PROCESSING AND FROZEN STORAGE CHARACTERISTICS OF RAY FILLETS

by

A. RAMACHANDRAN and T.V. SANKAR
School of Industrial Fisheries, Cochin University of Science and Technology,
Fine Arts Avenue, Cochin-682 016, INDIA

ABSTRACT

Rays, belonging to the class Elasmobranchii, constitute a major fishery in many states in India like Tamil Nadu, Gujarat, Andhra Pradesh, Kerala and Maharashtra. The estimated landings are 21,700 tonnes per annum. Even though the meat of rays is nutritious and free from bones and spines, there is little demand for fresh meat due to the presence of a high urea content. The landings are mainly used for salt curing which fetches only very low prices for the producers.

Urea nitrogen constituted the major component (50.8%) of the non-protein nitrogen of the meat. An attempt has been made to standardize the processing steps to reduce the urea levels in the meat before freezing by using different simple techniques like dipping the fillets in stagnant chilled water, dipping in chilled running water and dipping in stirred chilled running water. It was found that meat dipped in stirred running water for two hours reduced the urea level of the meat by 62%. The yield of the lateral fin fillets and caudal fin fillets vary with the size of the ray. The drip loss during frozen storage is found to be more in the case of samples frozen stored after the treatment for urea removal by the method of stirring in running water. The samples treated in stagnant chilled water had the lowest drip loss. The total nitrogen was higher in samples treated in stagnant chilled water and lowest in the samples treated in stirred running water. The overall acceptability was high in the case of samples treated with stirred running water and frozen stored.

INTRODUCTION

Elasmobranchs constitute a major fishery in India. The total landings of elasmobranchs and the contribution of rays (Table 1) indicate a potential for utilisation. Gujarat has the maximum landings of elasmobranchs among the states in India with average landings during the last 12 years of 14,300 tonnes. Tamil Nadu has an average landing of 13,000 tonnes, Maharashtra 10,000 tonnes and Kerala 5,100 tonnes (Anon., 1995; Anon., 1996; Anon., 1997). In Tamil Nadu, elasmobranchs accounted for 6.9% of the total marine fish landings. Central Marine Fisheries Research Institute (CMFRI) has estimated the potential yield in Tamil Nadu as 20,000 tonnes using a Maximum Contribution Approach (Anon., 1987). In Andhra Pradesh, the potential yield is expected to be 12,000 tonnes (Anon., 1987a). Gujarat and Maharashtra have a substantial elasmobranch resource. The important genera of rays found in India are *Dasyatis, Gymmura, Himantura, Urogymnus, Aetobatus, Aetomylaeus, Rhinoptera, Manta, Mobula and Nercine* (Anon., 1987).

Rays make up 67.7% of elasmobranch landings in Tamil Nadu. In Kerala, rays contribute 33.9% and in Karnataka 20.6% of the total elasmobranch landings. The contribution of rays to the total elasmobranch landings in Maharastra is 15.1%, Gujarat 20%, and Andhra Pradesh 30%. Substantial quantities of rays are landed as bycatch from shrimp trawls in Gujarat (Badonia *et al.*, 1990). Among elasmobranchs, sharks are mostly preferred by most people as technologies are already evolved for their processing (Joseph and Solanki, 1985) and the studies on the removal of urea, which contributes to undesirable odour, have been carried out by Kandoran *et al.* (1965); Solanki and Venkataraman (1978). Production of semi-dried fish products from shark, an intermediate moisture product, also increased its utilization for human consumption (Ramachandran and Solanki, 1991).

Table 1. Total Elasmobranch landings and contribution of Ray in India during 1985-96.

Year	Total Elasmobranch landing	Contribution of Ray (%)
1985	52154	29.9
1986	51898	29.9
1987	56585	39.3
1988	56847	31.8
1989	49979	39.1
1990	49820	48.0
1991	50420	34.5
1992	63132	25.3
1993	66423	28.3
1994	58097	31.1
1995	69274	30.3
1996	58634	37.1

However, no such concentrated efforts have been made to utilize the major families of rays belonging to the super order *Batoidimorpha* of subclass *Elasmobranchii* for human consumption, though they are believed to be similar to sharks in composition and are landed in substantial quantities. Hence, the objectives of the present study are:

1. To develop a simple method for the easy removal of urea from ray fillets so as to improve commercial acceptability.
2. To prepare fillets from ray and elucidate the frozen storage characteristics.

MATERIALS AND METHODS

Fresh rays belonging to the species *Himantura uarnak* (Forsskal, 1775), popularly called honeycomb sting ray, was used for the study. The rays are classified into different size groups for the purpose of filleting as, 4.00-4.99 kg, 5.00-5.99 kg, 6.00-6.99 kg, 7.00-7.99 kg, 8.00-8.99 kg, 9.00-9.99kg, 10.00-10.99 kg, 11.00-11.99 kg, 12.00-12.99 kg, 13.00-13.99 kg, 14.00-14.99 kg, and 15.00-15.99 kg. The yield of skin-on lateral fins and skinless lateral fins and caudal fins obtained from these size groups were then calculated. For the purpose of studies on urea removal and frozen storage characteristics, fillets of uniform sizes (average length 22 cm, average breath (measured at the central point) 18.5 cm and thickness (measured at the central point) 3.81 cm) fillets were prepared. The fillets were treated by three different methods - immersion in chilled stagnant water (20:1 v/w water to fillets), in chilled running water with a flow rate of 2 litres/minutes and in chilled running water with stirring having a rate of flow of 2 litres/ minutes and a stirring speed of 2000 RPM /minutes, approximately. A micro tissue homogenizer was used to get the stirring effect.

The treated samples were surface dried using filter paper and taken for analysis. Moisture, salt, total nitrogen (TN) and non-protein nitrogen (NPN) were analysed by AOAC methods (1975). About 10g muscle was homogenized in chilled distilled water (20V) and centrifuged to collect the water-soluble nitrogen (WSN). The salt-soluble nitrogen was estimated by the methods of King and Poulter (1985) using pre-cooled buffers. Nitrogen was estimated by the micro Kjeldahl method. The trimethylamine (TMA), total volatile nitrogen (TVN) and urea nitrogen were estimated by the diffusion method of Conway (1947). Urea was calculated by multiplying urea nitrogen with 2.14. The total bacterial count was estimated using tryptone-glucose agar as per the standard method and incubated at 37°C.

A test panel of 8 members evaluated the physical and olfactory characteristics of the fillets treated by different methods. Similarly, the same test panel assessed the physical and olfactory characteristics of the frozen stored products during a period of six months. The scale used for scoring the physical and olfactory characteristics is given in Table 2. The average of the scores given by the test panel members is reported.

Table 2. Proximate biochemical composition of Ray.

Moisture	78.16±1.7
Protein (TN-NPN)	17.16±1.4
Fat g %	0.31±0.1
Ash g %	1.09 ±0.1
NPN g %	1.10±0.06
Urea N g %	0.54
WSN (% of TN)	36.40
SSN (% of TN)	48.38
Salt g %	0.506

RESULTS AND DISCUSSION

The ray was processed into lateral fin fillets and caudal fin fillets as these two were the only fleshy parts of the body, which could be used for human consumption. The yield of fillets from lateral fins varied from 35% to 60% by weight depending on the size of the ray while that from caudal fin ranged from 0.75 to 1.75%. Fig. 1 shows the yield of fillets from different sized rays and it can be seen that the larger the animal the lesser the yield of fillets. More than 50% yield was obtained from animals of up to 8 kg. Above this, the increase in weight of the rays the yield dropped to about 35%. This may be due to the calcification of the cartilaginous skeleton, especially of the central part of the body separating the two lateral fins. It was also noticed that in bigger size rays the central cartilaginous skeletal support is heavy and occupies a greater volume, probably to adapt to its swimming nature.

The composition of the ray used for the experiment is given in Table 2. The composition compares well with fish and other elasmobranchs except that it contains large amounts of NPN, especially urea. Ray has about 28% NPN and urea nitrogen contributes to about 47% of NPN. Considering the other nitrogenous fractions, salt soluble nitrogen contributes about 49% while the water-soluble fraction to about 36% of TN. The composition was in agreement with the earlier report (Kandoran *et al.*, 1965) and compares well with the composition of sharks (Solanki and Venkataraman, 1978; Ramachandran and Solanki, 1990).

The results of experiments conducted to remove the urea from the meat to improve its consumer acceptability are given in Figures 2 and 3. It can be seen from Fig. 2. that stirring fillets in ice chilled running water for 2h removes as much as 65% of the urea. Immersing in ice chilled running water for 1h removed about 46% urea, which is comparable to 2h treatment in either running water alone (46%) or in stagnant water (41%). The stirring in running water treatment accounts for about 29% loss in the total nitrogen (Fig. 3). A 45% loss in the NPN and 32% loss in the water-soluble nitrogen were also seen. The SSN content was found to be 1.94 g/100g muscle. Thus the method also effectively removes NPN, especially urea, and makes the fillets comparable to other fish products. Kandoran *et al.* (1965) reported that salting, desalting followed by resalting removes as much as 98% urea in both sharks and rays. Similarly, Solanki and Venkataraman (1978) reported that by simply keeping the shark fillets in ice for 7 days removes up to 25% urea. However, in both the cases the fish is exposed for a longer time at higher temperature, which affects the actual quality of the meat.

Table 3. Organoleptic evaluation of Ray fillets during processing.

Duration	Types of treatment		
	Urea removal in stagnant water	**In running water**	**In running water with stirring**
1 h			
Colour and appearance	4.6	4.7	4.8
Texture	4.8	4.6	4.5
Odour	1.8	2.8	3.6
Total	11.2	12.1	12.9
Overall acceptability	good	very good	excellent
2 h			
Colour and appearance	4.6	4.8	4.8
Texture	4.6	4.4	4.2
Odour	2.8	3.6	3.8
Total	12.0	12.8	12.8
Overall acceptability	very good	excellent	excellent

The organoleptic scoring showed (Table 3) improvements in the colour and appearance, texture, odour and overall acceptability as a result of washing by different methods. The overall acceptability was in greater for fillets subjected to urea removal in running water with stirring and this correlates well with the urea content in treated fillets (Fig. 2). Hence, the method described here is mild and can be used effectively by the industry.

The moisture content of the fillets treated for urea removal, increases as a result of the treatment. About 7% increase was noticed in stirring in running water (Fig. 4) compared to about 5% in the other two methods. There is a decrease in the moisture content of the fillet treated by the earlier method during frozen storage up to 120 days (Fig. 4) and this may be due to the loss of water holding capacity of the meat as a result of excessive uptake of water. But in the other cases the moisture remained at the initial level up to about 4 months. This finding is supported by the loss in weight during frozen storage (Fig. 5). The fillets kept stirring in ice chilled running water for 2h recorded about 12 to 14 % loss of weight while in the other cases only 4 to 6 % weight loss was noticed through out the frozen storage period.

The samples treated in stagnant and running water lost about 7% TN (Fig. 6) by the end of 180 days while only 3.9% loss was noticed in the samples stirred in running water. The low initial TN value in the case of the latter experiment could be the reason. The loss of SSN contributed more to this, as the loss of WSN was almost negligible during frozen storage (Figures 7 and 8). A major portion of the WSN and SSN were lost in the initial urea removal stage. The SSN and WSN showed a slight increase during initial storage, which could be due to the excessive moisture loss noticed in the respective samples. The NPN value did not show any change during frozen storage.

Organoleptic evaluation showed (Table 4) considerable changes in acceptability of ray fillets subjected to different treatments of urea removal and subsequent storage at -18°C. The fillets treated in stagnant water showed good acceptability up to 120 days, while the fillets treated by the other methods were in good condition even after 180 days of frozen storage. The major problem noticed was the ammoniacal odour, which affected the overall acceptability of the fillet treated in stagnant water.

Table 4. Organoleptic evaluation of Ray fillets during frozen storage at –18°C.

Duration of Storage (days)	Types of treatment		
	Urea removal in stagnant water	In running water	In running water with stirring
0 day			
Colour and appearance	4.6	4.8	4.8
Texture	4.4	4.4	4.2
Odour	3.0	3.8	4.0
Total	12.0	13.0	13.0
Overall acceptability	very good	excellent	excellent
30th day			
Colour and appearance	4.5	4.6	4.8
Texture	4.2	4.6	4.2
Odour	3.0	3.8	4.1
Total	11.7	13.0	13.1
Overall acceptability	very good	excellent	excellent
60th day			
Colour and appearance	4.4	4.6	4.6
Texture	4.2	4.0	4.2
Odour	3.1	3.9	4.0
Total	11.7	12.5	12.8
Overall acceptability	very good	excellent	excellent
120th day			
Colour and appearance	4.0	4.4	4.6
Texture	3.8	3.6	3.5
Odour	3.2	3.9	4.1
Total	11.0	11.9	12.2
Overall acceptability	good	very good	very good
180th day			
Colour and appearance	3.8	4.0	4.1
Texture	3.0	3.0	3.0
Odour	3.0	3.8	3.8
Total	9.8	10.8	10.9
Overall acceptability	satisfactory	good	good

Numerical scores were given based on the following scales:

Colour and general appearance: 5 = characteristic, 4 = slightly dull, 3 = dull, 2 = dull with slight discoloration, 1 = discoloured.

Texture: 5 = firm, 4 = slight loss of characteristic texture, 3 = loss of characteristic texture, 2 = slightly soft, 1 = very soft.

Odour: 5 = complete loss of characteristic urea smell, 4 = considerable reduction in urea smell, 3 = Reduction in urea smell, 2 = slight reduction in urea smell, 0 = characteristic urea smell.

The average total bacterial count of the fillets before treatment was 2.08 x 10^4. Upon treatment for urea removal, the bacterial count was reduced by one log cycle in the fillets treated with running water. The treatment involving stirring reduced the count further. There was no reduction in the bacterial count in the fillets treated with stagnant water compared to untreated fillets. The microbiological analysis (Table 5) showed a similar pattern in the fillets during frozen storage except that the microbial content of the fillets treated in stagnant water was slightly higher than that of the other fillets. There was a slight increase in the count during the initial period of storage up to 60 days then decreased.

Table 5. Changes in total bacterial count in Ray fillets during frozen storage.

	Stagnant water	**Running water**	**Stirring in running water**
0 day	2.41 x 10^4	2.86 x 10^3	1.69 x 10^3
30 days	5.66 x 10^4	1.56 x 10^4	9.73 x 10^3
60 days	2.87 x 10^4	1.56 x 10^3	4.30 x 10^3
120 days	8.80 x 10^2	3.06 x 10^2	2.25 x 10^2
180 days	2.57 x 10^2	2.21 x 10^2	160 x 10^2

It can be summarized that the utilization of rays can be improved by effectively removing the urea by the method stated above and the treated fillets were in acceptable condition after treatment and also after frozen storage up to six months.

REFERENCES

Anon. 1987a. An appraisal of the marine fisheries of Andhra Pradesh, Special publication, Number 33, CMFRI, Cochin.

Anon. 1987. An appraisal of the marine fisheries of Tamil Nadu and Pondicherry, Special Publication No.34, CMFRI, Cochin, India.

Anon. 1995. Mar. Fish. Infor. Serv, T7E ser., No.136, January, February , March, CMFRI, Cochin.

Anon. 1996. Annual Report, CMFRI, Cochin.

Anon 1997. Annual Report, CMFRI, Cochin.

AOAC. 1975. Official methods of Analysis, (Horwitz, W., Ed.), 13th edn. Association of Official Analytical Chemists, Washington.

Badonia, R. , Solanki, K.K and Ramachandran, A. 1990. Bycatch of shrimp trawls in Gujarat, Presented in the Second Indian Fisheries Forum, Asian Fisheries Society, Mangalore.

Conway, A.J. 1947. Micro diffusion analysis and volumetric error, 4th edition, Van Nostrand Co., Inc., New York.

Joseph, A.C, and Solanki, K.K. 1985. Frozen storage characteristics of Elasmobranch shark (Scoliodon laticaudas), In: Harvest and post harvest technology of fish, (Ravindran, K. , Unnikrishnan Nair, N. , Perigreen, P. , Madhavan, P. , Gopalakrishna Pillai, A.G. , Panicker, P.A. and Thomas, M. eds.), SOFT(I), Cochin, 536-8.

Kandoran, M.K., Govindan, T.K and Suryanarayana Rao, S.V. 1965. Some aspects of curing sharks and rays, Fish Technol, 2, 193.

King, D.R., and Poulter, R.G. 1985. Frozen storage of Indian mackerel (Rastrelliger kanagurta) and big eye (Priacanthus humrur) Tropical Sciences, 25, 79-90.

Ramachandran, A. and Solanki, K.K. 1990. Processing and quality aspects of semi dried fish products of commerce from Veraval, In. M. Mohan Joseph (ED) The first Indian Fisheries Forum, Proceedings, Asian Fisheries Society, Indian Branch, 419-23.

Ramachandran, A. and Solanki, K.K. 1991. Studies on the processing and storage characteristics of semi dried products from shark, J.mar. biol. Ass. India, 33, (1 and 2), 19-25.

Solanki, K.K. and Venkataraman, R. 1978) Ice storage characteristics of fresh and brined shark fillets, Fish Technol, 15, 7-11.