SMOKING AND SUNDRYING OF *CHICOREUS RAMOSUS* MUSCLES

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ABSTRACT

Foot and columella muscles of *C. ramosus* were processed by smoking and sundrying. The sliced meat was blanched in 10% brine for 20 minutes and divided into two lots. One lot was subjected to sundrying and another to smoking. The quality of the processed meat was assessed by chemical, microbial and organoleptic characters at monthly intervals. The shelf life of sundried meat was about 210 and 180 days for foot and columella muscles, and about 270 and 240 days for smoked foot and columella muscles, respectively.

INTRODUCTION

Seafood is processed to increase shelf-life and hygiene by maintaining fresh quality through delay of microbiological spoilage and chemical deterioration (Bleustein & Labuza 1975). Smoking is a combination of drying and chemicals from the thermal breakdown of wood (Cutting 1965). Drying inactivates the microorganisms causing spoilage (Govindan 1985). Smoking gives effective bactericidal (Kochanowshi 1962; Incze 1965), fungicidal, and antioxidative effects (Tilgner & Daun 1970; Fretheim *et al.* 1980) as well as an attractive flavour to the products. The flavouring properties of smoking is effected mainly by acids, aldehydes and phenol contents (Husaini & Cooper 1957; Wasserman 1966). Burt (1989) has given a reviewed and detailed account of the sundried and smoked products which revealed that this preservative techniques are mostly applied on finfishes and rarely on shellfishes. Though many gastropod shellfishes play a vital role as food and in coastal economy, no scientific studies have so far been carried out on sundrying and smoking in India. The aim of this study is to evaluate the quality of the meat of *C. ramosus* by smoking and sundrying, and to propose some quality improvements.

MATERIALS AND METHODS

Chicoreus ramosus were collected by gill nets from Mandapam coastal waters (Lat. 9°17'N; Long. 79°8'E), Gulf of Mannar, southeastern India. Unbored animals, 17-19 cm long, were transported to the laboratory. The shells were washed, operculum removed, boiled in water for 20 minutes, and the meat shucked off. The foot and columella muscles were carefully separated and sliced (2 mm thick). The slices were blanched in 10 % brine for 20 minutes, and divided into two lots. One lot was used for sundrying and the other for smoking. For sun-drying, the meat was spread separately on palm leaves and kept in sunlight for about 8 hrs (8 AM to 4 PM). Smoking with saw dust was done using an AFOS-Torry Mini Kiln. The duration of smoking was about one and a half hour at 40 °C during the initial 30 minutes and 60-70 °C thereafter. The samples were sundried after smoking.

Both samples were dried to a 10 % moisture level, packed in polyethylene bags separately and stored at room temperature. The quality of the meat was analyzed by chemical, microbial and organoleptic characters. The biochemical constituents were analyzed monthly.

The quality of meat was assessed chemically by the estimation of trimethylamine (TMA) and total volatile base nitrogen (TVBN) following the Conway microdiffusion method (Beatty & Gibbons 1937).

Microbiological examination

The total bacterial number (TBC) was calculated by the pour plate technique. A 1 gram sample was collected aseptically and transferred to 99 ml of sterile 50 % sea water and disintegrated with a sterile glass rod. Dilutions were made with 9 ml of 50 % sea water blank. One ml aliquots of 10^{-1} to 10^{-6} dilutions were pipetted out into sterile petri dishes, and 15-20 ml sterile ZoBell 2216e Marine agar (Himedia) was poured into the petri dishes. The plates in triplicates were incubated at room temperature (28 ± 2 °C) for 1 to 2 days. The average number of bacteria were

expressed as colony forming units (CFU) per gram of sample.

Total coliforms: Three tubes, three dilutions, and series of lauryl tryptose broth (Himedia) were used to determine most probable number (MPN) of coliforms (10, 1 and 0.1 ml samples in single strength broth of 10 ml each). Lauryl tryptose broth MPN tubes were incubated at 37 °C for 48 hrs and examined for growth and gas production. From the positive tubes a loopful of the cultures was reinoculated to brilliant green lactose bile broth (BGLB) (Himedia) and again incubated for 48 hrs at 37 °C. Tubes showing acid and gas production were recorded as confirmed for total coli-forms. Most probable numbers were obtained by employing MPN tables.

Faecal coliforms: The MPN series of EC broth (Himedia) were incubated at 44 ± 0.5 °C for 48 hrs. The tubes showing growth and gas production were recorded as faecal coliform. For the purpose of MPN counting, a loopful of the culture from the positive tubes was streaked on to eosin methylene blue (EBM) agar and Mac Congy agar and incubated at 37 °C for 24 hrs.

Staphylococcus aureus: Following the pour plate method, the sample dilutions were plated in triplicate with Baired-Parker agar medium (Himedia) incubated for 72 hrs in 37 °C and counted.

Salmonella: Each 25 g sample was ground and transferred to 225 ml of lactose broth and incubated at 37 °C for 24±2 hrs. From this a 1 ml sample was transferred to 10 ml selenite cystine broth and 10 ml tetrathionate broth and incubated at 37 °C for 24 hrs. From each broth a loopful of culture was streaked on brilliant green (BG) agar and bismuth sulphite (BS) agar and incubated at 37 °C for 24 hrs before the examinations.

Total mould count was carried out by the pour plate method. The serial dilutions were plated in rose bengal agar media (Himedia). The plates in triplicate were incubated for 5-7 days, and the fungal colonies counted.

Organoleptic characters like colour, flavour, crispness and taste of sundried and smoked meat were analyzed by five members of the Indian TMMP team. The meat was fried in refined sun flower oil for about one minute before the evaluation.

Biochemical analysis: The moisture was calculated by the difference in the wet and dry weight. Total protein content was estimated by the micro-Kjeldhal's method (AOAC 1970); total lipid by the Bligh & Dyer (1959) method; total carbohydrate by the phenol sulphuric acid reagent method (Dubois *et al.* 1956); glycogen by the Carrol *et al.* (1956) method; ash content by the A.O.A.C. (1970) method; sodium chloride content by the Gerasimov & Antonova (1979) method; water activity (a_w) by the Doe *et al.* (1983) method and steam volatile and steam non-volatile phenol by the Foster & Simpson (1961) method.

RESULTS

The percentage of total protein, total lipid, total carbohydrate, glycogen and sodium chloride were higher in the shucked meat than in the fresh (Table 1). However, the moisture, TMA, and TVBN contents were lower in shucked meat than in fresh.

Table 1. Biochemical constituents (in %) of fresh and shucked foot muscle (FM) and columella muscle (CM) of *C. ramosus*.

	Fresh		Shucked	
Parameters	FM	CM	FM	CM
Moisture	67.4	70.8	62.3	64.8
Protein	19.4	18.5	20.1	19.2
Lipid	0.2	0.2	0.3	0.2
Carbohydrate	5.3	4.7	5.9	4.7
Ash	1.7	1.6	1.7	1.6
Glycogen	2.6	2.6	3.0	2.8
TMA	1.8	3.4	1.5	1.6
TVBN	4.4	4.8	4.0	3.9
Salt	0.6	0.6	0.7	0.6

Generally the microbial load will be significantly reduced in shucked sample (Table 2). *Staphylococcus aureus* and *Salmonella* could not be detected in either fresh or shucked samples.

The smoked meat had longer shelf-life than the sun-dried, and generally the foot muscle of both sample types had longer shelf-life than the adductor. The shelf-life of sundried meat was 210 and 180 days for foot and columella muscles and 270 and 240 days for smoked foot and columella muscles, respectively.

The content of trimethylamine (TMA) in sundried and smoked meat steadily increased during storage (Fig. 1). The TMA content was higher in sun-dried than in smoked meat and the columella muscle had higher TMA content than the foot muscles. The increasing trend of total volatile base nitrogen (TVBN) was as in the case of TMA (Fig. 2). The increase of the water

activity was remarkably higher in sundried than in smoked meat (Fig. 3). The sodium chloride content gradually decreased with increasing storage in both sundried and smoked meat (Fig. 4). The steam volatile phenol and steam non-volatile phenol contents were estimated in the smoked meat. The Steam volatile phenol content was higher than the steam non-volatile phenol content (Fig. 5). Both phenol contents were higher in foot than in columella muscle and it gradually decreased during storage.

Table 2a. Microbiological characteristics of fresh foot and columella muscles of *C. ramosus*. (A) Total bacterial count; (B) Total coliforms; (C) Faecal coliforms; (D) *E. coli* ; (E) *Staphylococcus aureus*; (F) *Salmonella*; (G) Total mould count.

	Amount present in	
Microbes	Foot muscle	Columella muscle
(A)	53000 CFU/g	46000 CFU/g
(B)	22 MPN/100 g	32 MPN/100/g
(C)	16 MPN/100 g	20 MPN/100/g
(D)	8 MPN/100 g	6 MPN/100/g
(E)	Nil	Nil
(F)	3.5 MPN/100 g	2.0 MPN/100/g
(G)	53000 CFU/g	31000 CFU/g

Table 2b. Microbiological characteristics of shucked foot and columella muscles of *C. ramosus*. Same legend as 2a.

	Amount present in	
Microbes	Foot muscle	Columella muscle
(A)	3600 CFU/g	1800CFU/g
(B)	13 MPN/100 g	12 MPN/100/g
(C)	12 MPN/100 g	12 MPN/100/g
(D)	2 MPN/100 g	2 MPN/100/g
(E)	Nil	Nil
(F)	Nil	Nil
(G)	400 CFU/g	1700 CFU/g

Salmonella and *Staphylococcus aureus* were not detected during the storage periods in sundried meat (Table 3). Total coliforms, and faecal coliforms were not detected up to 60 days, and thereafter only in low numbers. *E. coli* was absent in foot and columella muscle up to 90 days, but appeared thereafter. Total bacterial number and total mould number increased with storage. *Salmonella* and *S. aureus* were not found in smoked products (Table 4), and total coliforms and faecal coliforms were not detected until after 90 days and *E. coli* not until after 120 days of storage.

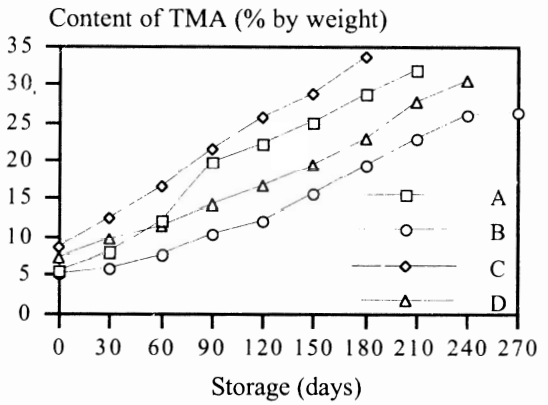

Figure 1. Changes in Trimethylamine (TMA) in sundried and smoked meat of *C. ramosus*. A: Sundried foot muscle; B: Smoked foot muscle; C: Sundried Columella muscle; D: Smoked Columella muscle.

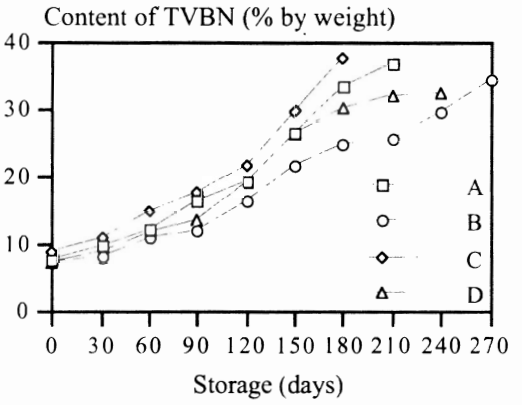

Figure 2. Changes in Total volatile base Nitrogen (TVBN of sundried and smoked meat of *C. ramosus*. A: Sundried foot muscle; B: Smoked foot muscle; C: Sundried Columella muscle; D: Smoked Columella muscle.

The organoleptic evaluation gave decreasing acceptability for both treatments. The samples were rejected after 210, 180, 270 and 240 days of storage for sundried foot, sundried columella muscles, smoked foot and smoked columella muscles respectively. The moisture content increased with storage. The total protein, total lipid, total carbohydrate, ash and the glycogen contents, decreased with increasing storage (Tables 6 and 7).

Table 3. Microbiological characteristics of sundried foot and columella muscles of *C. ramosus* during storage

Storage	TBC (CFU/g)		TC (MPN/100 g)		FC (MPN/100 g)		*E. Coli* (MPN/100 g)		TMC (CFU/g)	
(days)	FM	CM	FM	CM	FM	CM	FM	CM	FM	CM
0	40	20	-	-		-	-	-	20	30
30	160	90	-	-	-	-	-	-	30	30
60	100	1100	-	-	-	-	-	-	70	100
90	500	3000	2	3	1	2	-	-	400	300
120	3900	73000	4	4	1	2	2	-	1000	1200
150	180000	60000	6	4	5	5	4	2	1300	1700
180	160000	18000	12	18	12	17	12	8	29000	25000
210	360000	-	20	-	17	-	10	-	16000	-

FM - Foot muscle; CM - Columella muscle

Table 4. Microbiological characteristics of smoked foot and columella muscles of *C. ramosus* during storage.

Storage	TBC (CFU/g)		TC (MPN/100 g)		FC (MPN/100 g)		*E. Coli* (MPN/100 g)		TMC (CFU/g)	
(days)	FM	CM	FM	CM	FM	CM	FM	CM	FM	CM
0	-	-	-	-	-	-	-	-	-	-
30	20	70	-	-	-	-	-	-	-	-
60	40	220	-	-	-	-	-	-	-	-
90	180	400	-	-	-	-	-	-	10	30
120	200	2800	3	1	2	-	-	-	30	40
150	700	44000	4	4	1	2	2	-	30	40
180	3600	13000	4	4	4	4	3	2	110	70
210	108000	14000	7	5	6	6	5	3	200	300
240	76000	2800	13	12	12	12	12	12	400	1700
270	84000	-	17	-	22	-	20	-	2200	-

FM - Foot muscle; CM - Columella muscle

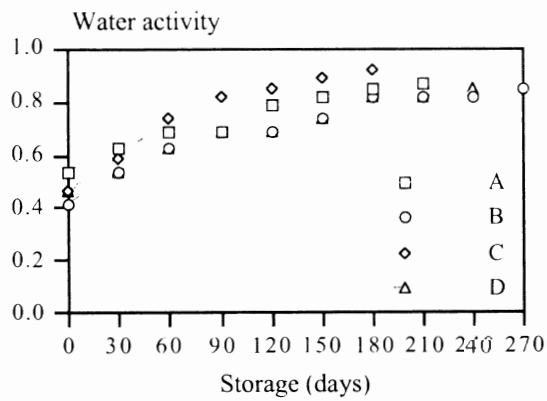

Figure 3. Changes in water activity of sundried and smoked meat of *C. ramosus*. A: Sundried foot muscle; B: Smoked foot muscle; C: Sundried columella muscle; D: Smoked columella muscle.

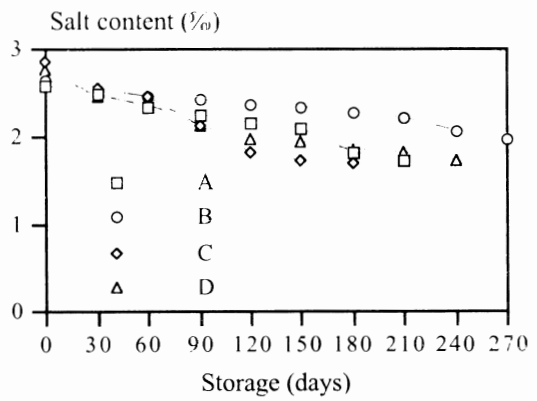

Figure 4. Changes in salt content of sundried and smoked meat of *C. ramosus*. A: Sundried foot muscle; B: Smoked foot muscle; C: Sundried columella muscle; D: Smoked columella muscle.

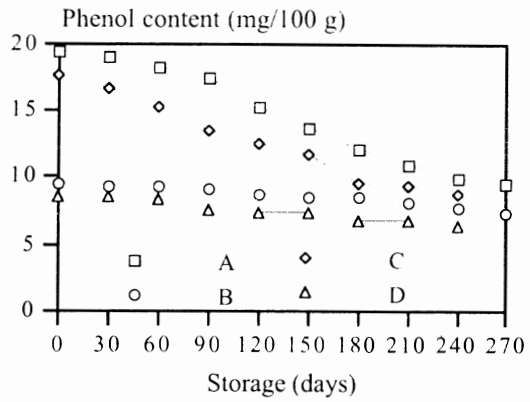

Figure 5. Changes in SVP and SNVP in smoked foot and columella muscle of *C. ramosus*. A: SVP foot muscle; B: SNVP foot muscle; C: SVP columella muscle; D: SNVP columella muscle.

Table 5. Average organoleptic scores of sundried and smoked foot and columella muscles of *C. ramosus* during storage. (Scale 0-5).

Storage	Sundried		Smoked	
(days)	FM	CM	FM	CM
0	4.8±0.8	4.7±0.16	4.9±0.05	4.8±0.08
30	4.6±0.7	4.6±0.80	4.8±0.50	4.7±0.04
60	4.6±0.1	4.5±0.02	4.7±0.05	4.5±0.13
90	4.5±0.05	4.5±0.26	4.7±0.04	4.5±0.06
120	4.5±0.05	4.4±0.10	4.6±0.07	4.4±0.06
150	4.4±0.22	4.1±0.09	4.5±0.04	4.2±0.05
180	4.3±0.08	4.2±0.15	4.5±0.04	4.2±0.05
210	4.2±0.12	3.5±0.22	4.5±0.04	4.1±0.72
240	3.7±0.16	-	4.3±0.06	4.1±0.62
270	-	-	4.2±0.05	3.9±0.04
300	-	-	3.7±0.08	-

Table 6. Changes in the biochemical composition of sundried foot and columella muscles during storage. (Values are expressed in % of the dry weight).

Storage	Moisture		Protein		Lipid		Carbohydrate		Ash		Glycogen	
(days)	FM	CM	FM	CM	FM	CM	FM	CM	FM	CM	FM	CM
0	10.02	10.42	65.42	62.19	1.65	1.63	15.74	14.24	6.43	6.14	7.63	7.23
30	11.16	13.53	65.21	62.12	1.65	1.61	15.48	14.10	6.36	5.93	7.56	6.72
60	13.52	15.62	65.34	61.64	1.64	1.55	15.21	13.87	6.21	5.82	7.49	6.51
90	14.56	18.36	65.28	61.34	1.64	1.59	14.96	13.53	5.86	5.66	7.36	6.24
120	16.61	19.71	64.16	61.03	1.64	1.55	14.72	13.42	5.43	5.52	7.22	6.12
150	17.65	21.92	63.43	60.75	1.62	1.53	14.24	12.72	5.24	5.38	7.17	5.76
180	19.68	23.48	63.13	60.53	1.62	1.53	13.63	12.06	5.03	5.14	7.06	5.21
210	20.32	-	62.51	-	1.52	-	13.42	-	4.89	-	6.98	-

FM: Foot muscle; CM : Columella muscle

Table 7. Changes in the biochemical composition of smoked foot and columella muscles during storage. (Values are expressed in % of the dry weight).

Storage	Moisture		Protein		Lipid		Carbohydrate		Ash		Glycogen	
(days)	FM	CM	FM	CM	FM	CM	FM	CM	FM	CM	FM	CM
0	10.01	10.18	60.73	60.46	1.54	1.48	14.28	13.76	8.74	8.23	6.89	6.53
30	11.13	11.31	60.52	60.34	1.55	1.45	14.14	13.62	8.69	7.83	6.72	6.26
60	12.15	12.36	60.54	60.28	1.44	1.43	14.02	13.36	8.54	7.78	6.62	6.18
90	12.67	13.44	60.52	60.17	1.44	1.43	13.88	12.75	8.22	7.46	6.44	5.86
120	14.24	14.52	60.48	60.08	1.44	1.37	13.70	12.59	8.10	7.22	6.21	5.63
150	15.36	15.58	60.42	59.82	1.42	1.35	13.65	12.38	7.84	6.96	6.13	5.42
180	17.41	17.95	60.29	59.71	1.41	1.34	13.54	12.14	7.62	6.78	5.95	5.31
210	17.53	18.74	60.19	59.53	1.39	1.33	13.11	11.02	7.36	6.53	5.82	5.17
240	18.54	19.82	60.08	59.22	1.35	1.32	12.78	11.82	7.25	6.43	5.66	5.04
270	19.65	-	59.14	-	1.32	-	12.64	-	7.16	-	5.42	-

FM: Foot muscle; CM: Columella muscle

DISCUSSION

The moisture of boiled and shucked meat decreased, resulting in a proportional increase of all the biochemical contents.

The TMA and TVBN contents increased in the sundried and smoked muscles, mainly due to the TMA production as a result of bacterial reduction of trimethylamine oxide (TMAO) (Beatty and Gibbons 1937). The bacterial enzymes present in the flesh of certain species are also known to degrade TMAO (Castell *et al.* 1968). Antonacopoulos (1971) noted that the TMA and TVBN values should be used in comparison with sensory evaluations but not as obligatory limits.

The water content increased gradually in both treatments, though, the initial level was remarkably low. The increasing water activity during the storage was remarkably lower in smoked than in sundried meat. The smoking process lowered the water content and hence contributed to the stability of the products (Proctor 1977). The present study also confirmed that the shelf-life of the smoked samples was higher than that of sundried meat, 270 days for foot and 240 days for columella muscles. The increase in water content of both treatments might be due to the absorption of moisture.

More than 10 % salt will effectively prevent bacterial growth (Shewan 1951). In the present study, the salt content of the sundried and smoked meat were below 3 % during the initial and storage periods. According to Shewan (1943) smoked fish becomes unpalatable if the salt content exceeds 4 %.

Phenol content was higher in smoked foot muscle than in columella muscle, probably due to a higher mucus secretion. The steam volatile phenol content was relatively higher than the steam-non-volatile phenol. It has been reported that in smoked products the phenol contents varied between 0.06 mg/kg and 5 g/kg (Lustre & Issenberg 1970; Akila 1992). In the present study a gradual decrease in both the phenol contents was noted during the storage period. This may be attributed to the volatile characters of the steam volatile phenol. Similar results were observed by Hanumanthappa & Chandrasekhar (1987) who reported a 16.22 % to 8.13 % reduction in steam volatile phenol during a 105 days storage of hot smoked mackerel.

In the present study pathogenic bacteria such as *Salmonella* and *Staphylococcus aureus* were not detected. The growth of microorganisms increases with the water activity (Scott 1957; Waterman 1976). Waterman reported that most bacteria causing spoilage will cease to grow below a water activity of 0.9 and halophilic bacteria do not grow below 0.75. Scott (1957) reported that *S. aureus* required a minimal water activity of 0.86 to grow, and *Salmonella* sp. needs 0.95 (Christian & Scott 1953). In the present study, the water activity during the entire storage (Fig. 3) was below the required value for both species. Moreover Lee and Pfeifer (1973) observed that *Staphylococcus* was inactivated by a temperature of 52 ± 1 °C for 8.5 minutes. The products in this study were smoked at 60-70 °C for one hour. The heat might therefore have killed *S. aureus*. *E. coli* was not detected until 90 and 120 days for sundried and smoked meat respectively. During this period, the water activity ranged between 0.69 and 0.85. According to Ware *et al.* (1955) the minimum water content requirements for growth of *E. coli* is 0.95. However, *E. coli* was detected in the remaining period even though the water activity was lower than the minimum requirement, which might be due to a secondary contamination, due to handling. In the sundried and smoked foot and columella muscles mould was found and the growth was higher in the dried meat than in the smoked, probably due to the fungicidal effects of the smoke. Waterman (1976) stated that the growth of mould is inhibited below a 0.8 water activity. Olley *et al.* (1989) reported that moulds present on food are not necessarily directly related to the measured water content of the food at a particular time. The level of all microbes were in this study within the EEC commission's acceptability limit (MPEDA 1993) and hence the products are safe and fit for consumption during the shelf-life period.

The overall acceptable limits of the organoleptic characters like colour, flavour, crispness and taste of the sundried foot and columella muscles were about 210 and 180 days respectively, and 270 and 240 days for the smoked foot and columella muscles respectively. The flavour of the sundried meat was like boiled potato. In smoked samples the flavour was found to be good during the storage period.

CONCLUSION

The present study revealed that the quality of *C. ramosus* meat was enhanced due to the processing. If the processed meat is packed in moisture proof packing

material, the storage time could possibly be increased. It was found that the characteristic flavour depended on the wood used for smoking, hence, standardization of suitable raw material is essential before popularizing the smoked *C. ramosus* meat.

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