

# QUALITY STUDIES ON ROUND, HEADLESS AND PEELED AND DEVEINED PRAWNS HELD IN ICE STORAGE

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## INTRODUCTION

In India, prawn processing industry has been assuming great importance in recent years. During the last decade, a number of prawn processing plants have sprung up in the country mainly engaged in export trade and the industry has thereby become important as a foreign exchange earner. Considerable amount of work has been carried out on the chemistry and technology of prawn in U.S.A. (Feiger *et al.*, 1954, 1956; Bailey *et al.*, 1956). The preliminary investigations made by Pillai *et al.* (1961) have thrown light on the factors responsible for spoilage of and deterioration of quality in raw and frozen prawns.

The raw prawn for freezing and canning plants is held in crushed ice during transport and subsequent storage prior to processing. The raw material may be transported either as 'whole', 'headless' or 'peeled and deveined' prawn. Knowledge of chemical and bacteriological changes occurring in these three forms of raw material is of considerable importance to the industry as this would enable predicting the quality of processed products apart from indicating their suitability as processing raw material. Spoilage of prawns held in or out of contact with ice and its assessment have been studied by Velankar *et al.* (1959, 1961). The present investigation was aimed at studying the chemical and bacteriological changes in prawns during storage in ice when held in the three forms of 'Round', 'Headless', or 'Peeled and Deveined' under commercial handling conditions.

## MATERIALS AND METHODS

The prawns employed for the experiments were obtained in fresh condition either from Manassery, a fish landing place in Cochin or from Departmental trawler *Fish Tech.* The studies have been conducted with two species *Metapenaeus dobsonii* and *M. affinis* (Count; 100-120/kg.). These were

iced immediately and brought to the laboratory where they were divided into three lots: (1) 'Round'—whole prawns washed thoroughly with cold water. (2) 'Headless'—prawns beheaded so as to remove the cephalothorax and washed and (3) 'Peeled and Deveined' (P and D)—prawns beheaded, peeled and the 'vein' removed as practised in processing plants and washed as above. The material was stored in separate containers with layers of crushed ice (ice to fish 1 : 1) in insulated box, repacking in ice being done every day. Sampling was carried out regularly for a period of 10–12 days for chemical and bacteriological quality. Total solids, total nitrogen, non-protein-nitrogen and volatile acid number (A.O.A.C., 1960), total volatile nitrogen trimethylamine (Conway and Byrene, 1933) free alpha-amino nitrogen (Pope and Stevens, 1939), orthophosphate (Fiske and Subba Row, 1925) were determined in the meat. The bacterial plate count was taken using sea-water agar. Tetrazolium reduction test and picric acid turbidity measurements have been made in the samples after methods of Fairbridge *et al.* (1951) and Kurtzman and Synder (1960) respectively. The course of blackening or melanosis has been watched visually in round and headless samples. For purposes of comparison, a few samples of headless and P and D prawns, collected from the prawn freezing and canning plants were also analysed.

TABLE I

Prawns: *Metapenaeus affinis*. (Count: 100–120  $\lambda$  kg.). R = Round. H = Headless. P and D = Peeled and deveined.

Days	T.M.A.N. mg. %			T.V.N. mg. %			V.A.N.		
	R	H	P & D	R	H	P & D	R	H	P & D
0	1.40	1.40	1.40	42.35	42.35	42.35	4.69	4.69	4.69
1	1.40	1.75	1.05	35.70	33.25	24.85	6.09	4.46	3.07
2	2.45	1.40	1.05	33.60	30.45	16.10	..	..	..
3	1.40	1.40	1.05	30.80	26.95	16.10	5.39	2.61	1.68
4	1.40	1.40	1.05	28.35	27.65	27.65	..	..	..
5	1.75	1.40	1.40	27.30	24.50	17.50	4.00	3.53	3.07
6	1.75	1.75	1.05	22.05	27.65	11.20	..	..	..
7	1.40	1.40	1.40	23.80	23.10	15.05	..	..	..
8	2.10	1.75	1.05	21.70	25.55	11.55	6.09	4.93	1.45
9	1.40	1.75	1.40	17.85	18.55	9.10	..	..	..
10	1.75	1.75	1.05	19.60	24.50	9.10	4.00	4.46	1.21
12	1.75	1.75	1.40	16.45	17.15	8.75	3.53	3.07	1.45

RESULTS

The trend of values for T.V.N., T.M.A.N. and V.A.N. is more or less similar. T.M.A.N. does not indicate any significant change during 10 days of storage in crushed ice. The values for headless were generally intermediate between those of round and P and D. In the case of P and D group, T.V.N., T.M.A.N. and V.A.N. always registered values lower than the corresponding initial levels. At no stage their values did indicate any significant change suggestive of incipient spoilage.

The changes in free alpha-amino nitrogen and soluble orthophosphate are represented graphically (Figs. 1 and 2). There is great similarity in the

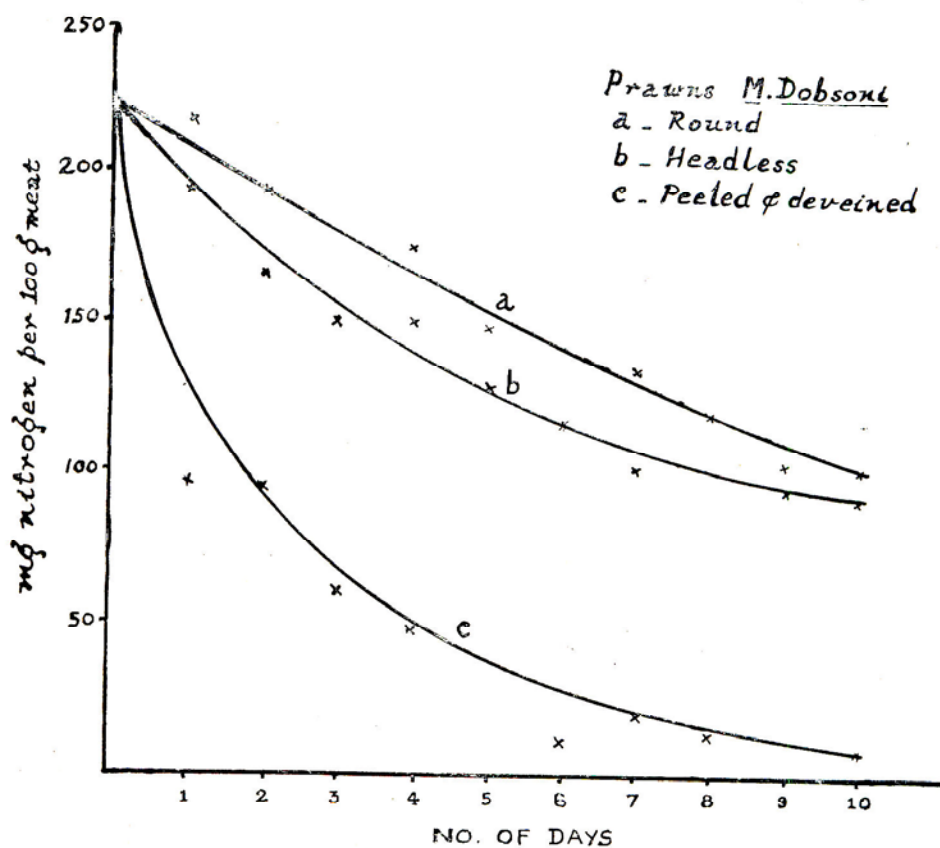


FIG. 1. Changes in free  $\alpha$ -amino nitrogen.

nature of curves for both  $\alpha$ -amino N and orthophosphate, the rate of fall in their levels being in the order Round < Headless < P and D. The level of  $\alpha$ -amino N reached below about half its value in round and headless

groups in 10 days' storage whereas in P and D group this level was reached in two days. In this group the values for  $\alpha$ -amino N and orthophosphate P in series *M. dobsonii* at the end of 10 days were as low as 6.73 and 5.81 mg.% respectively.

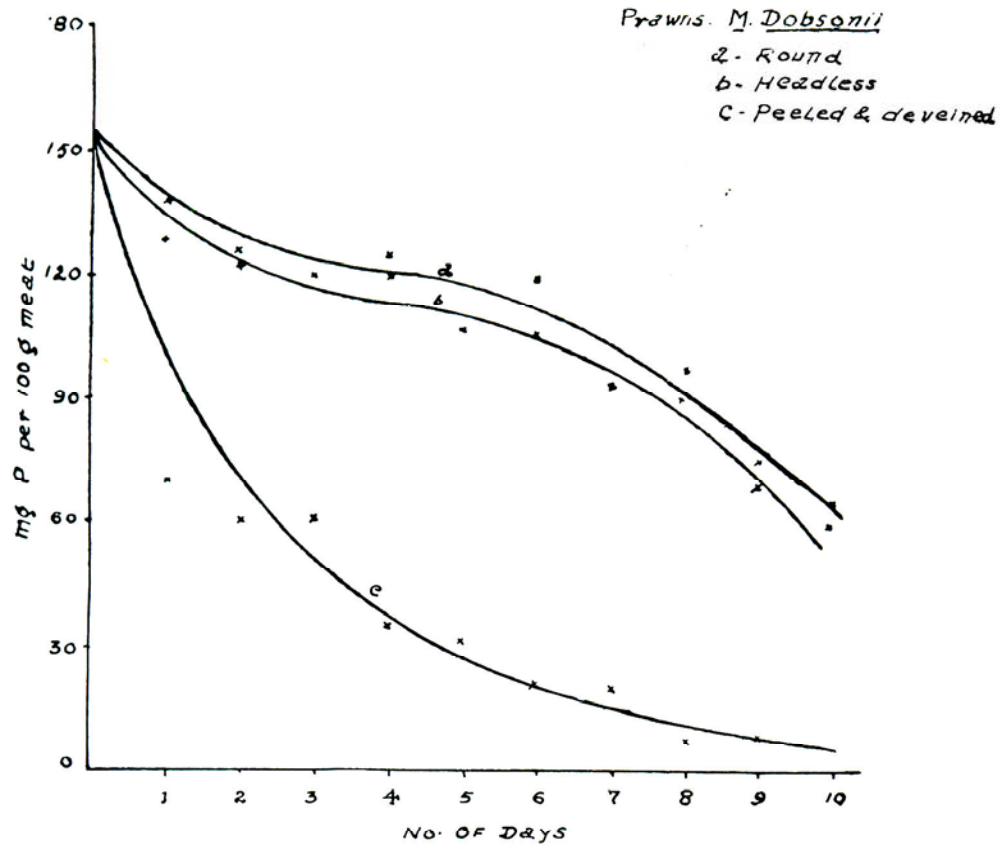


FIG. 2. Changes in Orthophosphate Phosphorus.

There is considerable loss of solid matter in the three groups, the loss being found to increase with number of days of storage. Concomitantly fall in levels of total nitrogen and non-protein nitrogen has been recorded. The results obtained in one series with *M. affinis* are shown in Table II. The values for P and D are found to be the lowest and the headless taking an intermediate position. In P and D prawns the total nitrogen has fallen to one half and non-protein nitrogen to about one-tenth of the initial values at the end of 10 days of storage. All the samples picked up moisture from ice, the percentage of water taken up being related to the percentage of solids lost.

TABLE II

Prawns: *M. affinis*. R = round. H = Headless. P and D = Peeled and deveined.

Days	% Solids in meat			Total nitrogen (gm. %)			Non-protein nitrogen (gm. %)		
	R	H	P & D	R	H	P & D	R	H	P & D
0	24.21	24.21	24.21	3.132	3.132	3.132	0.789	0.789	0.789
1	20.79	20.62	18.06	2.857	2.733	2.483	0.667	0.635	0.462
3	20.23	17.40	15.80	2.807	2.664	2.240	0.583	0.506	0.327
5	19.17	18.45	15.47	2.602	2.479	2.135	0.541	0.462	0.302
8	16.67	17.10	13.86	2.423	2.464	2.003	0.361	0.412	0.182
10	15.88	17.15	13.62	2.279	2.503	1.890	0.322	0.372	0.120
12	14.89	15.65	13.00	2.173	2.069	1.690	0.233	0.252	0.098

The course of development of blackening in *M. affinis* during ice storage (Table III) showed that 50% of the prawns in round condition were blackened in about 5 days, 75% in 7 days and 100% in 8 days. In the headless group the blackening did not appear in the shells till 6 days and even at the end of 10 days, the percentage was only 35%. The bacterial count of the different groups in the series (Table III) gave interesting trend. P and D prawns always registered the highest count among the three lots during the early days of storage. The same is true of factory raw material (Table IV). In the case of round and headless prawns the outer shell protects the meat from contamination from ice as well as from the hold. However, because of the presence of cephalothorax which carries the bulk of bacterial load, the round prawns gave higher counts than 'headless' samples. Although general correlation did not exist between the bacterial count on one hand and the two tests, viz., picric acid turbidity and tetrazolium reduction on the other, the results of the two latter tests have been found to be more or less parallel.

The results of analysis of 19 samples of headless and P and D prawns with known history which formed the raw material in various processing plants in Cochin are given in Table IV for comparative purpose and to judge the extent of suitability of the tests for assessing their quality. Among the

TABLE III

Prawns: *M. affinis*

Days	% Blackened		Bact. count Log/gm. muscle			Picric acid turbidity O.D. at 530 m $\mu$			Tetrazolium redn. formazan/gm. muscle on 20 hrs. incubation		
	R	H	R	H	P & D	R	H	P & D	R	H	P & D
0	Nil	Nil	3.177	3.177	3.177	0.186	0.186	0.186	400	400	400
2	"	"	3.813	3.813	4.097	0.312	0.267	0.213	420	400	560
4	20	"	3.431	3.362	4.505	0.354	0.330	0.213	480	420	670
5	50	"	..	..	..	..	..	..	..	..	..
6	75	"	3.732	3.279	4.114	0.420	0.312	0.186	590	480	540
7	85	25	..	..	..	..	..	..	..	..	..
8	100	25	4.839	3.699	4.602	0.444	0.348	0.153	670	500	520
9	100	30	..	..	..	..	..	..	..	..	..
10	100	30	5.690	3.431	4.447	0.354	0.354	0.153	560	420	480
11	100	30	..	..	..	..	..	..	..	..	..
12	100	30	5.079	4.000	4.857	0.367	..	0.186	580	420	440

headless samples examined T.M.A.N. varied from 0.35-5.77 mg.%. T.M.A.N. content did not always parallel the bacterial count. Samples having higher T.M.A.N. values generally indicated higher values for V.A.N although the bacterial counts were not comparatively higher. Free  $\alpha$ -amino nitrogen content in headless samples was of the order 150-250 mg.% except in one sample where it was 63.9 mg.%. This particular sample unlike others was held in ice for about 6 days. Orthophosphate content in this sample was also exceptionally low. The P and D prawn samples even for a day in ice have shown higher bacterial counts. T.M.A.N., T.V.N., V.A.N.,  $\alpha$ -amino N and orthophosphate showed lower levels as compared to headless samples. In two samples, however, higher V.A.N. values have been recorded,

TABLE IV  
Analysis of factory raw material (headless and P and D samples)

Sl. No. of samples	Source and description of samples	Days of storage in ice before processing	T.M.A.N. mg. %	T.V.N. mg. %	V.A.N.	α amino N-mg. %	Ortho-phosphate P m. %	Log bact. count gm.
1	A. Headless samples : Factory I Sea prawns—Malipuram	1 day in ice+water	0.35	22.60	2.40	210.70	153.8	4.081
2	" " " "	6 days in ice	1.79	15.44	4.06	63.9	5.1	6.017
3	" " " —Alleppey	1 day in ice	1.75	29.75	9.36	216.3	122.3	7.301
4	II Backwater prawns—Alleppey	2 days in ice+water (beheaded after 1 day in ice)	5.77	29.59	13.64	214.0	142.0	6.831
5	" " " "	" "	4.00	32.02	14.07	183.1	125.0	6.914
6	" " " "	Not known	2.48	21.92	7.0	212.0	137.4	..
7	III Sea prawns—Alleppey	2 days in ice	0.35	24.85	3.43	232.2	156.3	7.431
8	" " <i>P. indicus</i> sp. "	1 day in ice	0.70	20.30	5.20	230.5	107.5	4.940
9	IV Sea prawns—Quilon	Uniced during transport and later 1 day in ice	3.89	31.46	14.13	183.5	130.3	7.138
10	V " " "	1 day in ice	..	..	7.23	154.8	115.9	..
11	B. Peeled and Deveined samples : Factory I Sea prawns—(faint off odour)	1 day in ice+water	1.06	8.09	..	35.7	65.8	8.041
12	" " " "	" "	1.44	5.74	2.69	29.6	23.4	..
13	" " " Alleppey	1 day in ice	3.15	18.20	16.91	80.8	62.5	7.435
14	II Backwater Sp.—Edacochin	2 days in ice+water	1.06	11.67	3.79	47.1	62.5	8.435
15	" " Sea prawns	1 day in ice	2.14	10.00	2.45	42.4	46.9	6.639
16	" " " Narakkal	" "	2.11	14.07	6.98	103.0	67.9	6.401
17	IV <i>M. Affinis</i>	1 day in ice in round condition and 1 day in P & D	1.06	6.75	2.40	51.8	41.9	5.569
18	" " Sea prawns—Manasery	1 day in ice	1.06	12.37	4.93	43.8	45.4	5.699
19	" " " "	..	0.98	31.27	17.50	90.9	71.8	..

## DISCUSSION

That the usual chemical criteria of fish spoilage, *viz.*, T.M.A.N., T.V.N., V.A.N. are of very limited application in judging the loss of quality in the three types of commercial packs of prawn, *viz.*, round, headless and P and D, could be seen from the results obtained. It seems possible that the products of bacterial action are progressively being lost due to the washing action of ice. In the case of P and D prawns, because the entire surface is exposed to ice, the rate of fall in the values for above was the greatest. Fieger *et al.* (1954) and Iyengar *et al.* (1960) have also observed that the levels of these indices for quality would fluctuate in ice-stored prawns because of the leaching action of ice.

In commercial handling of prawns, the degree of leaching action would depend, besides the number of days of storage, on the methods of icing, transport and subsequent storage in factory. There is no definite proportion by which ice is mixed with prawns. Very often ice and water are employed which would facilitate quicker losses of soluble extractives. Secondly, the constant mechanical churning of the prawns in ice when the material is trucked from landing place to the factory which may be one complete overnight journey or more, would also contribute substantially to this type of loss. The temperature of storage of iced material in factory premises would also affect the rate of melting of ice and subsequent loss of soluble compounds. For example, it has been observed by Pillai *et al.* (1961) that headless prawns held in ice in chill room of factory, there were no significant changes in the above constituents.

However, it should be pointed out that the commercial samples showing usually higher values for T.M.A.N., T.V.N. and V.A.N. require to be viewed seriously (samples No. 4, 5, 9, 13, 19, Table IV) as these are distinctly spoiled samples. Although these samples were not held in ice for more than 2 days, they should have undergone definite spoilage before they were iced. Nevertheless, in control work there is little value for these tests which are valid only after definite organoleptic evidence of spoilage.

In the studies on prawns held at 0° C. out of contact with ice, the changes in these spoilage indices are quite significant [Velankar *et al.* (1961)] and as suggested by them it may be possible to lay down the limits of storage life under these conditions.

Although Bailey *et al.* (1956) differentiated three phases in the quality of ice stored whole prawns with particular reference to the organoleptic characteristics, correlated with  $\alpha$ -amino N levels it has not been found possible

to lay down such demarkation in our experimental samples as the fall in amounts of free-amino N had been observed to be more or less continuous. It was all the more difficult in the case of commercial raw material to specify its organoleptic stage because the observed levels might be dependent on several factors described above. The analytical data on sample No. 2 (Table IV) which was held in ice for 6 days indicated much lower levels of  $\alpha$ -amino N and orthophosphate-P than corresponding values for experimental samples (Figs. 1 and 2).

The changes in various nitrogenous fractions and orthophosphate are solely due to the physical action by melting ice since the fall in levels are always in the order Round < Headless < P and D and as such under uncontrolled conditions of icing, as is practised in commerce, their levels have very little significance in judging the loss of quality as well as the length of storage.

Beheading of prawns has definite advantage in inhibiting 'melanosis' or darkening. The darkening is almost complete in round prawns in about a week's storage, the ice-stored samples giving brown to blackish drip. Although blackening is a phenomenon having no effect on the aforesaid chemical changes, this is viewed as a serious disadvantage in commercial raw material for processing. It is common practice in the trade to cover up iced prawn with water to prevent this blackening which is essentially an oxidative change. Besides inhibiting blackening, removal of head brings down the total bacterial load thereby improving their keeping quality during storage as compared to round prawns. However, even after 10 days of storage, the bacterial count was not sufficiently high in all the three forms showing that during early days of ice storage, the bacterial load plays very little role in bringing out the loss of quality. The P and D prawns always registered the highest count which is evidently due to extraneous contamination, since in this case, the entire surface is exposed to ice. In round prawn towards the later days of storage, because of the presence of head which carries more than 70% of total bacterial load, the spoilage bacterial flora slowly get established in the meat and lower its shelf life.

While employing picric acid turbidity test for predicting the shelf life of meat, Saffle (1961) was of opinion that increase in O.D. of picric acid was large only at low odour scores and that from practical standpoint the test appeared to be unpromising. In the case of round prawns, the picric acid turbidity test showed in a general way, the deterioration of quality and there is fairly good correlation with bacterial count. However, the test in itself could not be relied upon in judging the relative loss of quality. The fall in

O.D. in case of P and D prawns although whose bacterial count showed an increase during storage is at present not possible to explain. Comparatively higher degree of tetrazolium reduction obtained with P and D samples go to some extent parallel with bacterial load in the first few days of storage. Direct proportionality between bacterial load and reduction of the dye was however not obtained. It is possible that the rate at which the oxidation—reduction potential gets lowered may be determined by the nature and activity of micro-organisms besides poisoning action exerted by the substrate (Castell, 1950). The extent of poisoning action on this account has not been investigated in the present study. The reduction method and bacterial count support the view expressed earlier that for short-term storage, as it becomes necessary, generally in processing plants, the prawns held as 'headless' will be comparatively of better quality than if they are held as round or P and D. Moreover since P and D prawns showed greater rate of loss of solid especially proteins, the processor would suffer a significant loss in yield as a function of holding time in ice.

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