there is an increase in the T.M.A. figures after 200 days of storage while T.V.N. values show an exceptional decrease. It may further be seen that in Sample VI after 280 days of storage out of 9·3 mg. total volatile nitrogen, trimethylamine accounts

for about 6·3 mg., while immediately after freezing the corresponding figures were 14·4 mg. and 2·3 mg. respectively. This shows that some form of activity, possibly microbiological. which produces T.M.A. is going on in this block which is prepared from an apparently spoiled raw material.

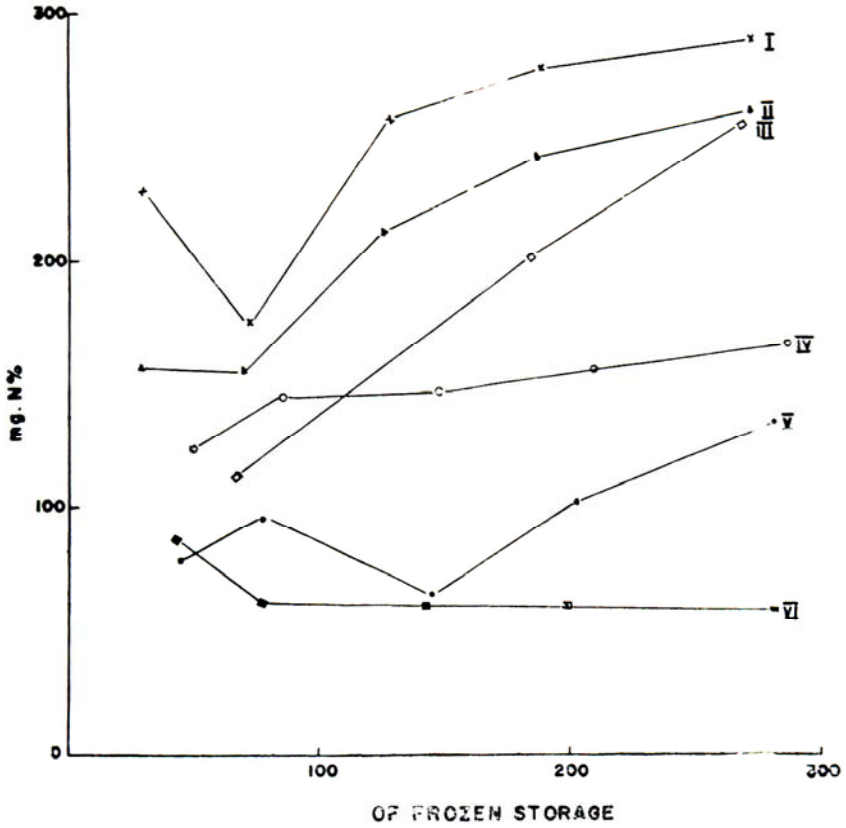

FIG. 8. Changes in free amino nitrogen in frozen prawn during storage.

Non-protein nitrogen and water-soluble nitrogen (Figs. 6 and 7) also do not show change during storage. However, the quantity present shows a regular and significant decrease from blocks I to VI. In Block I frozen from uniced fresh raw material W.S.N. is above 1,400 mg. N% throughout the period of storage while N.P.N. is above 600 mg. N%. In blocks frozen from material kept for more than seven days (*viz.*, Blocks V and VI) W.S.N. is below 1,000 mg. N% while N.P.N. is below 400 mg. N%. This is again highly significant in that the W.S.N. and N.P.N. values of the frozen prawn could approximately give the history of the raw material.

Amino N (Fig. 8) shows a significant increase in the case of blocks I, II and III, while the increase is only very little in blocks IV and V and in block VI there is no increase at all during storage. These changes are inversely correlated to the moisture contents of the respective frozen material. However, one significant factor is that the amino N remains below 120 mg. N% in blocks frozen from material stored for more than seven days in ice.

Summary and Conclusions

Freezing trials were carried out with fresh prawns (*P. indicus*) stored for different periods in ice. The changes in the chemical and bacteriological characteristics of the frozen products during storage have also been followed. It is observed that these characteristics are subjected to wide fluctuations as a result of the initial storage in ice. The implication of these changes in quality assessment of the products are also discussed.

Acknowledgement

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