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Effects of various processing techniques on the nutritional composition of exotic and indigenous fish species of Pakistan

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Abstract

This study assessed the effects of different processing techniques on proximate compositions of exotic fish species Tilapia (*Oreochromis niloticus*) and indigenous fish species Rohu (*Labeo rohita*) and Mori (*Cirrhinus miragla*). Total 109 specimens were collected from earthen fish ponds located in Fisheries and Aquaculture Department at Ravi Campus Pattoki, Lahore, Pakistan. The size of specimens belonging to tilapia was 200 g approximately while the weight of specimens of rohu and mori was approximately 1 kg. Fish products were developed by different preservation methods like drying, freezing, smoking and salting. The developed products were subjected to chemical analysis for nutrients. Two samples of each species were used to determine nutritional properties of the raw fish which was used as control group.

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Introduction

Fish is the economical, healthy and a very important food stuff with high quality of animal protein and other required nutrients that are rare in cereal based diets (Jamin and Ayinla, 2003; Virk and Sexena, 2003). Fish meat contain about 16-20% protein as compared to about 12% in egg, 6.6% in rice & wheat and 3.5% in milk (Ojutiku *et al*., 2009; Abowei and Tawari, 2011; Idah and Nwankwo, 2013). It contains amino acids such as lysine that serve as an efficient supplement to low protein, carries anticancer properties, minimizes the risk of heart ailment, source of therapeutic substances for the treatment of coronary diseases, anaemia and protein energy malnutrition (Barlas, 1986; Chua, 1986; Glomset, 1986; Idah and Nwankwo, 2013). It is the most important food available in the tropics, and it represents about 14% of all animal protein on a global basis, 50% in Asian region and in West Africa it provides between 30-80%, In Pakistan 14 kg meat/person/year is available and share of fish meat is only 2 kg/person/years (Eyo, 2001; Abolagba and Melle, 2008; Abowei and Tawari, 2011; Aberoumand, 2013). Fish meat can be converted into body tissues more efficiently than best known farm animals such as sheep, goat, cow and camel. Its digestibility is also very high and ranges between 85-90% (Rudolf, 1971).

Studies on fishes have assumed greater significance due to rapidly growing aquaculture industry. Such studies have generally been used as an effective and sensitive index to monitor physiological and pathological changes in fishes. While studying the effects of different processing techniques and their effect on the nutritional composition of different fish species, it is the utmost importance to establish baseline for these processing methods in Pakistan as very less work has been done on that economically important issue. Research has been conducted on the effect of smoking, salting, canning and other parameters of many fish species (Cardinal *et al.,* 2004; Colako, 2004; Donderoc *et al.,* 2004; Goulas and Kontominas, 2005) in the world but this aspect is poorly addressed in Pakistan and same is the case with fish products for consumption among masses to maintain desired health status (Hetzel, 1994; Onasanya, 2002; Mumba and Jose, 2005).

The need therefore arises for development of fish handling techniques for their wider applicability and further investigates their effects in nutritional quality of fish and its products to develop feasible and applicable techniques of fish processing to preserve and secure fish during and after harvesting and to study the physical and chemical effect of different processing methods on the nutritional composition of fish.

The basic aim of the research conducted was to detect the change of nutritional values of moisture, protein, lipid, ash, fiber and carbohydrate in three fish species after applying various techniques like drying, freezing, smoking salting and sensory evaluation. Objectives of this study were to develop feasible and applicable techniques of fish processing to save and secure fish during and after harvesting and to study effect of various processing methods on the nutritional composition to compare the nutritional value of developed products both physically and chemically under different method.

Materials and methods

The study was aimed to check the effects of drying, freezing, smoking salting on nutritional composition of one exotic fish species (*O. niloticus*) and two indigenous fish species (*L. rohita* and *C. miragla*) which were collected with the help of net from earthen fish ponds from Fish Farms Complex, Research and Training Facilities for Fisheries and Aquaculture at Ravi Campus Pattoki, UVAS Lahore.

Effect of drying on nutritional composition

Six samples of each freshly harvested tilapia, rohu and mori were selected to study the effect of drying on their nutritional composition. Fishes were divided into two groups: three fishes were processed (Eviscerated, beheaded and washed) and dried using smoking kiln (70-85°C) for 20 hours and the second group was dried using electric oven (110°C) for 45 minutes. After drying nutritional composition of both groups was analysed and compared.

Effect of freezing on nutritional composition

Two sample of each fish species were washed with tap water several times rinsed with distilled water and were cut into slices. The fishes were frozen at -18°C for duration of 30 and 60 days. A representative and homogenous sample was taken from the front, rare and the middle of fish. Two categories of fishes were independently for moisture, ash, fat, protein, fibre and carbohydrate contents as described by association of official analytical chemists (AOAC, 2000). The chemicals used were of reagent grade, while the water used were glass distilled.

Effect of smoking process on nutritional composition

A total of six fish samples two from each species were obtained and were gutted and washed thoroughly with clean water. Smoking of the fishes was carried out for 4 h. The smoke was produced by the burning of coal and wood (Salan *et al.,* 2006). After smoking, the product was divided into two parts: one was freshly smoked and ready for nutritional composition analysis; Second part of smoked fishes was packed in transparent polyethylene bags, sealed with a sealing machine to reduce microbial infestation (Salan *et al.,* 2006; Abolagba and Melle, 2008) and stored at a temperature of 4 ± 1°C (Bilgin *et al.,* 2008) for 20 days and then effect of smoking on nutritional components of fish were evaluated after 20 days preservation.

Effect of salting on nutritional composition

Two fish from each fish species were selected to determine the effect of salting on the nutritional composition. The fish were washed, cleaned, gutted and sprinkled with salt prior to analyse for proximate compositions described below. Salt was applied on the specimens. Two groups were made those salted for 30 days and then analysed and those salted for 60 days and then were analysed for nutritional composition.

Proximate composition analysis

From the samples the moisture content, crude protein, crude lipid, crude fibre and ash content were analysed by using the method of analyses by Association of Official Analytical Chemists (AOAC, 2005) as follows:

Moisture (%):

Moisture content was determined by oven drying method (AOAC 1980). Pre weighted samples were oven dried (95-105°C) using pre weight porcelain dishes. Moisture contents were computed as;

Weight of the crucible = W_0 Weight of the crucible +Wet sample = W_1

Moister contents of the sample (%) = $[(W_1\text{-}10)\text{-}W_2\text{-}20)] \times 100/W_1\text{-}W_0$

Weight of the crucible +Dry sample = W_2

Moisture factor = (100 – moisture)/100.

Ash (%):

Ash content was determined by ignition of samples in a muffle furnace at 550°C for 16 hours (AOAC, 1980). The percentage of ash were calculated as follows

Weight of the clean dry crucible = W_0 Weight of the clean dry crucible + dry sample = W_1, Weight of the clean dry crucible + ash = W_2

Ash content of the fresh sample (%) = $[W_2\text{-}20/W_1\text{-}W_0\times100] \times$ moisture factor.

Crude Protein (%):

Crude protein content was determined by using Kjeltec machine (Model TecatorKjeltec System 1026 Manual, 1987). Conversion factor of 6.25 was used to convert nitrogen to crude protein. The percentage of Nitrogen in the sample was calculated by using the following formula;

% of nitrogen= S-BxAxCx100/Weight of sample x1000

S = Titration reading for sample

B = Titration reading for blank

A = Strength of 0.01N HCl (0.01)

C = Digest taken for distillation (dilution factor)

% crude protein (fresh sample) = N_2 x 6.25 x moisture factor.

Crude Lipid (%):

Crude lipid was determined by using the Soxhlet system (model TecatorSoxtec System HT 1043-001 Manual, 1983) for extracting lipids of samples by petroleum ether.

Percentage of fat

% of fat (fresh sample) = [W_2-W_1/Sx100] x moisture factor

W_2 = Final weight of the conical flask, W_1= Initial weight of the empty conical flask S= Weight of the sample taken.

Crude fibre (%)

Crude fibre was determined by taking 3 g well mixed samples. Samples were dried and weight and crude fat was extracted from it with petroleum ether. Residue was transferred in digestion flask along with 0.5 g asbestos. 200 ml boiling 0.255 N H_2SO_4 was added and connected with condenser and boiled for 30 min. filtered the contents with linen cloth in fluted funnel, washed with distilled water. Transfer the residue to digestion flask with the help of boiling 0.313 N NaOH. Added more boiling 0.313 N NaOH till its volume is 200 ml. Then flask was connected with reflux condenser and boiled for 30 min. material was filtered with Gooch crucible and washed with boiling water and then 15 ml ethyl alcohol. This was cooled and weight and denoted as W_1. These contents were ignited in muffle furnace and weight again and denoted as W_2. Loss in weight (W_1 W_2) is crude fibre.

Crude fibre (%) = (W_1 W_2)/weight of sample X 100

Carbohydrates (%)

Nitrogen free extract or carbohydrate was extracted by adding up all determined components like moisture, ash, crude fibre, protein and fat in sample. This sum of components was subtracted from 100 to get carbohydrate (NFE).

% NFE = % DM - (% EE + % CP + % Ash + % CF)

Where NFE = Nitrogen free extract, DM = dry matter, EE = ether extract or crude lipid, CP = crude protein, CF = crude fibre

Statistical analysis

Data was analysed by two way ANOVA. Means were expressed using Minitab statistical programme at significant values $p<0.05$.

Results and discussions

The proximate compositions of control group i.e. raw Tilapia, Rohu and Mori are described in Table 1. Raw samples offered low protein, intermediate lipids and fibre, high moisture and ash contents, similar to formerly described by Eyo, 1998.

Moister

In control group the moister contents were maximum i.e. 91.14, 91.17 and 92.85 in Talapia, Rohu and Mori respectively. The smoking kiln (15.02, 17.65, and 16.75 in Talapia, Rohu and Mori respectively) produced superior product as compared to oven drying method (16.12, 18.74, and 17.85 in Talapia, Rohu and Mori respectively) by protecting the fish from microbes and other insects as moisture contents are more reduced in the first process. The result attained after 20 hours drying in smoking kiln in this work is not significantly different from the results recorded by Ogbonnaya, 2009. After drying decrease of moisture content and increase of protein, contents were noted this trend is in agreement with the results by Tao and Linchun, 2008.

The result showed that both techniques of drying are helpful to reduce the moisture content of fish as compared to control group in which moister contents are highest while moister contents are minimum in drying as shown in tables 2 & 3. And it is obviously confirm that reduced moisture contents as Clucas (1982) reported will cease mould growth and increase the shelf-life of fish. In 30 days salting moisture contents remain high (74.12, 74.5, 74.23) as compared to 60 days salting (64.14, 61.45, 63.45) in tilapia, rohu and mori respectively. In treated groups overall maximum value (84.15, 87.23 and 86.22) is observed in freshly smoked fish while minimum value (15.02, 17.65 and 16.75) is observed in drying by smoking kiln in tilapia, rohu and mori respectively.

Crude protein

The results of nutritional value of experimented fish revealed that protein content in control tilapia, rohu and mori are 23.14, 20.19 and 19.74 respectively which is comparable with Nurullah *et al.*,2003.

Table 1. Evaluation of Proximate composition (%age) of Raw fish, dried fish using electric oven and smoking. (Means ± SD).

Parameters	Control group			Drying in electric oven (110°C for 45 minutes)			Drying in Smookiig kiln (70-85°C for 20 hours)		
Proximate Composition (%)	Tilapia (*Oreochromis niloticus*)	Rohu (*Labeoro hita*)	Mori (*Cirhinus mrigala*)	Tilapia (*Oreochromis niloticus*)	Rohu (*Labeoro hita*)	Mori (*Cirhinus mrigala*)	Tilapia (*Oreochromi sniloticus*)	Rohu (*Labeoro hita*)	Mori (*Cirhinus mrigala*)
Moisture	91.14 ± 0.06	91.17 ± 0.08	92.85 ± 0.07	16.12 ± 0.12	18.74 ± 0.05	17.85 ± 0.07	15.02 ± 0.11	17.65 ± 0.04	16.75 ± 0.05
Crude Protein	23.14 ± 0.16	20.19 ± 0.18	19.74 ± 0.006	63.44 ± 0.28	64.19 ± 0.118	62.74 ± 0.16	62.43 ± 0.24	63.17 ± 0.18	63.74 ± 0.13
Crude Lipid	11.75 ± 0.19	9.64 ± 0.05	10.54 ± 0.27	23.35 ± 0.119	26.67 ± 0.15	24.56 ± 0.03	20.32 ± 0.15	21.67 ± 0.35	21.56 ± 0.04
Ash	3.8 ± 0.33	1.4 ± 0.006	1.14 ± 0.002	14.8 ± 0.173	11.4 ± 0.04	13.14 ± 0.02	12.7 ± 0.123	12.4 ± 0.02	12.17 ± 0.03
Crude Fiber	1.92 ± 0.01	1.57 ± 0.02	1.01 ± 0.01	1.52 ± 0.155	1.57 ± 0.04	1.51 ± 0.02	1.42 ± 0.165	1.46 ± 0.03	1.54 ± 0.03
Carbohydrate	3.75 ± 0.043	4.21 ± 0.116	4.52 ± 0.022	3.65 ± 0.14	4.15 ± 0.116	4.12 ± 0.062	4.55 ± 0.12	4.23 ± 0.13	4.15 ± 0.052

It is observed that protein content is variable as like other various contents at different conditions. It has been observed that there is a significant increase in protein levels ($P<0.05$) in dried fish (electric oven dried fish value 53.44, 54.19, 52.74) as compared to raw fish as described in case of results during this study. This is in agreement with the results of Puwastien *et al.,* 1999; Gokoglu *et al.,* 2009; Tao and Linchun, 2008.

Table 2. Evaluation of proximate composition (%) of processed fish by freezing method at -18°C.

Proximate Composition(%)	Tilapia (*Oreochromisniloticus*)		Rohu (*Labeorohita*)		Mori (*Cirhinusmiragla*)	
	Sample 1 30 days	Sample 2 60 days	Sample 1 30 days	Sample 2 60 days	Sample 1 30 days	Sample 2 60 days
Moisture	72.54 ± 0.11	74.55 ± 0.21	76.65 ± 0.17	78.52 ± 0.18	76.45 ± 0.16	77.55 ± 0.16
Crude Protein	10.25 ± 2.12	11.65 ± 1.33	11.45 ± 1.62	12.33 ± 1.24	11.51 ± 1.19	12.11 ± 1.16
Crude Lipid	6.21 ± 0.03	6.22 ± 0.02	6.20 ± 0.04	6.23 ± 0.03	6.18 ± 0.02	6.21 ± 0.03
Ash	0.49 ± 0.13	0.58 ± 0.13	0.54 ± 1.10	0.65 ± 1.12	0.51 ± 1.12	0.59 ± 1.13
Crude Fiber	1.55 ± 0.112	1.42 ± 0.165	1.45 ± 0.11	1.52 ± 0.10	1.30 ± 0.12	1.35 ± 0.14
Carbohydrate	3.95 ± 0.11	4.55 ± 0.12	4.23 ± 0.12	4.35 ± 0.13	4.15 ± 0.11	4.33 ± 0.13

These findings supported the validity of the present study the determined values differed from others and within different species (Viswanathan and Mathew, 2000).

A significant difference (P>0.05) within the treatments is noted as higher values 68.40% and 64.07% were recorded by Ime-Ibanga and Fakunle (2008) and Olayemi *et al.* (2011) after smoking.

Table 3. Evaluation of proximate composition (%) of smoked fish.

Proximate Composition(%)	Tilapia (*Oreochromis niloticus*)		Rohu (*Labeo rohita*)		Mori (*Cirhinus miragla*)	
	Sample 1 freshly smoked	Sample 2 after 20 days	Sample 1 freshly smoked	Sample 2 after 20 days	Sample 1 freshly smoked	Sample 2 after 20 days
Moisture	84.15	83.12	87.23	86.45	86.22	84.36
	±	±	±	±	±	±
	0.13	0.12	0.14	0.15	0.13	0.12
Crude Protein	20.45	19.58	22.15	21.45	19.88	18.37
	±	±	±	±	±	±
	0.121	0.142	0.26	0.27	0.32	0.31
Crude Lipid	14.22	14.05	13.45	12.32	11.67	11.45
	±	±	±	±	±	±
	0.03	0.041	0.32	0.21	0.43	0.23
Ash	24.33	25.45	24.55	25.54	22.51	23.11
	±	±	±	±	±	±
	0.02	0.05	0.12	0.14	0.13	0.14
Crude Fiber	1.02	1.01	1.51	1.35	1.65	1.23
	±	±	±	±	±	±
	0.125	0.13	0.14	0.134	0.15	0.12
Carbohydrate	4.55	4.15	4.87	4.25	4.11	4.05
	±	±	±	±	±	±
	0.12	0.12	0.11	0.10	0.14	0.13

Table 4. Evaluation of proximate composition (%) of processed fish by salting method.

Proximate Composition (%)	Tilapia (*Oreochromisniloticus*)		Rohu (*Labeorohita*)		Mori (*Cirhinusmiragla*)	
	Sample 1 30 days	Sample 2 60 days	Sample 1 30 days	Sample 2 60 days	Sample 1 30 days	Sample 2 60 days
Moisture	74.12	64.14	74.51	61.45	74.23	63.45
	±	±	±	±	±	±
	0.1	0.12	0.2	0.1	0.32	0.12
Crude Protein	54.31	53.15	56.24	49.75	56.13	48.18
	±	±	±	±	±	±
	0.04	0.05	0.05	0.03	0.02	0.01
Crude Lipid	14.34	12.25	13.67	11.56	14.34	12.15
	±	±	±	±	±	±
	0.121	0.14	0.12	0.13	0.17	0.11
Ash	71.15	64.11	69.55	61.23	68.45	60.12
	±	±	±	±	±	±
	0.20	0.19	0.23	0.15	0.24	0.17
Crude Fiber	1.62	1.45	1.85	1.22	1.35	1.15
	±	±	±	±	±	±
	0.131	0.121	0.13	0.21	0.14	0.11
Carbohydrate	4.65	4.15	4.84	4.05	4.92	4.12
	±	±	±	±	±	±
	0.11	0.10	0.09	0.08	0.13	0.14

This result is contrasting with earlier readings which all observed that smoking can increases crude protein, crude lipid, crude fibre and ash content of fish and meat products (Oparaku and Mgbenka, 2012; Ahmed *et al.,* 2011; Aliya *et al.,* 2012; Olayemi*et al.,* 2011; Akhter *et al.,* 2009; Afolabi *et al.,* 1994). As freshly smoked values are 20.45, 22.15, 19.88 and 20 days preservation after smoking protein values are 19.58, 21.45 and 18.37 in tilapia, rohu and mori respectively. This work confirmed the findings of Abolagba and Osifo (2004) who worked on fatty fish *Clariasgariepinus* that protein decomposes with passing time after smoking.

Tilapia, rohu and mori respectively indicating that salting, drying will increase the value of crude protein but still these values are less than protein value reported by Olayemi *et al.,* 2011 and Ime-Ibanga and Fakunle (2008) which were 68.40% and 64.07%. Overall comparison show that maximum protein values are observed in rohu 56.24 in fish salted for 30 days along with high values in fish dried in electric oven as shown in tables 2 and 3.

Table 5. Two-way ANOVA: Moisture versus Treatment, Species.

Source	DF	SS	MS	F	P
Treatment	8	19425.3	2428.17	1671.92	0.000
Species	2	19.7	9.84	6.78	0.007
Error	16	23.2	1.45		
Total	26	19468.3			

S = 1.205 R-Sq = 99.88% R-Sq (adj) = 99.81%.

Table 6. Two-way ANOVA: Crude Protein versus Treatment, Species**.**

Source	DF	SS	MS	F	P
Treatment	8	11957.3	1494.66	836.36	0.000
Species	2	4.3	2.13	1.19	0.329
Error	16	28.6	1.79		
Total	26	11990.1			

S = 1.337 R-Sq = 99.76% R-Sq (adj) = 99.61%.

Crude lipid

The result indicates that crude lipids values are 11.75, 9.65, 10.54 in control group while its values are increased in drying in electric oven (23.25, 26.67, 24.56) and drying in smoking kiln (20.32, 21.67, 21.56). Minimum crude lipid is noted in freezing up to 30 days (10.25, 11.45,11.51) in tilapia, rohu and mori respectively. Crude lipid values are also increased in freshly smoked and 20 days preserved after smoking and salting for 30 and 60 days are not significantly different as shown in tables 5-6. Crude lipids values are increased in smoked fish are also agreed with the values given by Ime-Ibanga and Fakunle (2008); Ogbonna and Ibrahim (2009).

Table 7. Two-way ANOVA: Crude Fibre versus Treatment, Species.

Source	DF	SS	MS	F	P
Treatment	8	918.487	114.811	118.02	0.000
Species	2	0.950	0.475	0.49	0.622
Error	16	15.565	0.973		
Total	26	935.002			

S = 0.9863 R-Sq = 98.34% R-Sq (adj) = 97.29%.

Ash content

Maximum ash contents have been observed in case of salting while minimum ash contents are observed (0.49,0.54,0.51) in freezing methods which is in agreement with earlier studies (Oparaku and Mgbenka, 2012; Eyo, 2001; Ekeocha *et al.,*2010). It has been observed that ash contents increased after using drying, smoking and salting as compared to control group while there is significant decrease in case of freezing methods. The results in case of salting (71.15, 69.55, 68.45) are deviated while in case of smoking and drying fall within the values (16.1%) given by FAO, 2007. The higher values of ash contents in salting method may be due to the presence of salt because unsalted control group has less ash value (3.8, 1.4, and 1.14) from salted samples.

Crude fibre

The values obtained in control group are 1.92, 1.57, 1.01 in tilapia, rohu and mori respectively. When all the treated groups are compared it is noted that value of crude fibre remain same and no significant difference is observed as compared to control group. The values of crude fibre after 30 days salting are 1.62, 1.85 and 1.35 while after 60 days salting values are1.45, 1.22 and 1.15 which show decrease in crude fibre value in 60 days samples. The results indicating crude fibre value are in agreement with those obtained in earlier studies (Afolabi*et al.,* 1994). Overall crude fibre is highest in raw tilapia (1.92) and 30 days salted rohu (1.85) while minimum value (1.01) is observed in 20 days preserved after smoking tilapia.

Table 8. Two-way ANOVA: Ash versus Treatment, Species.

Source	DF	SS	MS	F	P
Treatment	8	16036.7	2004.59	2187.60	0.000
Species	2	14.0	7.02	7.66	0.005
Error	16	14.7	0.92		
Total	26	16065.4			

S = 0.9573 R-Sq = 99.91% R-Sq (adj) = 99.85%.

Carbohydrates

Ogbonnaya and ibrahim (2009) perform an experiment to study proximate compositions of a catfish (*Clarias gariepinus*) and from the dried samples they determined and calculated 5.48±0.02. Chukwu (2009) also studied effects of two different methods of drying by smoking kiln and electric oven and calculated nutritional properties of Tilapia fish (*Oreochromis nilotieus*) and the carbohydrate analysis produce calculation was 3.67±0.04. In our calculations after performing experiment on three fishes Thaila,Rohu and Mori, the carbohydrate contents were 3.75, 4.21 and 4.52 in raw fish respectively. The values of carbohydrate have no significant difference in raw and treated groups. The maximum value 4.92 is observed in 30 days salted mori while minimum value 3.65 is observed in dried tilapia in electric oven.

Table 9. Two-way ANOVA: Crude fibre versus Treatment, Species.

Source	DF	SS	MS	F	P
Treatment	8	0.38673	0.0483417	0.95	0.508
Species	2	0.11180	0.0559000	1.09	0.359
Error	16	0.81827	0.0511417		
Total	26	1.31680			

S = 0.2261 R-Sq = 37.86% R-Sq (adj) = 0.00%.

Analysis of variance

Statistical analysis was conducted by Two-way ANOVA through Minitab programme and it was calculated that moister contents remain highly significant among treatment and among species. Crude protein remains are showed highly significant differences among treatment but non-significant among species. Crude fat has highly significant difference among treatments while non-significant among species. Ash contents highly significant difference among treatments while significant among species. As crude fibres are not degraded so these are non-significant among treatment as well as species. Carbohydrate significant difference among treatments while non-significant among species as shown in the data described in tables 5-10.

Table 10. Two-way ANOVA: Carbohydrate versus Treatment, Species.

Source	DF	SS	MS	F	P
Treatment	8	1.58654	0.198318	3.57	0.014
Species	2	0.08472	0.042359	0.76	0.483
Error	16	0.88848	0.055530		
Total	26	2.55974			

S = 0.2356 R-Sq = 65.29% R-Sq (adj) = 43.60%.

Conclusions

It is concluded that best colour, aroma, texture and taste values were observed in rohu and mori in specimens processed after 30 days freezing while poor quality of colour, aroma, texture and taste was observed in smoked fish due to burning effect and methods of smoking. So, 30 days freezing technique is can be considered best as a comparative result of this study while drying and salting may be considered second and third best way of processing fish for marketing in future. The effect of freezing duration on the nutrient composition of the selected fish species, which were used in the experiment, was not same. The results showed that freezing is the best when preservation of the fish is of priority but not more than 30 days freezing is recommended.

As smoking is employed by remote fishing communities due to traditional preference of the local people due to lack of sophisticated preservation techniques so it is less recommended as wood smoke produce microscopic particles, have dull and unattractive colour whereas and due to overall less acceptability which is observed during organoleptic analysis (unpublished data). The health risk may also be faced due to inappropriate smoking. Finally it is so, it is concluded that fish may consume after freezing but try to consume the fish in fresh condition as early as possible as quality remain better in earlier stage and also freezing is better processing method when preservation of nutrient is the focus also this processing made fish less susceptible to spoilage.

This project had provided beneficial results to maintain good quality in fish raw material after using different processing techniques and was helpful to establish guidelines for the fisheries sector about the preservation of different indigenous and exotic fish species of Pakistan.

Based on data collected problems in the handling and preservation process in Pakistan are pointed out and solutions are presented which can possibly be useful in the Pakistani fisheries industry in the near future and also are helpful to enhance production and export of processed fish.

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