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NUTRITIONAL QUALITIES OF SMOKED SHRIMP FROM THE SUNDARBANS MANGROVE AREA, BANGLADESH

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Quality aspects of a traditional smoked product from the shrimp *Metapenaeus brevicornis* in the Sundarbans mangrove area have been discussed. Studies on the physical properties, proximate composition, mineral content and amino acid value show that the quality of traditional smoked product is quite good. During 90 days of storage period the product was found to lose its characteristic properties and overall acceptability. However, smoked shrimp retained its overall acceptability up to 60 days of storage.

Key words: Smoking, Shrimp, Proximate composition, Micronutrient, Amino acid

Introduction

In artisanal fisheries of coastal Bangladesh, the common methods of preservation are sun drying and smoking with the exception of salted hilsa (*Tenualosa ilisha*). In the Sundarbans area, artisanal fishing dominates in both inshore and offshore water, about 60% of the catch is used for sun drying. Of the rest, small-sized shrimps, which represent 20-30% of catch, are smoke-dried. These shrimps, which are found in vast quantity, the fisherfolk heat and smoke over a fire using forest wood, and the semi-dried, characteristic brown coloured product can be stored for substantial period (Hossain 1984). This product is economically high-priced and is used as food by large numbers of coastal people.

In tropical countries, particularly in Africa, smoking is the most important method of fish preservation. Smoking is also practiced as a means of fish preservation in many south-east Asian countries, e.g. fish and prawn in India (Salagrama 1990), tuna in Maldives and Sri Lanka (BOBP 1988).

The importance of fisheries products is related to its nutritional quality, market value and acceptability to consumers. Smoking of shrimp in Sundarbans area has been considered as a technique for preservation since time immemorial due to availability of shrimp and smoking wood. This "hot smoking" process is traditional and the acceptable storage duration of the product is comparatively short. In this paper attempts have been made to evaluate the smoking process and the product of *Metapenaeus brevicornis* from nutritional point of view, and also storage quality.

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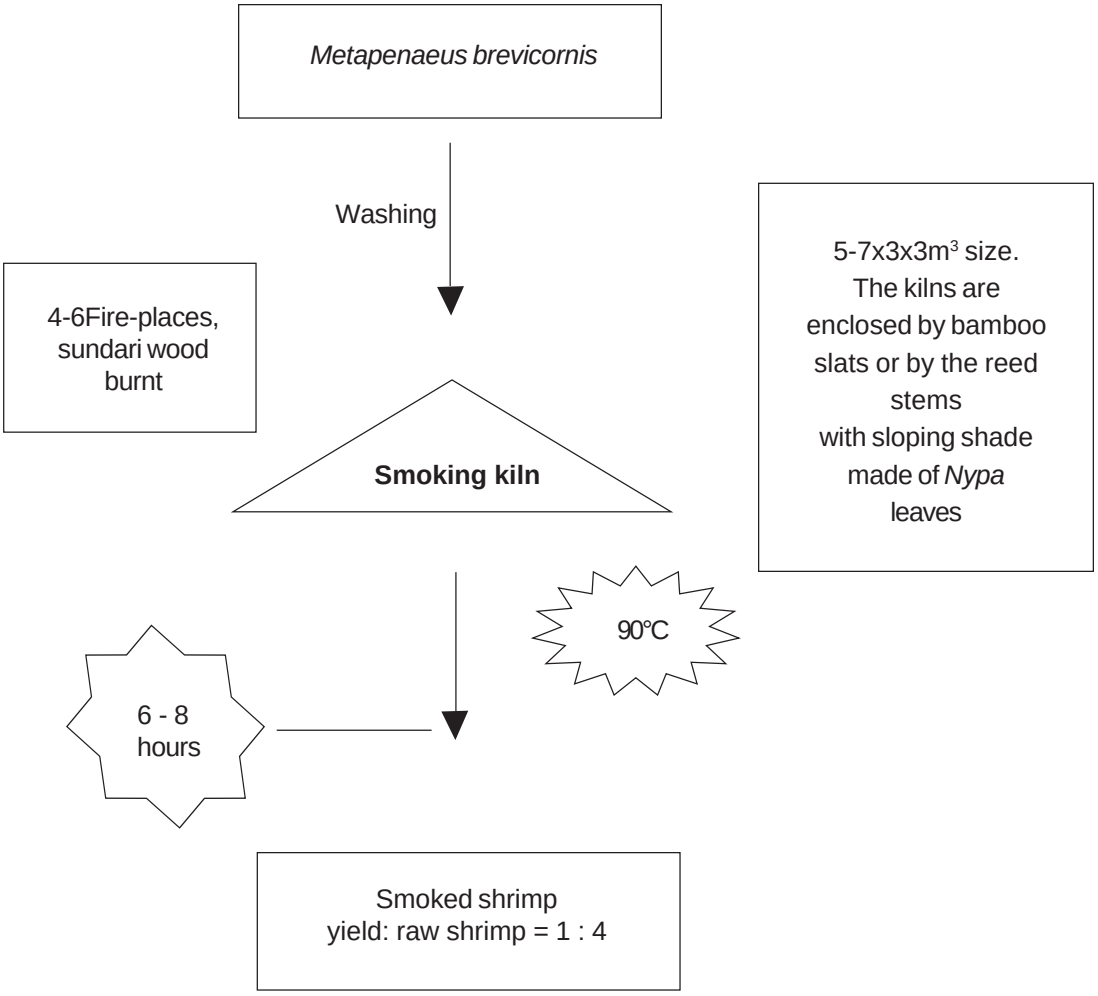
Materials and Methods

Smoking process. The traditionally smoked product is prepared near the coastal rivers. The smoking kilns are bamboo structures with a sloping roof of mangrove origin and thatched golpata (*Nypa fruticans* leaves). Sometimes a one meter high muddy wall surrounds the kiln. Usually, the size of the kiln is about 5-7x3x3 meters which can be opened along one side like a flap. A platform made of bamboo slats and woven reeds is made about 1.5 m high from the floor. At least 4 fire-place are operated inside kiln and the wood like "sundri" (*Heritiera fomes*) is used as fuel. The characteristic nature of sundri wood is that it burns very slowly and produces smoke. Burning inside the kiln is controlled by a long bamboo handle, which is operated through the holes of kiln. The kiln has enough ventilation to exit the smoke produced.

Smoking kilns normally run during the rainy season (mid June to mid September) when plenty of mixed species of shrimp/ prawns are available in the rivers of the Sundarbans mangrove forest. Usually, shrimp/prawns of commercial importance *Penaeus monodon*, *P.indicus*, *Metapenaeus monocerous*, *Macrobrachium rosenbergii* are marketed fresh or frozen for export. Other species like *Metapenaeus brevicornis, M. dobsoni, Palaemon styliferus, Macrobrachium* spp. are used for smoking. In the present study, *M. brevicornis* was used as raw material and the smoking operation was carried out in a kiln located near the Sundarbans (Scheme 1). Whole operation was slightly improved over that of the traditional method of smoking. After collection from local fishermen, the *Metapenaeus brevicornis* locally known as "kucho chingri" were sorted out from other species groups and those above



Scheme 1. Schematic diagram of smoking process.

4 cm total length were used as raw material. At the time of sorting, other foreign particles like leaf-fragments, molluscan shell, other fish and shrimp species were removed. Then the shrimps were placed in bamboo baskets and washed several times with tube-well water. Generally, during traditional method mixed shrimp species are used in smoking process and proper handling and washing is not done, hence, there is ample scope for quality deterioration.

After washing and removal of excess water, the shrimps were weighed (130 kg) and placed on the bamboo platform and the wood in the fire-place is lit. The quantity of fire-wood used not measured, but it was enough to produce adequate smoke. After 2 h, when the shrimps turned reddish colour, they were turned upside down with the help of a long arm wooden handle. The fire-place was operated for 6 h and the burning charcoal extinguished with water, and smoked shrimp were kept inside the kiln for another 2 h to be cooled. After that the folded door was opened and the end products were taken out and weighed for yield estimation.

The inside temperature of the kiln was recorded at 15 to 30 min interval using a Celsius thermometer. Temperature was measured on the layer of shrimps placed on bamboo platform, and recorded at 3 different places inside the kiln. For a better understanding of temperature distribution inside a traditional two other smoking kilns, nearby, were monitored and the temperature during smoking operation was recorded on consecutive days.

Immediately after smoking, ready to be marketed, smoked shrimps were placed in air tight clear polythene bags and divided into 3 groups to be analyzed after 30, 60 and 90 days of storage study. While some of the shrimps, were analyzed for various parameters and this was taken as zero-time sample. Polythene bags containing smoked shrimps, were then placed in a cardboard box and kept in the laboratory at room

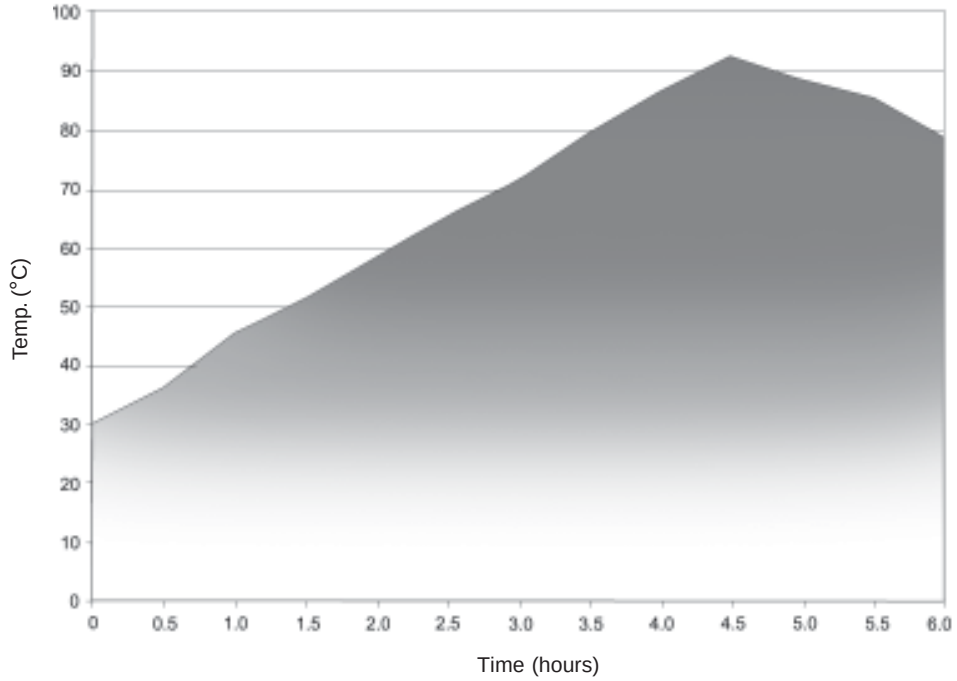


Fig 1. Mean inside temperature of smoking kiln during 6 h time.

temperature. The smoked product is normally stored in bamboo baskets or reed stem bags and marketed during the lean season.

Market samples of smoked shrimp were collected from the city of Chittagong to compare with the above.

Ambient temperature, rainfall and relative humidity data were collected from the local Meteorological Station.

Analytical procedure. Proximate composition of the raw shrimp and smoked shrimp at different storage periods was conducted by following the methods of AOAC (1980).

For pH determination, 2 g of ground sample was diluted in 10 ml of distilled water and pH was measured using a direct reading digital pH meter (pH 523, WTW, Germany).

Reconstitution property was assessed as percentage of water imbibed by 100 g of sample soaked in 400 ml of water, both at room temperature and 80˚C for a period of 2 h by following the method of Valsan (1975).

Total Volatile Base Nitrogen (TVB-N) of the smoked samples were determined accordingly to the method described by Commission of the European Communities (1995).

Peroxide Value (POV) of samples was determined by following the methods described by Egan *et al* (1981).

Total bacterial count expressed as colony forming units (CFU/g) of smoked products was estimated by standard plate count method on plate count agar by following the dilution technique.

For mineral content, pre-digested sample composition was determined using Perkin-Elmer 2380 Atomic Absorption Spectrophotometer by following modified method of Cresser and Parson (1979).

Amino acid composition of smoked product was determined at Stirling University, UK using an LKB 4151 Alpha-Plus Amino acid analyzer (LKB Bichrom Ltd., Cambridge).

Results and Discussion

Mean inside temperature of the 3 smoking kilns is presented in Fig 1. The initial temperature recorded was 30˚C.During 1 h period the temperature increased to 45˚C, after 2 h when the shrimp on bamboo platform turned upside down the temperature remained at 60˚C (66˚C in experimental kiln) then, it further increased to 92-94˚C in 4.5 h period. The temperature then gradually decreased to78˚C (75˚C in experimental kiln) when smoking operation was closed down. As the kiln was made of bamboo splits structure, it had enough ventilation through which some heat loss is expected. As 6 fire-places were placed uniformly inside the kiln, the temperature generated inside the kiln varies within a 4-7˚C range.

Table 1 represents the physical properties of smoked product. During 90 days storage, the smoky odour of the product was greatly reduced, pH of the product was initially 6.44, after 90 days, the pH value remained at 7.65. The pH of raw shrimp was 7.41. Water reconstitution property gradually increased with the storage at room temperature from 98.75 to 157.18% and was higher at 80˚C (130.43-163.44%) during 90 days of storage.

Table 1
pH, Reconstitution properties and sensory evaluation of smoked shrimp (*Metapenaeus brevicornis*)

Days		pH	Reconstitution (%)		Organoleptic properties		
			Room temperature	80°C	Smoky odour	Colour	Texture
Fresh shrimp		7.41	-	-	-	-	-
Smoked shrimp	0 day	6.44	98.75	130.43	Strong	Reddish brown	Springy
	30 days	7.32	121.78	139.94	Medium	Yellowish red	Less springy
	60 days	7.57	135.64	148.15	Less	Brownish yellow	Medium soft
	90 days	7.65	157.18	163.44	Poor	Reddish yellow	Soft

Table 2
Biochemical composition and bacterial load of smoked shrimp

Days	Moisture (g/100g)	Protein (g/100g)	Lipid (g/100g)	Ash (g/100g)	TVBN (mg/100g)	POV (meq/kg)	Bacterial load (cfu/g)
Fresh shrimp	79.95	72.37	11.62	15.46	-	-	-
Smoked - 0 day	12.70	77.98	7.88	13.08	22.75	17.40	2.46×10^4
30 days	16.89	77.58	9.54	11.71	25.93	31.50	2.70×10^4
60 days	21.42	72.75	12.59	13.97	27.16	46.05	1.65×10^6
90 days	24.19	68.74	15.38	14.72	29.33	55.30	1.41×10^7
Market sample	19.51	75.57	9.83	12.87	-	-	6.50×10^4

During the smoking operation, the ambient temperature was recorded as 29.3°C (September). After 30 days, the temperature decreased to 21.2°C with moderately heavy rainfall (82.5 mm). The day-time temperature decreased from 15.2 - 10.8°C in the next 60 days. The humidity (RH) during storage was recorded as 96 to 71%.

Storage quality of the smoked product was also studied for 90 days, the results of which is presented in Table 2. Moisture level at 90 days interval increased to 24% from initial 13%. The protein content of raw shrimp was 14.51%, after smoking the protein content found to be 68.08% due to loss of about 60% moisture. After one month storage protein content reduced to 64.48%. The protein percentage further reduced to 57.17% after 60 days and at 90 day it stands at 52% due to gradual increase of moisture content. Lipid content gradually increased to 11.66% from 6.88%. Proximate composition and bacterial load study in market sample revealed increased moisture level (19.51%) and decreased protein content (60.83%) with a microbial load of 6.5×10^4 cfu/g.

Total volatile base nitrogen (TVBN) value increased with storage time from 22.75% at ' 0' day to 29.33% at 90 day. Peroxide value (POV) increased largely from initial 17.4 to final 55.3 meq/kg of oil. Total bacterial counts of the smoked product increased to 1.41×10^7 cfu/g from an initial 2.46×10^4 cfu/g over 90 days (Table 2).

In an attempt to evaluate the biological and nutritive value of smoked shrimp, nutrient and amino acid composition of the product are given in Tables 3 and 4. Smoked shrimp was found to be rich in calcium, phosphorus, potassium, magnesium, iron, and essential amino acids.

There are more than 100 shrimp smoking units now operating in and around the Sundarbans, although the total production could not be estimated. Abundant shrimp catch and easily available fuel woods enable fishermen to operate these traditional smoking kilns during a particular season. Although collection of wood specially sundri from Sundarbans is prohibited, unauthorized collection of wood not only for fuel but for many other purposes is a common practice within the Sundarbans boundaries. Shrimps are smoked mainly to give it a flavour rather than to preserve it. Moreover, people from eastern boundaries of the country traditionally like to eat smoked shrimp.

The good smoky odour of the product lasts up to 30 days. Reconstitution property gradually increased with time due to changes in texture. Water reconstitution properties of 123-144% were observed in a market sample of smoked snakehead fish (*Channa* spp.) (Lilabati *et al* 1997). The pH value after 60 days indicated slightly alkaline nature of the smoked product. A good quality product that keeps well must lose 12-14% of its original weight during traditional smoking.

Table 3
Nutrient composition (mg/100g) of smoked shrimp

Mineral	Content	Mineral	(% Dry matter basis) Content
Phosphorus	1070	Copper	4.99
Potassium	500	Zinc	6.99
Magnesium	180	Manganese	2.76
Calcium	100	Iron	36.08

products of Bangladesh (Khan *et al* 1997). Moisture content increased rapidly during initial 30 days then slightly with the lapse of storage time. Smoked shrimps were stored in polythene bags, but due to tiny pores created by the pointed rostrum and telson of shrimps, air-tight conditions for the product could not be maintained. Moreover, moist weather due to rainfall may have caused increased moisture level in smoked product. For the storage and packaging of *Sardinella* spp. best results were obtained by misty and clear polythene rather than aluminium foil, brown paper or jute bags at ambient

Table 4
Amino acid composition (g/100g) of smoked shrimp

Amino acid	Content	Amino acid	Content	Amino acid	Content
Aspartic acid	4.13	Alanine	2.57	Tyrosine	1.43
Threonine	1.89	Cystine	0.45	Phenylanine	1.91
Serine	1.70	Valine	1.99	Histidine	1.11
Glutamic acid	5.85	Methionine	0.88	Lysine	3.24
Proline	2.20	Isoleucine	1.83	Arginine	3.35
Glycine	2.49	Leucine	3.11		

Traditional kilns often give the operator little or no control over the smoking process, although shrimps are turned upside down on bamboo split platform after 2 h when the inside temperature rises to 66˚C in experimental kiln and final smoking was completed in 4.5h at 92˚C. After that the folded door was partially opened to reduce the inside temperature to 75˚C at closing of smoking process (extinguishing of fuel woods). The way in which shrimps are placed on the bamboo platform in a kiln, in most cases too thickly, coupled with uneven heat distribution results in varying and poor quality of products. Although brining is recommended in hot smoking for flavour development but it was not done in the smoking process as the raw shrimps originated from moderately salt water sources (river salinity10-20 ppt) (Bannerman 1976). Fish that are hot smoked are cooked during the process, the kiln temperature may be as high as 80˚C and the fish temperature may reach 60˚C (Burgess and Bannerman 1963). The wood normally used for fuel is often freshly fallen from mangrove forests and the moisture it contains will affect its burning and drying qualities, and also smoking time. Fuel efficiency is not easy to measure accurately, but 0.5-1 kg of fire wood will be needed to process 1 kg of fresh fish of approximately 30-50% moisture (Ward 1995).

Although, previous data on smoked shrimp is not available, the composition and nutritive quality of the smoked shrimp was found to be comparable with exportable dried/salted dried

temperature (Eyabi and Ningo 1985). The quality of smoked fish products can be deteriorated due to mold growth if the moisture content is above 15% (Kaneko 1976). Attempts should be made to reduce the rate of moisture absorption of the product by using appropriate packaging material or storage facilities. Proximate composition of the present product is also comparable with the smoked dried products of Nigeria (Ikeme 1991), but much higher protein content was found in the present product than smoked prawn (protein content of 31.15%) (Lobao *et al* 1989). Total bacterial load increased near to double after 90 days of storage. Bacterial spoilage in smoked fish is mostly due to presence of nonspore forming rods which are most likely to be introduced during handling of the product (Graikoski 1973).

Mineral and amino acid content of the smoked product is satisfactory. Mineral content of smoked shrimp is much higher than smoked *Barbus* spp. (Qudrat-i-khuda *et al* 1962) and comparable to local sun dried shrimp (INFS 1977). A smoking temperature of about 150˚C will affect the availability of lysine, one of the essential amino acids found in fish protein (Virulhakul 1995) but this is higher than the temperature used to smoke prawns. It is well known that high temperature can damage food proteins (Hoffman *et al* 1977). During smoking of Atlantic mackerel, it was observed that 25% of lysine and 7% of other amino acids were lost (Bhuiyan *et al* 1986). Available lysine in smoked shrimp was 3.24%, which is comparable

with smoked *Sardinella* spp. from Nigeria (Egwele *et al* 1985). In the tropics, loss of available lysine on drying of fish is small and not significant from nutritional point of view (Blake 1990). From a nutritional point of view smoked shrimp can be considered as a product with good nutritive value. Economically, the product is comparatively high priced. One kg of smoked shrimp costs about 4 US$ at production site and during marketing the price increased to 5 US$.

Smoked shrimp produced in Sundarbans located in south-west corner of the country is mainly marketed in south-east part and requires about 15 h road journey. For transportation smoked shrimp is generally packed in special cylindrical basket made of reed stems and marketed in bamboo basket. Smoked products are vulnerable to damage and loss after processing (Poulter *et al* 1988). The mode of transportation and storage supports microbial spoilage which may deteriorate the quality of the product. Proper storage and keeping moisture at low level will help to improve product's quality. The smoked product available in local market only before the winter season as fish drying in coastal belt generally, starts with the beginning of winter. So, most of the product is consumed within 2-3 months of production and present study revealed that smoked shrimp is acceptable in good condition at 60 days of storage.

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