SHELF LIFE OF CRAYFISH (*PROCAMBARUS CLARKII*) AND SHRIMP (*PENAEUS SEMISULACTUS*) STORED AT DIFFERENT TEMPERATURES

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(Manuscript received 12 April 1998)

Abstract

Texture, odor, total aerobic plate count (TPC), inosine 5-monophosphate (IMP), hypoxanthine (HX), pH, total volatile nitrogen (TVN) and trimethylamine-nitrogen (TMA-N) changes were determined in crayfish and shrimp stored at -7^{o}C, 4^{o}C and 35^{oC}. (TAPC) of cryafish and shrimp were increased by time and storage temperatures, the increase was higher for shrimp than for crayfish. Texture and odor qualities and (IMP) levels were decreased; (HX), PH, (TVN), and (TMA-N) levels were increased by time. Shelf lifes of crayfish and shrimp were 3.5 and 2 months at -7^{o}C; 14 and 10 days at 4^{o}C; and 13 and 17 hr at 35^{o} C, respectively.

INTRODUCTION

Crayfish meat often competes with small, imported shrimp in the seafood industry (Huner and Romaire, 1990). Crayfish (Procambarus clarkii), by far, is considered the most important crayfish of the 400 species known in the world, and has been successfully introduced to all countries, except, Antarctica and; Austraalia, since it is highly prolific and tolerant to poor water quality (Huner 1991; 1995; Ibrahim *et al.*, 1995). Freshwater crayfish are found virtually in every North American aquatic ecosytem. Significant quantities of the animals are harvested for food. There is a large aquaculture industry for crayfish, and over 80% of the crayfish produced are consumed locally in Lousisiana (Wang and Brown, 1983). The crayfishes have been found in Egypt during early 1980's, they, however, have estabilised viable populations in the aquatic ecosystems of Giza, Cairo and some Nile delta governorates and its estimated average annual yield was about 4.6 tons (Ibrahim *et al.*, (1996). In Egypt, as well as in other countries, the crayfish, Procambarus clarkii, most certainly becomes an improtant new food source for some invertebrates and vertebrates. Also, it is a valuble human food replacing the expensive marine crustaceans (Emam and khalil, 1995). Ice storage of shrimp, is not always done properly, particularly in developing countries. Temperature is a critical variable in the quality of various foods including fisshery products. Since storage/holding temperatures for shrimp in commercial handling and distribution vary, the capability to estimate shelf life at temperatures which prevail is an important need. Handling and storage at elevated temperatures had a profound effect on the quality of shrimp, which in turn, reduce its shelf life drastically (Shamshad *et al.* (1990), they found that according to the sensory panel, the shelf life of shrimp ranged from 12-16 days (13 days) at $0^{O}C$, 1-3 days (3days) at $15^{O}C$, to 6-12 hr (7hr) at $35^{O}C$. Fatima *et al.* (1981) reported that inosine 5-monophosphate (IMP) and hypoxanthine (HX) have been found to be good indices for assessing shrimp quality. It is now well established that, adenosine 5-triphosphate (ATP) is degraded to hypoxanthine (Hx) in sevesral species of fish during storage (Burt and Simmonds, 1971; Flick and lovell, 1972). Two pathways for the breakdown of ATP in Japanese prwan (Pandalus hypsinotus) have been proposed by Arai, (1966). One involves the direct deamination of adenosine 5-monophosphate (AMP) to inosine 5-monophosphate (IMP), while the second involves the dephosphorylation of AMP to adennosine, which is followed by deamination to inosine. Both pathways subsequently lead to hypoxanthine. Enzymic dephophorylation of IPM to hypoxanthine occurs within the period of ediblity during ice storage and these changes are invloved in the loss of desirable fresh flavors and the development of bitter off-flavor in staling fish (Jones *et al*; 1964; Dyer *et al.* 1966). Since the dephosphorylation of IMP is predominantly autolytic, its concentration can be considered as a measure of freshness of a particular fish species befor the onset of bacterial attack. The accumulation of hypoxanthing results from both autolytic and bacterial enzymes, its measurement, therefore, is valuable throughout storage life (Burt *et al.* 1969). The changes in biochemical and bacteriological quality of iced shrimp (Penaeus monodon) during 26 hours were, the volatile base nitrogen (VBN) accumulated in shrimp through out the 26 hr storage period, the degradation sequence of ATP in shrimp muscle was as follows : ATP ______ ADP ______ AMP ______ inosinne ______ hypoxanthine. Initial concetrations of ATP in shrimp muscle was 6.38 micromole/g. ATP decreased during ice storage. The initial levels of IMP were high and increased slowly during the 26 hr storage period. Hypoxanthine was detected in low concentrations after 18 hr of icing. pH value increased during storage but was below 7.4 even after 26 hr storage time. The aerobic plate cont (APC) decreased significantly over the 26 hr storage period (Chen *et al.*, 1990). The pH of shrimp has been suggested as a good index of freshness, pH 7.8

was found to be a critical margin for acceptability (Chung and Lain, 1979). The spoilage pattern of fresh seafood generally shows a trend of an increase in TMA concentration, which closely parallels the bacterial population. Thus, TMA analysis is often used as an index in assessing the shelf life and keeping quality of seafood products. Fresh seafood is generally considered to have little odor. As seafood is stored, and odor develops that is often characterized as being "fishy". Sensory methods are frequently applied in estimating the quality of seafood, and correlated to the microbiological data and chemical analysis (Wang and Brown, 1983). The use of low temperatures is important in protecting certain qualitites of seafood. The temperature not only affects the rate of spoilage reactions, which involves both bacteria and autolytic enzymes, but also affects the rate at which bacteria multiply in the food (Ronsivalli and Charm, 1974; Shewan, 1962; Farber and Lerke, 1961).

The purpose of this investegation was to study the shelf life of crayfish and shrimp at various storage temperatures.

MATERIALS AND METHODS

Material

Crayfish (Procambarus clarkii) was harvested from the river Nile at Giza and shrimp (Penaeus semisulacius) was harvested from the red sea at Suez. The crayfish transported to the laboratory alive, but the shrimp transported in ice. The analysis was Carried out at zero time and the crayfish and shrimp amounts were divided into three groups, two groups of crayfish were placed in boiling water for 5 minutes, each group of both species were packed in polyethylene bages and stored at 35^{o}C, 4^{o}C and -7^{o}C. Durign storage, the analysis was carried out after 6, 12, 18, 21 and 24 hr for the 35^{o}C; 13, 16, and 18 days for the 4^{o}C; and 1, 2, 3, 3.5 and 4 months for the -7^{o}C treatment.

Analytical methods

Texture and odor of the studied crayfish and shrimp meat samples were evaluated organoleptically by five trained members of the Meat and Fish Tecnology. Lab., food Technology Research Institute, Agric. Res. Center, Minsistry of Agric. These were rated as follows:

Judging scale of texture as follows:

Firm	8-9
Less firm	6-7
Slightly soft	4-5
Soft	2-3
Very soft	0-1

Judging scale of odor as follows:

Fresh	8-9
slightly fishy	6-7
Fishy	4-5
Bad	2-3
Putrid	0-1

Total aerobic plate counts (TAPC) were conducted using tryptone peptone agar as suggested by Liston and Matches (1976) and modified by Souder (1980).

Inosine 5-monophosphate (IMP) and hypoxanthine (HX) concentrations were determined by using High performance Liquid chromatography (HPLC) analysis as described by Ryder (1985).

pH value was measured in a slury of samples according to the method recommended by Krilova and Liskovskaia (1961) using a Beachman pH meter with a combined electrode.

Total volatile nitrogen (TVN) and trimethylamine nitrogen (TMA-N), as indicators of quality, were determined according to the method reported by winton and Winton (1958)

RESULTS AND DISCUSSION

The results of the Sensory evaluation of the texture and odor of crayfish and small shrimp meat during storage at different temperatures, are shown in Tables 1 and 2. According to the sensory panel, the shelf life, at 35°C, was 12-18 (13 hr) of raw crayfish, but was 6-12 (7 hr) of shrimp as found by Shamshad *et al*, (1990), due to that the crayfish about 9-12 hr are still alive; at 4°C, was 13-16 (14 days) for cooked crayfish, but was 9-13 (10 days) for shrimp as found by wang and Brown (1983) that the air stored cooked crayfish samples had a significantly stornger fishy odor after 14 days of storage at 4°C; and at -7°C, was 3-4 months) of cooked crayfish, but was 2-3 (2 months) of shrimp, due to the partial cooking of crayfish. therefore, the high quality shelf life of crayfish and shrimp is 12 and 6 hr at 35°C; 13 and 9 days at 4°C; and 3 and 2 months at-7°C, and acceptable shelf life up to 18 and 12 hr at 35°C; 16 and 13 days at 4°C; and 4 and 3 months at -7°C respectively. According to the taste panel the shrimp stored in ice for 20 days retained prime quality upto 8 days (Fatima *et al.* 1981). The enzyme responsible for the tissue softening in iced prawn is a collagenase (Baranowski *et al.* 1984; and Nip *et al.* 1985).

Table 1. Texture scores of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	8	9	0	9	9	0	9	9
6	8	8	9	8	7.5	1	8.5	8
12	8	6	13	7.5	6	2	8	7
18	6	4	16	6	4	3	7.5	5
21	4	2	18	4	2	3.5	7	4
24	2	0				4	5	2

Firm 8-9 Less firm 6-7 Slightly soft 4-5 soft 2-3 Very soft 0-1

Table 2. Odor scores of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	9	9	0	9	9	0	9	9
6	9	8	9	8.5	8	1	8.5	8
12	9	6	13	7.5	6	2	7.5	7
18	8	5	16	6.5	5	3	7	6
21	6	4	18	4.5	4	3.5	6.5	5
24	4	2				4	6	4

Fresh 8-9 Slightly Fishy 6-7 Fishy 4-5 Bad 2-3 Putrid 0-1

The results of the total aerobic plate count (TAPC) of fresh crayfish and shrimp are shown in (Table, 3 (TAPC) values were 1.2 x 10^5 and 4.8 x 10^5 cfu/g. For raw crey fish and shring respectively, when crayfish was cooked for 5 min., the (TAPC) decreased to 2.3 x 10^3 CFU/g. Counts of crayfish and shrimp were increased by time at each temperature and reached 8.1 x 10^7 and 1.5x10^9 CFU/g. after 24 hr at 35°C; 8.3 x 109 CFU/g. after 18 days at 4°C; 8.1 x 10^6 and 2.7x10^9 CFU/g. after 4 months at-7°C, respectively. Cox and Lovell (1973) found that the inital level of total aerobic plate count of peeled crayfish stored at 0 and 5°C was 1.6x10^5 CFU/g. and spoilage of the meat occurred when these counts reached 10^9 CUF/g. Shamshad *et al.* (1990) found that (APC) of fresh shrimp was 5.0x105 CFU/g. which increased by time and temperatue to 6.4 x 10^9 after 24 hr at 35°C, bacterial counts have been used as index of sanitary quality and that high bacterial counts are unacceptable but do not always indicate extent of quality loss or spoilage. Lovell (1968) found that, in correlating sensory tests of cooked crayfish to bacterial counts samples having aerobic plate counts of 10^7 cells/tailmeat were considered spoiled and the samples with bacterial counts exceeding 10^8 cells/g tailmeat were considered spoiled and the samples with bacterial counts exceeding 10^8 cells/sample were determined unfit for consumption.

Table 3. Total aerobic plate count (TAPC) of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	1.2x10^5	4.8x10^5	0	2.3x10^3	4.8x10^5	0	2.3x10^3	4.8x10^5
6	1.3x10^5	6.4x10^5	9	1.8x10^4	5.0x10^6	1	6.9x10^3	8.8x10^5
12	1.4x10^5	4.3x10^6	13	3.6x10^5	1.8x10^7	2	4.2x10^4	1.9x10^6
18	2.1x10^6	3.5x10^7	16	2.5x10^6	3.2x10^8	3	3.0x10^5	2.9x10^7
21	3.2x10^7	4.6x10^8	18	8.3x10^6	2.1x10^9	3.5	2.3x10^6	5.1x10^8
24	8.1x10^7	1.5x10^9				4	8.1x10^6	2.7x10^9

The results of the inosine monsphasphate (IMP) are shownin table 4. the initial levels of inosine monophosphate (IMP) were, 7.81 and 6.88 micromole/g for fresh crayfish and shrimp respectively. these high levels are probably the result of the dephosphorylation and deamination of adenosine triphosphate (ATP) during the struggle in the capture as reprted by Fatima *et al.* (1981); they determined the initial level of IMP which was 5.7 micromole/g in fresh shrimp. Also, they reported that it is quite probable that IMP is related to the characteristic flavor of fresh shrimp and part of the reason for flavor deterioration in ice-stored shrimp could be related to the degradation of IMP and to the increase in hypoxanthine in imparting a bitter teste to seafood, plus a concurrent loss of IMP which is an important flavor complement in seafoods. IMP levels increased slowly during 21 hr storage at 35°C for raw crayfish and shrimp as found by Chen *et al* (1990) who stated that IMP levels of shrimp increased slowly during 26 hr in ice storage. While during storage at 4°C and -7°C, the IMP levels decreased for the studied crayfish and shrimp samples as found by Fatima *et al.* (1981) who found that the levels of IMP decreased very rapidly from 5.7 to 1.307 micromole/g after 4 days and to 0.08 micromole/g after 12 days of ice storage of shrimp.

Table 4. Inosine 5-monophosphate (IMP) concentration of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	7.81	6.88	0	7.74	6.88	0	7.74	6.88
6	7.97	7.58	9	7.52	6.45	1	7.01	5.99
12	8.05	7.69	13	6.65	5.89	2	6.36	5.28
18	8.11	7.98	16	5.93	4.92	3	5.66	4.49
21	8.35	7.85	18	4.98	3.80	3.5	4.65	3.38
24	7.98	7.77				4	4.14	2.80

The hypoxanthine (Hx) levels as shown in table, 5, were increased slowly during the early storage at 4°C and -7°C. However, a rapid and consistent increases in (Hx) levels were noted after 16 days at 4°C and after 3 months at-7°C for shrimp and cooked crayfish, but at the end the (Hx) level did not reach 2 micromole/g as found by Fatima et al (1981) who found that the initial level of (Hx) of shrimp was 0.075 micromole/g and increased to 0.953, 2.0 and 4.5 micromole/g at 12, 16 and 20 days of ice storage. Formation of (Hx) continued beyond the acceptability level and this may be used as a confirmatory test of spoilage and that shrimp were rejected by tastepanel after a certain level of (Hx) in shrimp muscle reach 2 micromole/g and above). At this point, appreciable bitterness was noted by the panelists.

Table 5. Hypoxanthine (HX) concentration of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	Trace	0.04	0	0.02	0.04	0	0.02	0.04
6	Trace	0.08	9	0.37	0.45	1	0.48	0.56
12	Trace	0.12	13	0.54	0.66	2	0.65	0.74
18	0.03	0.28	16	0.61	0.73	3	0.71	0.82
21	0.19	0.40	18	1.05	1.24	3.5	1.15	1.32
24	0.31	0.80				4	1.59	1.82

The results of the pH values of crayfish and shrimp during storage at different temperatres are shown in Table 6.

Table 6. pH values of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	5.49	6.84	0	6.52	6.84	0	6.52	6.84
6	5.49	6.96	9	6.53	7.30	1	6.54	6.87
12	5.48	7.05	13	6.55	7.35	2	6.57	6.94
18	5.48	7.20	16	6.59	7.38	3	6.60	7.02
21	5.52	7.24	18	6.67	7.50	3.5	6.64	7.11
24	5.91	7.35				4	6.69	7.20

The initial pH of raw crayfish and shrimp was 5.49 and 6.84 respectively, when crayfish was cooked, the pH became 6.52, during storage the pH values increased. Wang and Brown (1983) found that the pH in air stored cooked crayfish samples rose from 7.94 to 8.36 during the first week of refrigerated storage, in some seafood, increases in pH are usually observed with advanced bacterial spoilage; Presumably due to the production of basic amines. pH value also increased with time and temperature of shrimp from 7.05 to 8.6 after 24 hr at 35°C, when pH reached 7.6 the shrimp were rated unacceptable or spoiled (Shamshad *et al.*, 1990).

Changes in total volatile nitogen (TVN) of crayfish and shrimp at 35°C, 4°C and -7°C are shown in Table 7. The initial levels were 3.29, 2.48 and 4.31 mg/100g for raw crayfish, cooked crayfish and raw shrimp respectively, which increased continuously during storage at all temperatures as reported by Shamshad et al (1990) who found that the total volatile bases (TVB) of shrimp increased with time and temperature. A level of 30 mg/100g of muscle has been considered the upper limit above which fishery products are considered unfit for human consumption (Montgomery et al, 1970). therefore, from tabel (7) it can be observed that the level of TVN was below the upper limit of acceptability, 18 and 12 hr at 35°C; 16 and 13 days at 4°C; and 4 and 3 months at -7°C for crayfish and shrimp respectively.

Table 7. Total volatile nitrogen (TVN) content of crayfish and shrimp during storage at 35°C, 4°C and -7°C (mg/100g).

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	3.29	4.31	0	2.48	4.31	0	2.48	4.31
6	3.29	12.43	9	8.00	12.11	1	8.31	12.32
12	3.30	20.42	13	14.02	20.30	2	14.16	20.60
18	21.98	29.80	16	22.71	29.95	3	21.92	25.36
21	30.85	38.91	18	31.50	37.21	3.5	24.00	30.87
24	41.11	49.01				4	28.24	38.96

The results of trimethyl amine-nitragen (TMA-N) are shown in table 8. The production of trimethylamine - nitrogen (TMA-N) followed a pattern similar to that of TVN. The initial levels of raw crayfish, cooked crayfish and raw shrimp were 0.88, 0.78 and 0.98 mg/100g which increased during storage at all temperatures but remained below the limit during the sensory helf-life as determined by the panelists. Montgomery et al (1970) found that 5 mg TMA-N/100g sample is the limit of acceptable shrimp in Australlia and Japan; while Fieger and Friloux (1954) found that less 2 mg TMA-N/100g of raw shrimp was considered acceptable. Flores and Crawford (1973) found that (TMA-N) of raw shrimp increased from 0.24 to 1.6 mg after 8 days of storage on ice. Wang and Brown (1983) found that the value of TMA-N/100g of fresh crayfish ranged from 1.11-1.87/100g mg/100g, these values were low, probably due to the fact that the crayfish is a partially cooked product and the tissue and/or bacterial enzymes had been destroyed in the boiling process. However, this may still be an useful quality index for assessing the quality of crayfish. As expected, the TMA concentration was consistent with bacterial plate counts.

Table 8. Trimethylamine - nitrogen (TMA - N) content of crayfish and shrimp during storage at 35^{o}C, 4o and -7^{o}C.

35^{o}C			4^{o}C			-7^{o}C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	0.88	0.98	0	0.78	0.98	0	0.78	0.98
6	0.88	2.79	9	1.42	2.85	1	1.69	1.90
12	0.89	4.61	13	2.98	4.74	2	2.07	2.89
18	4.41	8.12	16	4.51	9.11	3	3.55	4.92
21	8.01	13.57	18	8.05	14.62	3.5	4.20	6.59
24	13.32	19.35				4	4.81	9.21

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فترة صلاحية الإستاكوزا والجمبرى المخزنين على درجات حرارة مختلفة

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قدرت التغيرات فى القوام، الرائحة، العدد البكتيرى الكلى والإينوسين مونوفسفات، الهيبوزانسين، pH والنيتروجين الطيار الكلى، ثلاثى ميثايل أمين - نيتروجين للإستاكوزا والجمبرى المخزن على درجة -٥٧م، ٥٤م، ٥٣٥م. وقد زاد العدد البكتيرى الكلى للإستاكوزا والجمبرى مع الوقت وإرتفاع درجة الحرارة وكانت الزيادة أعلى للجمبرى عن الإستاكوزا. ويلاحظ أنه مع الوقت قلت جودة القوام والرائحه ومستويات الإينوسين مونوفسفات أما محتوى الهيبوزانسين والنيتروجين ودرجة الـ pH فقد زادت مع الوقت. وقد وجد أن فترة صلاحية الإستاكوزا والجمبرى كانت ٣,٥ و ٢ شهر على درجة -٥٧م، ١٤ و ١٠ يوم على درجة ٥٤ م، ١٣ و ٧ ساعه على درجة ٥٣٥ م على الترتيب،

and vertebrates. Also, it is a valuble human food replacing the expensive marine crustaceans (Emam and khalil, 1995). Ice storage of shrimp, is not always done properly, particularly in developing countries. Temperature is a critical variable in the quality of various foods including fisshery products. Since storage/holding temperatures for shrimp in commercial handling and distribution vary, the capability to estimate shelf life at temperatures which prevail is an important need. Handling and storage at elevated temperatures had a profound effect on the quality of shrimp, which in turn, reduce its shelf life drastically (Shamshad *et al.* (1990), they found that according to the sensory panel, the shelf life of shrimp ranged from 12-16 days (13 days) at $0^{O}C$, 1-3 days (3days) at $15^{O}C$, to 6-12 hr (7hr) at $35^{O}C$. Fatima *et al.* (1981) reported that inosine 5-monophosphate (IMP) and hypoxanthine (HX) have been found to be good indices for assessing shrimp quality. It is now well established that, adenosine 5-triphosphate (ATP) is degraded to hypoxanthine (Hx) in sevesral species of fish during storage (Burt and Simmonds, 1971; Flick and lovell, 1972). Two pathways for the breakdown of ATP in Japanese prwan (Pandalus hypsinotus) have been proposed by Arai, (1966). One involves the direct deamination of adenosine 5-monophosphate (AMP) to inosine 5-monophosphate (IMP), while the second involves the dephosphorylation of AMP to adennosine, which is followed by deamination to inosine. Both pathways subsequently lead to hypoxanthine. Enzymic dephophorylation of IPM to hypoxanthine occurs within the period of ediblity during ice storage and these changes are invloved in the loss of desirable fresh flavors and the development of bitter off-flavor in staling fish (Jones *et al*; 1964; Dyer *et al.* 1966). Since the dephosphorylation of IMP is predominantly autolytic, its concentration can be considered as a measure of freshness of a particular fish species befor the onset of bacterial attack. The accumulation of hypoxanthing results from both autolytic and bacterial enzymes, its measurement, therefore, is valuable throughout storage life (Burt *et al.* 1969). The changes in biochemical and bacteriological quality of iced shrimp (Penaeus monodon) during 26 hours were, the volatile base nitrogen (VBN) accumulated in shrimp through out the 26 hr storage period, the degradation sequence of ATP in shrimp muscle was as follows : ATP ______ ADP ______ AMP _______ inosinne ______ hypoxanthine. Initial concetrations of ATP in shrimp muscle was 6.38 micromole/g. ATP decreased during ice storage. The initial levels of IMP were high and increased slowly during the 26 hr storage period. Hypoxanthine was detected in low concentrations after 18 hr of icing. pH value increased during storage but was below 7.4 even after 26 hr storage time. The aerobic plate cont (APC) decreased significantly over the 26 hr storage period (Chen *et al.*, 1990). The pH of shrimp has been suggested as a good index of freshness, pH 7.8

was found to be a critical margin for acceptability (Chung and Lain, 1979). The spoilage pattern of fresh seafood generally shows a trend of an increase in TMA concentration, which closely parallels the bacterial population. Thus, TMA analysis is often used as an index in assessing the shelf life and keeping quality of seafood products. Fresh seafood is generally considered to have little odor. As seafood is stored, and odor develops that is often characterized as being "fishy". Sensory methods are frequently applied in estimating the quality of seafood, and correlated to the microbiological data and chemical analysis (Wang and Brown, 1983). The use of low temperatures is important in protecting certain qualitites of seafood. The temperature not only affects the rate of spoilage reactions, which involves both bacteria and autolytic enzymes, but also affects the rate at which bacteria multiply in the food (Ronsivalli and Charm, 1974; Shewan, 1962; Farber and Lerke, 1961).

The purpose of this investegation was to study the shelf life of crayfish and shrimp at various storage temperatures.

MATERIALS AND METHODS

Material

Crayfish (Procambarus clarkii) was harvested from the river Nile at Giza and shrimp (Penaeus semisulacius) was harvested from the red sea at Suez. The crayfish transported to the laboratory alive, but the shrimp transported in ice. The analysis was Carried out at zero time and the crayfish and shrimp amounts were divided into three groups, two groups of crayfish were placed in boiling water for 5 minutes, each group of both species were packed in polyethylene bages and stored at 35°C, 4°C and -7°C. Durign storage, the analysis was carried out after 6, 12, 18, 21 and 24 hr for the 35°C; 13, 16, and 18 days for the 4°C; and 1, 2, 3, 3.5 and 4 months for the -7°C treatment.

Analytical methods

Texture and odor of the studied crayfish and shrimp meat samples were evaluated organoleptically by five trained members of the Meat and Fish Tecnology. Lab., food Technology Research Institute, Agric. Res. Center, Minsistry of Agric. These were rated as follows:

Judging scale of texture as follows:

Firm	8-9
Less firm	6-7
Slightly soft	4-5
Soft	2-3
Very soft	0-1

Judging scale of odor as follows:

Fresh	8-9
slightly fishy	6-7
Fishy	4-5
Bad	2-3
Putrid	0-1

Total aerobic plate counts (TAPC) were conducted using tryptone peptone agar as suggested by Liston and Matches (1976) and modified by Souder (1980).

Inosine 5-monophosphate (IMP) and hypoxanthine (HX) concentrations were determined by using High performance Liquid chromatography (HPLC) analysis as described by Ryder (1985).

pH value was measured in a slury of samples according to the method recommended by Krilova and Liskovskaia (1961) using a Beachman pH meter with a combined electrode.

Total volatile nitrogen (TVN) and trimethylamine nitrogen (TMA-N), as indicators of quality, were determined according to the method reported by winton and Winton (1958)

RESULTS AND DISCUSSION

The results of the Sensory evaluation of the texture and odor of crayfish and small shrimp meat during storage at different temperatures, are shown in Tables 1 and 2. According to the sensory panel, the shelf life, at 35°C, was 12-18 (13 hr) of raw crayfish, but was 6-12 (7 hr) of shrimp as found by Shamshad *et al,* (1990), due to that the crayfish about 9-12 hr are still alive; at 4°C, was 13-16 (14 days) for cooked crayfish, but was 9-13 (10 days) for shrimp as found by wang and Brown (1983) that the air stored cooked crayfish samples had a significantly storn-ger fishy odor after 14 days of storage at 4°C; and at -7°C, was 3-4 months) of cooked crayfish, but was 2-3 (2 months) of shrimp, due to the partial cooking of crayfish. therefore, the high quality shelf life of crayfish and shrimp is 12 and 6 hr at 35°C; 13 and 9 days at 4°C; and 3 and 2 months at-7°C, and acceptable shelf life up to 18 and 12 hr at 35°C; 16 and 13 days at 4°C; and 4 and 3 months at -7°C respectively. According to the taste panel the shrimp stored in ice for 20 days retained prime quality upto 8 days (Fatima *et al.* 1981). The enzyme responsible for the tissue softening in iced prawn is a collagenase (Baranowski *et al.* 1984; and Nip *et al.* 1985).

Table 1. Texture scores of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	8	9	0	9	9	0	9	9
6	8	8	9	8	7.5	1	8.5	8
12	8	6	13	7.5	6	2	8	7
18	6	4	16	6	4	3	7.5	5
21	4	2	18	4	2	3.5	7	4
24	2	0				4	5	2

Firm 8-9 Less firm 6-7 Slightly soft 4-5 soft 2-3 Very soft 0-1

Table 2. Odor scores of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	9	9	0	9	9	0	9	9
6	9	8	9	8.5	8	1	8.5	8
12	9	6	13	7.5	6	2	7.5	7
18	8	5	16	6.5	5	3	7	6
21	6	4	18	4.5	4	3.5	6.5	5
24	4	2				4	6	4

Fresh 8-9 Slightly Fishy 6-7 Fishy 4-5 Bad 2-3 Putrid 0-1

The results of the total aerobic plate count (TAPC) of fresh crayfish and shrimp are shown in (Table, 3 (TAPC) values were 1.2 x 10^5 and 4.8 x 10^5 cfu/g. For raw crey fish and shring respectively, when crayfish was cooked for 5 min., the (TAPC) decreased to 2.3 x 10^3 CFU/g. Counts of crayfish and shrimp were increased by time at each temperature and reached 8.1 x 10^7 and 1.5x10^9 CFU/g. after 24 hr at 35°C; 8.3 x 109 CFU/g. after 18 days at 4°C; 8.1 x 10^6 and 2.7x10^9 CFU/g. after 4 months at-7°C, respectively. Cox and Lovell (1973) found that the inital level of total aerobic plate count of peeled crayfish stored at 0 and 5°C was 1.6x10^5 CFU/g. and spoilage of the meat occurred when these counts reached 10^9 CUF/g. Shamshad *et al.* (1990) found that (APC) of fresh shrimp was 5.0x105 CFU/ g. which increased by time and temperatue to 6.4 x 10^9 after 24 hr at 35°C, bacterial counts have been used as index of sanitary quality and that high bacterial counts are unacceptable but do not always indicate extent of quality loss or spoilage. Lovell (1968) found that, in correlating sensory tests of cooked crayfish to bacterial counts samples having aerobic plate counts of 10^7 cells/tailmeat were considered spoiled and the samples with bacterial counts exceeding 10^8 cells/g tailmeat were considered spoiled and the samples with bacterial counts exceeding 10^8 cells/sample were determined unfit for consumption.

Table 3. Total aerobic plate count (TAPC) of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	1.2x10^5	4.8x10^5	0	2.3x10^3	4.8x10^5	0	2.3x10^3	4.8x10^5
6	1.3x10^5	6.4x10^5	9	1.8x10^4	5.0x10^6	1	6.9x10^3	8.8x10^5
12	1.4x10^5	4.3x10^6	13	3.6x10^5	1.8x10^7	2	4.2x10^4	1.9x10^6
18	2.1x10^6	3.5x10^7	16	2.5x10^6	3.2x10^8	3	3.0x10^5	2.9x10^7
21	3.2x10^7	4.6x10^8	18	8.3x10^6	2.1x10^9	3.5	2.3x10^6	5.1x10^8
24	8.1x10^7	1.5x10^9				4	8.1x10^6	2.7x10^9

The results of the inosine monsphasphate (IMP) are shownin table 4. the initial levels of inosine monophosphate (IMP) were, 7.81 and 6.88 micromole/g for fresh crayfish and shrimp respectively. these high levels are probably the result of the dephosphorylation and deamination of adenosine triphosphate (ATP) during the struggle in the capture as reprted by Fatima *et al.* (1981); they determined the initial level of IMP which was 5.7 micromole/g in fresh shrimp. Also, they reported that it is quite probable that IMP is related to the characteristic flavor of fresh shrimp and part of the reason for flavor deterioration in ice-stored shrimp could be related to the degradation of IMP and to the increase in hypoxanthine in imparting a bitter teste to seafood, plus a concurrent loss of IMP which is an important flavor complement in seafoods. IMP levels increased slowly during 21 hr storage at 35°C for raw crayfish and shrimp as found by Chen *et al* (1990) who stated that IMP levels of shrimp increased slowly during 26 hr in ice storage. While during storage at 4°C and -7°C, the IMP levels decreased for the studied crayfish and shrimp samples as found by Fatima *et al.* (1981) who found that the levels of IMP decreased very rapidly from 5.7 to 1.307 micromole/g after 4 days and to 0.08 micromole/g after 12 days of ice storage of shrimp.

Table 4. Inosine 5-monophosphate (IMP) concentration of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	7.81	6.88	0	7.74	6.88	0	7.74	6.88
6	7.97	7.58	9	7.52	6.45	1	7.01	5.99
12	8.05	7.69	13	6.65	5.89	2	6.36	5.28
18	8.11	7.98	16	5.93	4.92	3	5.66	4.49
21	8.35	7.85	18	4.98	3.80	3.5	4.65	3.38
24	7.98	7.77				4	4.14	2.80

The hypoxanthine (Hx) levels as shown in table, 5, were increased slowly during the early storage at 4°C and -7°C. However, a rapid and consistent increases in (Hx) levels were noted after 16 days at 4°C and after 3 months at-7°C for shrimp and cooked crayfish, but at the end the (Hx) level did not reach 2 micromole/g as found by Fatima et al (1981) who found that the initial level of (Hx) of shrimp was 0.075 micromole/g and increased to 0.953, 2.0 and 4.5 micromole/g at 12, 16 and 20 days of ice storage. Formation of (Hx) continued beyond the acceptability level and this may be used as a confirmatory test of spoilage and that shrimp were rejected by tastepanel after a certain level of (Hx) in shrimp muscle reach 2 micromole/g and above). At this point, appreciable bitterness was noted by the panelists.

Table 5. Hypoxanthine (HX) concentration of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	Trace	0.04	0	0.02	0.04	0	0.02	0.04
6	Trace	0.08	9	0.37	0.45	1	0.48	0.56
12	Trace	0.12	13	0.54	0.66	2	0.65	0.74
18	0.03	0.28	16	0.61	0.73	3	0.71	0.82
21	0.19	0.40	18	1.05	1.24	3.5	1.15	1.32
24	0.31	0.80				4	1.59	1.82

The results of the pH values of crayfish and shrimp during storage at different temperatres are shown in Table 6.

Table 6. pH values of crayfish and shrimp during storage at 35°C, 4°C and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	5.49	6.84	0	6.52	6.84	0	6.52	6.84
6	5.49	6.96	9	6.53	7.30	1	6.54	6.87
12	5.48	7.05	13	6.55	7.35	2	6.57	6.94
18	5.48	7.20	16	6.59	7.38	3	6.60	7.02
21	5.52	7.24	18	6.67	7.50	3.5	6.64	7.11
24	5.91	7.35				4	6.69	7.20

The initial pH of raw crayfish and shrimp was 5.49 and 6.84 respectively, when crayfish was cooked, the pH became 6.52, during storage the pH values increased. Wang and Brown (1983) found that the pH in air stored cooked crayfish samples rose from 7.94 to 8.36 during the first week of refrigerated storage, in some seafood, increases in pH are usually observed with advanced bacterial spoilage; Presumably due to the production of basic amines. pH value also increased with time and temperature of shrimp from 7.05 to 8.6 after 24 hr at 35°C, when pH reached 7.6 the shrimp were rated unacceptable or spoiled (Shamshad *et al.*, 1990).

Changes in total volatile nitogen (TVN) of crayfish and shrimp at 35°C, 4°C and -7°C are shown in Table 7. The initial levels were 3.29, 2.48 and 4.31 mg/100g for raw crayfish, cooked crayfish and raw shrimp respectively, which increased continuously during storage at all temperatures as reported by Shamshad et al (1990) who found that the total volatile bases (TVB) of shrimp increased with time and temperature. A level of 30 mg/100g of muscle has been considered the upper limit above which fishery products are considered unfit for human consumption (Montgomery et al, 1970). therefore, from tabel (7) it can be observed that the level of TVN was below the upper limit of acceptability, 18 and 12 hr at 35°C; 16 and 13 days at 4°C; and 4 and 3 months at -7°C for crayfish and shrimp respectively.

Table 7. Total volatile nitrogen (TVN) content of crayfish and shrimp during storage at 35°C, 4°C and -7°C (mg/100g).

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	3.29	4.31	0	2.48	4.31	0	2.48	4.31
6	3.29	12.43	9	8.00	12.11	1	8.31	12.32
12	3.30	20.42	13	14.02	20.30	2	14.16	20.60
18	21.98	29.80	16	22.71	29.95	3	21.92	25.36
21	30.85	38.91	18	31.50	37.21	3.5	24.00	30.87
24	41.11	49.01				4	28.24	38.96

The results of trimethyl amine-nitragen (TMA-N) are shown in table 8. The production of trimethylamine - nitrogen (TMA-N) followed a pattern similar to that of TVN. The initial levels of raw crayfish, cooked crayfish and raw shrimp were 0.88, 0.78 and 0.98 mg/100g which increased during storage at all temperatures but remained below the limit during the sensory helf-life as determined by the panelists. Montgomery et al (1970) found that 5 mg TMA-N/100g sample is the limit of acceptable shrimp in Australlia and Japan; while Fieger and Friloux (1954) found that less 2 mg TMA-N/100g of raw shrimp was considered acceptable. Flores and Crawford (1973) found that (TMA-N) of raw shrimp increased from 0.24 to 1.6 mg after 8 days of storage on ice. Wang and Brown (1983) found that the value of TMA-N/100g of fresh crayfish ranged from 1.11-1.87/100g mg/100g, these values were low, probably due to the fact that the crayfish is a partially cooked product and the tissue and/or bacterial enzymes had been destroyed in the boiling process. However, this may still be an useful quality index for assessing the quality of crayfish. As expected, the TMA concentration was consistent with bacterial plate counts.

Table 8. Trimethylamine - nitrogen (TMA - N) content of crayfish and shrimp during storage at 35°C, 4o and -7°C.

35°C			4°C			-7°C		
Storage time (Hours)	Raw crayfish	Raw shrimp	Storage time (Days)	Cooked crayfish	Raw shrimp	Storage time (Mon.)	Cooked crayfish	Raw shrimp
0	0.88	0.98	0	0.78	0.98	0	0.78	0.98
6	0.88	2.79	9	1.42	2.85	1	1.69	1.90
12	0.89	4.61	13	2.98	4.74	2	2.07	2.89
18	4.41	8.12	16	4.51	9.11	3	3.55	4.92
21	8.01	13.57	18	8.05	14.62	3.5	4.20	6.59
24	13.32	19.35				4	4.81	9.21

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فترة صلاحية الإستاكوزا والجمبرى المخزنين على درجات حرارة مختلفة

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قسم بحوث اللحوم والأسماك، معهد بحوث تكنولوجيا الأغذية - مركز البحوث الزراعية - جيزة - مصر.

قدرت التغيرات فى القوام، الرائحة، العدد البكتيرى الكلى والإينوسين مونوفسفات، الهيبوزانسين، pH والنيتروجين الطيار الكلى، ثلاثى ميثايل أمين - نيتروجين للإستاكوزا والجمبرى المخزن على درجة -٥٧م، ٥٤م، ٥٣٥م. وقد زاد العدد البكتيرى الكلى للإستاكوزا والجمبرى مع الوقت وإرتفاع درجة الحرارة وكانت الزيادة أعلى للجمبرى عن الإستاكوزا. ويلاحظ أنه مع الوقت قلت جودة القوام والرائحه ومستويات الإينوسين مونوفسفات أما محتوى الهيبوزانسين والنيتروجين ودرجة الـ pH فقد زادت مع الوقت. وقد وجد أن فترة صلاحية الإستاكوزا والجمبرى كانت ٣,٥ و ٢ شهر على درجة -٥٧٠م، ١٤ و ١٠ يوم على درجة ٥٤ م، ١٣ و ٧ ساعه على درجة ٣٥ه م على الترتيب،