

Effect of Lemon, Mustard and Garlic Treatments on the Quality of Smoked Hilsa (*Tenualosa ilisha*) During Storage Period

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Abstract

The effects of lemon, mustard and garlic treatments on smoked hilsa during storage condition were analyzed. Hilsa fish was smoked, using a smoking kiln at 60°C to 70°C for 12 hours and stored in a polythene bag for further use. The proximate compositions of the smoked hilsa were determined in different storage period. The percentage of moisture (39.42 ± 4.87 to 56.74 ± 3.09), protein (31.01 ± 2.64 to 20.06 ± 9.87), lipid (16.12 ± 4.89 to 12.47 ± 3.09), ash (3.09 ± 0.27 to 4.19 ± 0.91), salt (5.27 ± 0.32 to 1.02 ± 0.82) and pH (6.16 ± 0.12 to 6.84 ± 0.18) value were found from smoked hilsa during storage condition. Smoking of hilsa showed high amount of protein value by the reduction of moisture. However, results of the study could be useful to fish consumers, processors and nutritionists to select their nutritional diet.

Keywords: Lemon; Mustard; Garlic; Smoked hilsa; Storage period

Introduction

Fish is one of the most essential sources of animal protein [1]. Fish preservation is a very important aspect of the fisheries. When the fishes are caught in numbers, greater than the amount of consumption; their preservation becomes a necessity for their future use. Preservation and processing therefore become a very important part of commercial fisheries. Fish is highly perishable, especially in tropical temperatures and need to be preserved for long term storage and about 30% of landed fish are lost through microbial activity alone [2]. So, fish Preservation become necessary to supply the distant market, to produce a range of products with different flavors' and textures and creations of condition unfavorable to the growth and survival of spoilage organisms [3]. Smoking is a method of fish preservation by a combination of drying and deposition of naturally produced chemicals resulting from the thermal breakdown of wood [4]. Smoking involves the application of heat to remove water and inhibits bacterial and enzymatic action on fish [5]. Some research study has been undertaken for the use of plant leaf extract for the control of quality on storage condition of smoked hilsa [6]. Storage time and temperature to be the major factors affecting the rate of loss of quality and shelf life of fish [7]. The effect of preservation methods and storage periods on nutritional values of fish species mainly was focusing on proteins, ash, lipids, moisture and carbohydrates [8]. The objective of this study was scrutinized the effect of lemon, mustard and garlic leaves extract on the quality of smoked hilsa.

Materials and Methods

Collection of fish

The experimental hilsa fish was collected from six selected regions (Barisal, Patuakhali, Bhola, Cox's Bazar, Chandpur and Shariatpur) of Bangladesh. The fish samples were transported to the laboratory in sterile polythene bags to avoid any type of microbial contamination.

Smoking procedure

The hilsa samples were killed gutted and washed thoroughly with clean water and were laid on the racks of the smoking kiln (model: ELC 1600). Heat was transferred by the burning of wood and smoking

carried out at 60°C to 70°C for 12 hours. At the end of smoking, the products were packed in polythene bags and kept in the refrigerator (Hajer Thermocool) for 60 days.

Proximate composition value

The proximate composition of hilsa fish were analyzed with following standard procedures [9]: moisture content by drying in an oven at 105°C for 24 h; crude protein content ($N \times 6.25$) by the Kjeldahl method using an Auto Kjeldahl System (Kjeltec™ 2300 Foss Tecator AB), lipid by ether extraction (Soxtec System HT6), ash by burning in a muffle furnace at 600°C for 6 h.

Salt value

Salt content of the raw fish were estimated by Mohor method [10]. The minced fishes were weighed and salt was extracted with distilled water. Sample were kept overnight at 10°C. The filtrate with salt content was titrated against standard N/10 silver nitrate ($AgNO_3$) solution in micro burette using potassium chromate as an indicator.

pH value

pH value of the sample was determined with the help of a pH meter (Mettler Toledo 320-s, Shanghai, China) following standard method [11].

Data analyses

After experiment, data were sorted, edited and encoded. All the collected data were summarized, scrutinized; tabulated and carefully

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Received September 27, 2016; Accepted October 14, 2016; Published October 21, 2016

Citation: Begum M, Bhowmik S, Juliana FM, Hossain MDS (2016) Effect of Lemon, Mustard and Garlic Treatments on the Quality of Smoked Hilsa (*Tenualosa ilisha*) During Storage Period. J Food Process Technol 7: 628. doi: 10.4172/2157-7110.1000628

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subjected to the descriptive analyses using the computer software MS Word, Microsoft Office Excel 2007 and XL-stat version 16 for DMRT to understand the differences of the variables.

Results and Discussion

Moisture

The moisture content of the smoked hilsa was increased during the storage period (Table 1). The ranged of moisture content lemon, mustard and garlic treatments smoked hilsa were $32.91 \pm 3.76\%$ to $52.64 \pm 2.09\%$, $34.55 \pm 3.09\%$ to $52.91 \pm 2.98\%$ and $27.57 \pm 4.33\%$ to $51.98 \pm 2.09\%$ respectively in storage condition. The results of the present

study, is consistent with the findings of in tilapia fish, who found an increasing trend in moisture composition with storage period [12]. The increase in moisture composition could be attributed to the loss of water holding capacity of tissue with increasing storage period [13].

Protein

The protein content of the smoked hilsa was decreased during the storage period (Table 2). The ranged of protein content lemon, mustard and garlic treatments smoked hilsa were $31.83 \pm 2.98\%$ to $20.27 \pm 3.67\%$, $32.27 \pm 5.31\%$ to $21.20 \pm 6.54\%$ and $34.57 \pm 7.42\%$ to $22.10 \pm 2.11\%$ respectively in storage condition. After smoking, the protein content of smoked hilsa slightly decreased during storage [14].

Treatments	Days	Chandpur	Barisal	Patuakhali	Bhola	Shariatpur	Cox's Bazar
Control	0 (fresh)	40.59 ± 7.12 ^a	39.42 ± 4.87 ^a	45.30 ± 4.76 ^a	44.29 ± 5.98 ^a	44.51 ± 2.99 ^a	42.08 ± 11.88 ^a
	15	42.45 ± 4.35 ^b	41.87 ± 5.34 ^b	47.87 ± 2.90 ^b	47.98 ± 7.65 ^b	45.34 ± 4.76 ^b	44.65 ± 9.09 ^b
	30	45.62 ± 5.83 ^c	44.35 ± 5.23 ^c	50.54 ± 7.09 ^c	49.08 ± 6.76 ^c	47.32 ± 3.00 ^c	48.56 ± 9.97 ^c
	45	47.89 ± 12.73 ^d	46.23 ± 9.76 ^d	53.47 ± 4.76 ^d	48.45 ± 5.98 ^d	52.67 ± 3.88 ^d	51.54 ± 10.54 ^d
	60	51.26 ± 3.23 ^e	49.91 ± 6.54 ^e	56.74 ± 3.09 ^e	52.35 ± 3.09 ^e	55.74 ± 4.34 ^e	53.20 ± 3.76 ^e
Lemon	0 (fresh)	33.28 ± 7.43 ^a	32.91 ± 3.76 ^a	42.90 ± 2.98 ^a	40.72 ± 7.98 ^a	42.84 ± 7.54 ^a	33.99 ± 2.09 ^a
	15	36.78 ± 5.73 ^b	35.98 ± 2.75 ^b	44.76 ± 4.87 ^b	43.25 ± 4.34 ^b	43.73 ± 8.54 ^b	35.43 ± 2.76 ^b
	30	41.76 ± 4.98 ^c	38.31 ± 1.78 ^c	48.95 ± 4.32 ^c	46.65 ± 3.87 ^c	45.87 ± 3.98 ^c	39.24 ± 3.77 ^c
	45	44.79 ± 7.12 ^d	40.43 ± 6.89 ^d	50.54 ± 3.45 ^d	47.43 ± 2.98 ^d	48.01 ± 8.32 ^d	43.31 ± 4.55 ^d
	60	47.11 ± 4.35 ^e	43.18 ± 4.76 ^e	52.64 ± 2.09 ^e	48.67 ± 2.09 ^e	49.94 ± 2.33 ^e	45.87 ± 3.76 ^e
Mustard	0 (fresh)	34.84 ± 6.87 ^a	34.55 ± 3.09 ^a	44.95 ± 6.98 ^a	42.02 ± 4.98 ^a	42.90 ± 3.23 ^a	38.19 ± 6.56 ^a
	15	36.78 ± 5.83 ^b	36.74 ± 3.87 ^b	45.16 ± 5.98 ^b	44.34 ± 5.75 ^b	43.87 ± 8.44 ^b	41.23 ± 8.76 ^b
	30	41.98 ± 4.09 ^c	39.53 ± 7.98 ^c	47.82 ± 3.33 ^c	46.23 ± 3.87 ^c	46.32 ± 4.66 ^c	45.87 ± 6.55 ^c
	45	46.52 ± 2.89 ^d	43.56 ± 3.88 ^d	50.72 ± 3.86 ^d	48.31 ± 5.54 ^d	47.89 ± 6.34 ^d	49.42 ± 3.33 ^d
	60	48.33 ± 7.43 ^e	45.83 ± 6.65 ^e	52.91 ± 2.98 ^e	50.85 ± 11.98 ^e	50.95 ± 13.65 ^e	52.56 ± 15.32 ^e
Garlic	0 (fresh)	32.96 ± 6.66 ^a	27.57 ± 4.33 ^a	42.14 ± 3.09 ^a	38.60 ± 8.88 ^a	41.96 ± 1.88 ^a	36.48 ± 10.09 ^a
	15	34.98 ± 11.09 ^b	31.46 ± 3.22 ^b	43.99 ± 3.07 ^b	41.34 ± 4.67 ^b	43.45 ± 4.32 ^b	39.42 ± 5.92 ^b
	30	38.92 ± 4.39 ^c	35.98 ± 4.98 ^c	46.76 ± 4.47 ^c	43.87 ± 4.44 ^c	46.13 ± 14.34 ^c	45.76 ± 6.54 ^c
	45	42.67 ± 9.73 ^d	37.14 ± 5.77 ^d	48.97 ± 3.21 ^d	46.64 ± 11.09 ^d	48.21 ± 2.54 ^d	48.21 ± 3.88 ^d
	60	45.67 ± 5.87 ^e	39.08 ± 10.65 ^e	51.98 ± 2.09 ^e	49.70 ± 3.33 ^e	50.70 ± 3.32 ^e	50.15 ± 5.29 ^e

*The values in the same column having similar superscripts do not differ significantly ($p < 0.05$).

Table 1: Moisture (%) content in smoked hilsa during storage period.

Treatments	Days	Chandpur	Barisal	Patuakhali	Bhola	Shariatpur	Cox's Bazar
Control	0 (fresh)	24.17 ± 6.56 ^e	28.70 ± 6.43 ^e	26.76 ± 3.33 ^e	23.22 ± 7.54 ^e	31.01 ± 2.64 ^e	21.01 ± 2.87 ^e
	15	23.56 ± 3.07 ^d	28.02 ± 6.09 ^d	25.83 ± 5.89 ^d	23.03 ± 3.99 ^d	30.85 ± 3.09 ^d	20.99 ± 5.47 ^d
	30	23.05 ± 4.73 ^c	27.65 ± 8.65 ^c	25.04 ± 9.76 ^c	22.51 ± 5.12 ^c	30.45 ± 2.65 ^c	20.87 ± 6.31 ^c
	45	22.78 ± 4.44 ^b	26.98 ± 5.43 ^b	24.87 ± 5.76 ^b	21.98 ± 2.54 ^b	29.87 ± 4.32 ^b	20.65 ± 4.30 ^b
	60	22.30 ± 3.65 ^a	26.65 ± 15.32 ^a	24.53 ± 6.34 ^a	21.52 ± 4.09 ^a	29.25 ± 5.37 ^a	20.06 ± 9.87 ^a
Lemon	0 (fresh)	25.20 ± 4.79 ^e	29.67 ± 1.98 ^e	28.11 ± 4.33 ^e	23.49 ± 8.77 ^e	31.83 ± 2.98 ^e	21.35 ± 7.65 ^e
	15	24.78 ± 9.43 ^d	29.05 ± 2.43 ^d	27.91 ± 2.87 ^d	22.45 ± 5.54 ^d	31.34 ± 7.88 ^d	21.10 ± 4.98 ^d
	30	24.54 ± 6.89 ^c	28.96 ± 5.37 ^c	27.76 ± 6.54 ^c	21.97 ± 7.43 ^c	30.89 ± 5.44 ^c	20.96 ± 7.43 ^c
	45	23.98 ± 4.76 ^b	28.56 ± 4.09 ^b	27.45 ± 9.87 ^b	21.65 ± 3.09 ^b	30.67 ± 2.09 ^b	20.63 ± 2.54 ^b
	60	23.64 ± 5.32 ^a	28.12 ± 2.87 ^a	27.20 ± 9.45 ^a	21.27 ± 7.77 ^a	30.30 ± 8.77 ^a	20.27 ± 3.67 ^a
Mustard	0 (fresh)	26.43 ± 1.23 ^e	30.57 ± 6.89 ^e	28.63 ± 8.78 ^e	24.65 ± 4.14 ^e	32.27 ± 5.31 ^e	22.90 ± 8.95 ^e
	15	26.11 ± 4.09 ^d	29.54 ± 3.21 ^d	28.21 ± 8.76 ^d	24.13 ± 3.08 ^d	32.09 ± 2.98 ^d	22.02 ± 7.88 ^d
	30	25.89 ± 4.65 ^c	28.99 ± 3.89 ^c	27.78 ± 10.09 ^c	23.79 ± 7.54 ^c	31.99 ± 12.76 ^c	21.71 ± 3.09 ^c
	45	25.68 ± 3.78 ^b	28.71 ± 5.87 ^b	27.56 ± 4.93 ^b	23.59 ± 4.66 ^b	31.91 ± 3.22 ^b	21.49 ± 8.97 ^b
	60	25.27 ± 3.98 ^a	28.30 ± 6.11 ^a	27.45 ± 2.09 ^a	23.32 ± 3.43 ^a	31.75 ± 1.58 ^a	21.20 ± 6.54 ^a
Garlic	0 (fresh)	28.98 ± 4.76 ^e	31.76 ± 4.23 ^e	30.99 ± 4.33 ^e	25.80 ± 2.09 ^e	34.57 ± 7.42 ^e	23.79 ± 2.13 ^e
	15	28.82 ± 5.98 ^d	31.23 ± 2.09 ^d	30.32 ± 2.33 ^d	25.14 ± 13.98 ^d	34.27 ± 3.87 ^d	23.33 ± 4.44 ^d
	30	28.65 ± 4.32 ^c	30.87 ± 3.13 ^c	29.88 ± 1.87 ^c	24.81 ± 2.10 ^c	33.98 ± 6.54 ^c	22.73 ± 3.76 ^c
	45	28.41 ± 7.89 ^b	30.54 ± 4.99 ^b	29.51 ± 2.98 ^b	24.65 ± 0.99 ^b	33.65 ± 2.90 ^b	22.37 ± 5.43 ^b
	60	28.11 ± 9.67 ^a	30.25 ± 6.01 ^a	29.35 ± 2.44 ^a	24.50 ± 1.87 ^a	33.25 ± 7.44 ^a	22.10 ± 2.11 ^a

*The values in the same column having similar superscripts do not differ significantly ($p < 0.05$).

Table 2: Protein (%) content in smoked hilsa during storage period.

Fat

The lipid content of the smoked hilsa was decreased during the storage period (Table 3). The ranged of lipid content lemon, mustard and garlic treatments smoked hilsa were 21.99 ± 5.43% to 17.76 ± 2.09%, 22.90 ± 5.43% to 17.89 ± 6.74% and 23.48 ± 1.56% to 20.12 ± 6.65% respectively in storage condition. The total lipid content showed a progressive decrease in the entire smoked hilsa during storage period and it was probably due to oxidative deterioration, there-by affecting lipid extraction [15]. The high degree of unsaturation in the form of multiple double bonds in fatty acids renders fish highly susceptible to oxidative rancidity [16].

Ash

The ash content of the smoked hilsa was increased during the storage period (Table 4). The ranged of ash content lemon, mustard and garlic treatments smoked hilsa were 3.01 ± 0.48% to 3.90 ± 0.76%, 2.96 ± 0.31% to 3.97 ± 0.54% and 2.98 ± 0.52% to 3.99 ± 0.26% respectively in storage condition. Similar levels of ash content in smoked fish were noticed by several workers [17].

Salt

The initial salt content of smoked hilsa gradually decreased in storage period (Table 5). The ranged of salt content lemon, mustard and

Treatments	Days	Chandpur	Barisal	Patuakhali	Bhola	Shariatpur	Cox's Bazar
Control	0 (fresh)	15.08 ± 3.09 ^e	16.12 ± 4.89 ^e	15.35 ± 6.98 ^e	15.48 ± 2.98 ^e	16.03 ± 9.65 ^e	15.04 ± 5.94 ^e
	15	14.88 ± 7.65 ^d	15.87 ± 6.54 ^d	15.13 ± 4.56 ^d	14.65 ± 5.46 ^d	15.57 ± 5.48 ^d	14.79 ± 3.82 ^d
	30	14.45 ± 4.21 ^c	15.48 ± 3.23 ^c	12.97 ± 1.19 ^c	13.99 ± 7.54 ^c	14.87 ± 3.98 ^c	14.02 ± 5.16 ^c
	45	13.78 ± 2.18 ^b	14.98 ± 3.76 ^b	12.75 ± 2.87 ^b	13.67 ± 3.90 ^b	14.56 ± 7.65 ^b	13.78 ± 0.98 ^b
	60	13.18 ± 5.48 ^a	14.76 ± 1.23 ^a	12.47 ± 3.09 ^a	13.43 ± 1.36 ^a	14.27 ± 3.34 ^a	13.32 ± 1.65 ^a
Lemon	0 (fresh)	21.99 ± 5.43 ^e	20.33 ± 8.54 ^e	21.56 ± 5.34 ^e	19.07 ± 4.34 ^e	20.56 ± 1.43 ^e	19.23 ± 4.98 ^e
	15	20.47 ± 2.13 ^d	19.78 ± 3.21 ^d	21.31 ± 2.49 ^d	18.92 ± 5.98 ^d	20.31 ± 3.98 ^d	19.03 ± 3.24 ^d
	30	19.95 ± 2.57 ^c	19.45 ± 1.76 ^c	20.89 ± 4.57 ^c	18.57 ± 6.57 ^c	19.79 ± 5.76 ^c	18.77 ± 8.76 ^c
	45	19.67 ± 1.09 ^b	18.78 ± 5.90 ^b	20.69 ± 4.09 ^b	17.99 ± 4.23 ^b	19.47 ± 5.67 ^b	18.33 ± 5.63 ^b
	60	19.10 ± 1.79 ^a	18.42 ± 4.32 ^a	20.40 ± 1.79 ^a	17.76 ± 2.09 ^a	19.05 ± 4.53 ^a	17.99 ± 2.09 ^a
Mustard	0 (fresh)	22.90 ± 5.43 ^e	21.37 ± 5.09 ^e	22.01 ± 2.87 ^e	20.65 ± 6.78 ^e	21.04 ± 7.09 ^e	20.45 ± 8.76 ^e
	15	22.52 ± 3.22 ^d	20.01 ± 1.11 ^d	21.54 ± 9.73 ^d	19.99 ± 2.84 ^d	20.91 ± 2.34 ^d	20.02 ± 3.27 ^d
	30	21.98 ± 7.25 ^c	19.87 ± 1.76 ^c	20.96 ± 10.96 ^c	19.02 ± 5.80 ^c	20.68 ± 7.98 ^c	19.87 ± 4.98 ^c
	45	21.65 ± 6.31 ^b	19.49 ± 4.32 ^b	20.32 ± 3.28 ^b	18.45 ± 2.27 ^b	20.24 ± 2.09 ^b	19.56 ± 7.65 ^b
	60	21.34 ± 4.22 ^a	19.22 ± 3.78 ^a	19.78 ± 0.97 ^a	17.89 ± 6.74 ^a	19.78 ± 8.13 ^a	19.34 ± 4.67 ^a
Garlic	0 (fresh)	23.48 ± 1.56 ^e	22.02 ± 7.75 ^e	22.07 ± 1.30 ^e	21.70 ± 1.79 ^e	22.08 ± 2.76 ^e	21.78 ± 6.32 ^e
	15	23.02 ± 4.98 ^d	21.94 ± 6.23 ^d	21.93 ± 2.56 ^d	21.31 ± 2.98 ^d	21.89 ± 1.98 ^d	21.32 ± 1.98 ^d
	30	22.89 ± 4.21 ^c	21.76 ± 4.27 ^c	21.79 ± 6.89 ^c	20.87 ± 6.57 ^c	21.65 ± 9.56 ^c	20.83 ± 2.64 ^c
	45	22.46 ± 4.09 ^b	21.46 ± 1.06 ^b	21.56 ± 3.98 ^b	20.65 ± 1.67 ^b	21.34 ± 1.13 ^b	20.43 ± 3.70 ^b
	60	21.99 ± 5.43 ^a	21.13 ± 1.59 ^a	21.23 ± 2.76 ^a	20.43 ± 4.32 ^a	20.89 ± 3.24 ^a	20.12 ± 6.65 ^a

*The values in the same column having similar superscripts do not differ significantly (p<0.05)

Table 3: Fat (%) content in smoked hilsa during storage period.

Treatments	Days	Chandpur	Barisal	Patuakhali	Bhola	Shariatpur	Cox's Bazar
Control	0 (fresh)	3.38 ± 0.87 ^a	3.42 ± 0.45 ^a	3.40 ± 0.35 ^a	3.27 ± 0.32 ^a	3.09 ± 0.27 ^a	3.52 ± 0.10 ^a
	15	3.50 ± 0.65 ^b	3.53 ± 0.32 ^b	3.52 ± 0.65 ^b	3.42 ± 0.97 ^b	3.19 ± 0.43 ^b	3.68 ± 0.28 ^b
	30	3.65 ± 0.43 ^c	3.72 ± 0.63 ^c	3.67 ± 0.16 ^c	3.64 ± 0.45 ^c	3.33 ± 0.21 ^c	3.86 ± 0.37 ^c
	45	3.73 ± 0.93 ^d	3.81 ± 0.15 ^d	3.82 ± 0.57 ^d	3.70 ± 0.43 ^d	3.47 ± 0.53 ^d	4.02 ± 0.67 ^d
	60	3.85 ± 0.62 ^e	3.89 ± 0.54 ^e	3.95 ± 0.67 ^e	3.79 ± 0.32 ^e	3.58 ± 0.92 ^e	4.19 ± 0.91 ^e
Lemon	0 (fresh)	3.25 ± 0.13 ^a	3.33 ± 0.93 ^a	3.15 ± 0.28 ^a	3.04 ± 0.42 ^a	3.01 ± 0.48 ^a	3.40 ± 0.49 ^a
	15	3.38 ± 0.47 ^b	3.52 ± 0.42 ^b	3.29 ± 0.54 ^b	3.26 ± 0.79 ^b	3.19 ± 0.65 ^b	3.56 ± 0.52 ^b
	30	3.51 ± 0.42 ^c	3.67 ± 0.25 ^c	3.45 ± 0.32 ^c	3.43 ± 0.93 ^c	3.31 ± 0.36 ^c	3.69 ± 0.65 ^c
	45	3.59 ± 0.56 ^d	3.78 ± 0.21 ^d	3.53 ± 0.83 ^d	3.52 ± 0.65 ^d	3.37 ± 0.18 ^d	3.81 ± 0.37 ^d
	60	3.66 ± 0.91 ^e	3.86 ± 0.26 ^e	3.63 ± 0.11 ^e	3.61 ± 0.63 ^e	3.44 ± 0.53 ^e	3.90 ± 0.76 ^e
Mustard	0 (fresh)	3.40 ± 0.62 ^a	3.37 ± 0.66 ^a	3.10 ± 0.54 ^a	3.09 ± 0.76 ^a	2.96 ± 0.31 ^a	3.31 ± 0.92 ^a
	15	3.55 ± 0.38 ^b	3.49 ± 0.87 ^b	3.22 ± 0.42 ^b	3.26 ± 0.16 ^b	3.17 ± 0.22 ^b	3.48 ± 0.33 ^b
	30	3.65 ± 0.19 ^c	3.61 ± 0.37 ^c	3.43 ± 0.78 ^c	3.39 ± 0.27 ^c	3.29 ± 0.29 ^c	3.66 ± 0.39 ^c
	45	3.70 ± 0.52 ^d	3.69 ± 0.32 ^d	3.59 ± 0.43 ^d	3.52 ± 0.52 ^d	3.37 ± 0.47 ^d	3.81 ± 0.62 ^d
	60	3.76 ± 0.13 ^e	3.78 ± 0.27 ^e	3.68 ± 0.48 ^e	3.65 ± 0.17 ^e	3.42 ± 0.27 ^e	3.97 ± 0.54 ^e
Garlic	0 (fresh)	3.50 ± 0.54 ^a	3.29 ± 0.62 ^a	3.14 ± 0.31 ^a	3.16 ± 0.14 ^a	2.98 ± 0.52 ^a	3.34 ± 0.93 ^a
	15	3.56 ± 0.87 ^b	3.43 ± 0.91 ^b	3.32 ± 0.33 ^b	3.39 ± 0.76 ^b	3.14 ± 0.17 ^b	3.49 ± 0.11 ^b
	30	3.68 ± 0.93 ^c	3.55 ± 0.47 ^c	3.45 ± 0.16 ^c	3.67 ± 0.43 ^c	3.19 ± 0.06 ^c	3.63 ± 0.26 ^c
	45	3.77 ± 0.35 ^d	3.72 ± 0.37 ^d	3.59 ± 0.48 ^d	3.79 ± 0.87 ^d	3.28 ± 0.97 ^d	3.82 ± 0.53 ^d
	60	3.87 ± 0.56 ^e	3.80 ± 0.65 ^e	3.69 ± 0.90 ^e	3.91 ± 0.98 ^e	3.37 ± 0.38 ^e	3.99 ± 0.26 ^e

*The values in the same column having similar superscripts do not differ significantly (p<0.05)

Table 4: Ash (%) content in smoked hilsa during storage period.

Treatments	Days	Chandpur	Barisal	Patuakhali	Bhola	Shariatpur	Cox's Bazar
Control	0 (fresh)	2.05 ± 0.15 ^a	4.68 ± 1.16 ^e	3.80 ± 0.99 ^e	3.22 ± 0.56 ^e	1.46 ± 0.38 ^e	5.27 ± 0.32 ^a
	15	1.88 ± 0.26 ^d	3.73 ± 0.74 ^d	3.45 ± 0.63 ^d	3.02 ± 1.22 ^d	1.37 ± 0.30 ^d	5.02 ± 0.58 ^d
	30	1.67 ± 0.18 ^c	3.16 ± 0.38 ^c	2.98 ± 0.65 ^c	2.76 ± 0.48 ^c	1.28 ± 0.28 ^c	4.82 ± 0.42 ^c
	45	1.36 ± 0.71 ^b	2.87 ± 0.42 ^b	2.55 ± 0.28 ^b	2.22 ± 0.52 ^b	1.16 ± 0.42 ^b	4.52 ± 0.52 ^b
	60	1.17 ± 0.58 ^a	2.34 ± 0.48 ^a	2.05 ± 0.84 ^a	1.76 ± 0.63 ^a	1.02 ± 0.82 ^a	4.10 ± 0.73 ^a
Lemon	0 (fresh)	1.46 ± 0.04 ^e	4.10 ± 0.13 ^e	3.22 ± 0.31 ^e	2.93 ± 0.63 ^e	1.32 ± 0.58 ^e	4.83 ± 0.72 ^a
	15	1.40 ± 0.31 ^d	3.58 ± 1.45 ^d	2.87 ± 0.47 ^d	2.53 ± 0.38 ^d	1.27 ± 0.62 ^d	4.56 ± 0.49 ^d
	30	1.34 ± 0.26 ^c	2.55 ± 0.42 ^c	2.32 ± 0.74 ^c	2.23 ± 0.62 ^c	1.21 ± 0.52 ^c	4.39 ± 0.42 ^c
	45	1.27 ± 0.15 ^b	1.98 ± 0.16 ^b	1.76 ± 0.85 ^b	1.82 ± 0.53 ^b	1.12 ± 0.93 ^b	4.02 ± 0.63 ^b
	60	1.19 ± 0.18 ^a	1.46 ± 0.87 ^a	1.32 ± 0.74 ^a	1.46 ± 0.73 ^a	0.99 ± 0.13 ^a	3.80 ± 0.59 ^a
Mustard	0 (fresh)	1.76 ± 0.42 ^e	3.80 ± 0.28 ^e	2.93 ± 0.29 ^e	2.93 ± 0.43 ^e	1.26 ± 0.39 ^e	4.53 ± 0.30 ^a
	15	1.71 ± 0.91 ^d	3.03 ± 0.52 ^d	2.35 ± 0.52 ^d	2.46 ± 0.28 ^d	1.20 ± 0.62 ^d	4.32 ± 1.14 ^d
	30	1.66 ± 0.13 ^c	2.53 ± 0.78 ^c	1.87 ± 0.52 ^c	1.93 ± 0.73 ^c	1.14 ± 0.32 ^c	4.03 ± 0.52 ^c
	45	1.57 ± 0.47 ^b	1.95 ± 0.52 ^b	1.58 ± 0.49 ^b	1.67 ± 0.48 ^b	1.04 ± 0.17 ^b	3.87 ± 0.50 ^b
	60	1.46 ± 0.42 ^a	1.46 ± 0.76 ^a	1.35 ± 0.43 ^a	1.32 ± 0.32 ^a	0.97 ± 0.42 ^a	3.66 ± 0.42 ^a
Garlic	0 (fresh)	2.06 ± 0.32 ^e	3.22 ± 0.28 ^e	2.63 ± 0.43 ^e	2.34 ± 0.37 ^e	1.19 ± 0.16 ^e	4.39 ± 0.59 ^a
	15	1.94 ± 0.76 ^d	2.78 ± 0.55 ^d	1.98 ± 0.29 ^d	2.11 ± 0.37 ^d	1.11 ± 0.16 ^d	4.13 ± 0.58 ^d
	30	1.89 ± 0.17 ^c	2.33 ± 0.42 ^c	1.67 ± 0.62 ^c	1.87 ± 0.28 ^c	1.02 ± 0.32 ^c	3.87 ± 0.32 ^c
	45	1.83 ± 0.52 ^b	1.87 ± 0.43 ^b	1.21 ± 0.87 ^b	1.53 ± 0.52 ^b	0.93 ± 0.26 ^b	3.69 ± 0.19 ^b
	60	1.76 ± 0.55 ^a	1.17 ± 0.10 ^a	0.88 ± 0.91 ^a	1.02 ± 0.59 ^a	0.85 ± 0.42 ^a	3.51 ± 0.49 ^a

*The values in the same column having similar superscripts do not differ significantly (p<0.05)

Table 5: Salt (%) content in smoked hilsa during storage period.

Treatments	Days	Chandpur	Barisal	Patuakhali	Bhola	Shariatpur	Cox's Bazar
Control	0 (fresh)	6.53 ± 0.39 ^a	6.44 ± 0.65 ^a	6.25 ± 0.37 ^a	6.16 ± 0.12 ^a	6.30 ± 0.47 ^a	6.70 ± 0.16 ^a
	15	6.56 ± 0.28 ^b	6.47 ± 0.43 ^b	6.31 ± 0.31 ^b	6.19 ± 0.42 ^b	6.38 ± 0.27 ^b	6.72 ± 0.42 ^b
	30	6.57 ± 0.57 ^c	6.51 ± 0.49 ^c	6.37 ± 0.68 ^c	6.23 ± 0.18 ^c	6.49 ± 0.83 ^c	6.75 ± 0.58 ^c
	45	6.60 ± 0.93 ^d	6.54 ± 0.63 ^d	6.42 ± 0.52 ^d	6.26 ± 0.57 ^d	6.55 ± 0.68 ^d	6.79 ± 0.83 ^d
	60	6.64 ± 0.47 ^e	6.58 ± 0.52 ^e	6.49 ± 0.46 ^e	6.30 ± 0.87 ^e	6.66 ± 0.17 ^e	6.84 ± 0.18 ^e
Lemon	0 (fresh)	5.97 ± 0.41 ^a	5.98 ± 0.62 ^a	5.63 ± 0.86 ^a	5.45 ± 0.74 ^a	5.77 ± 0.32 ^a	6.03 ± 0.16 ^a
	15	6.09 ± 0.43 ^b	6.08 ± 0.17 ^b	5.69 ± 0.16 ^b	5.54 ± 0.13 ^b	5.82 ± 0.26 ^b	6.09 ± 0.42 ^b
	30	6.21 ± 0.38 ^c	6.17 ± 0.16 ^c	5.74 ± 0.15 ^c	5.68 ± 0.32 ^c	5.86 ± 0.31 ^c	6.15 ± 0.15 ^c
	45	6.28 ± 0.82 ^d	6.24 ± 1.01 ^d	5.87 ± 0.32 ^d	5.83 ± 0.36 ^d	5.90 ± 0.32 ^d	6.20 ± 0.65 ^d
	60	6.35 ± 0.48 ^e	6.36 ± 0.37 ^e	5.96 ± 0.15 ^e	5.90 ± 0.82 ^e	5.95 ± 0.58 ^e	6.23 ± 0.27 ^e
Mustard	0 (fresh)	6.40 ± 0.42 ^a	6.41 ± 0.51 ^a	6.31 ± 0.54 ^a	6.27 ± 0.18 ^a	6.49 ± 0.09 ^a	6.54 ± 0.53 ^a
	15	6.42 ± 0.29 ^b	6.44 ± 0.68 ^b	6.38 ± 0.47 ^b	6.28 ± 0.16 ^b	6.54 ± 0.51 ^b	6.59 ± 0.16 ^b
	30	6.45 ± 0.52 ^c	6.47 ± 0.51 ^c	6.50 ± 0.16 ^c	6.29 ± 0.37 ^c	6.65 ± 0.38 ^c	6.63 ± 0.48 ^c
	45	6.47 ± 0.59 ^d	6.51 ± 0.59 ^d	6.54 ± 0.82 ^d	6.30 ± 0.18 ^d	6.69 ± 0.28 ^d	6.69 ± 0.82 ^d
	60	6.49 ± 0.17 ^e	6.54 ± 0.52 ^e	6.58 ± 0.16 ^e	6.32 ± 0.18 ^e	6.71 ± 0.19 ^e	6.72 ± 0.11 ^e
Garlic	0 (fresh)	6.35 ± 0.43 ^a	6.35 ± 0.31 ^a	6.33 ± 0.49 ^a	6.35 ± 0.43 ^a	6.41 ± 0.48 ^a	6.35 ± 0.73 ^a
	15	6.38 ± 0.27 ^b	6.37 ± 0.42 ^b	6.44 ± 0.42 ^b	6.36 ± 1.03 ^b	6.45 ± 0.51 ^b	6.43 ± 0.38 ^b
	30	6.41 ± 0.42 ^c	6.39 ± 0.52 ^c	6.49 ± 0.29 ^c	6.37 ± 0.32 ^c	6.49 ± 0.19 ^c	6.51 ± 0.52 ^c
	45	6.45 ± 0.65 ^d	6.41 ± 0.11 ^d	6.54 ± 0.41 ^d	6.38 ± 0.72 ^d	6.56 ± 0.48 ^d	6.59 ± 0.18 ^d
	60	6.48 ± 0.19 ^e	6.43 ± 0.18 ^e	6.62 ± 0.39 ^e	6.40 ± 0.26 ^e	6.61 ± 0.32 ^e	6.65 ± 0.53 ^e

*The values in the same column having similar superscripts do not differ significantly (p<0.05)

Table 6: pH value in smoked hilsa during storage period.

garlic treatments smoked hilsa were 4.83 ± 0.72% to 0.99 ± 0.13%, 4.53 ± 0.30% to 0.97 ± 0.42% and 4.39 ± 0.59% to 0.85 ± 0.42% respectively in storage condition. The decreased in salt content can be attributed to uptake of moisture during the storage period [18].

pH

The pH content of the smoked hilsa was increased during the storage period (Table 6). The ranged of pH content lemon, mustard and garlic treatments smoked hilsa were 5.45 ± 0.74 to 6.36 ± 0.37, 6.27 ± 0.18 to 6.72 ± 0.11 and 6.33 ± 0.49 to 6.65 ± 0.53 respectively in storage condition. The increasing pH values could be associated with

the production of basic components induced by the growth of bacteria and chemical reaction [19]. The pH changes are in agreement with the findings of several studies [20,21].

Conclusion

The result of the investigation shows that the smoked hilsa is a good source of protein and fat and that quality of fish is best before storage condition and that quality of smoked hilsa is better achieved in the first thirty days of storage. The quality of smoked hilsa remains good as the lemon, mustard and garlic treatment before smoking and deterioration slowly increases duration of storage increases.

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Citation: Begum M, Bhowmik S, Juliana FM, Hossain MDS (2016) Effect of Lemon, Mustard and Garlic Treatments on the Quality of Smoked Hilsa (*Tenualosa ilisha*) During Storage Period. J Food Process Technol 7: 628. doi: [10.4172/2157-7110.1000628](https://doi.org/10.4172/2157-7110.1000628)

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