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EFFECTS OF SMOKE-DRYING METHODS ON PROXIMATE COMPOSITION OF LIPID AND WATER SOLUBLE VITAMINS IN *TENULOSA ILISHA* (HAMILTON 1822) FROM YANAM (U.T. OF PUDUCHERRY)

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ABSTRACT

The present study was made to evaluate the quality of smoked hilsa fish (*Tenulosa ilisha*) that is very popular among fish farmers and consumers, and commands a very high commercial value in Yanam markets. The fresh fish sample was collected from the fish farmer and was smoked in a smoking kiln using sawdust, rice bran and melon husk while electric oven was used as the control. In the present study proximate composition of total lipid and water soluble vitamins such as Ascorbic acid, Niacenamide, Folic acid and Pyridoxine were evaluated using standard analytical techniques. Smoke drying with melon husk method revealed the most suitable with enhanced total lipid, ascorbic acid, folic acid and pyridoxine.

Keywords: *Tenulosa ilisha*, Smoking, Vitamins, Lipid, Proximate composition.

INTRODUCTION

Fish is a highly perishable food item; its rate of deterioration is very rapid, especially at prevailing air temperatures in tropical countries. In many developing countries with tropical ambient temperature, quality deterioration and significant post-larval losses occur because of inadequate use of ice, long supply chains, poor access to roads and electricity, and inadequate infrastructure and services in physical markets (FAO, 1990).

There are some traditionally available methods of preservative techniques of fish like salting, sun drying, curing, and smoking etc. Preservation methods such as canning and freezing are relatively expensive in developing countries. Methods of drying and smoking fish vary between different countries and within same country depending on the species of fish and the type of product desired (Chukwu, 2009).

Different processing and drying methods have different effects on nutritional compositions of fish. The effects could be chemical and physical changes increase digestibility due to protein denaturation and reduction in the content of the mobile compounds and polyunsaturated fatty acids. The quality of fish using different methods differs and the shelf life of fish dried in an electrically operated oven varies from that of fish dried using a smoking kiln (Turkkan *et al.,* 2008).

The smoke-drying process effects on nutritional quality and composition of fish which is in the open space. This method is a cheap and inexpensive method; however, the oven drying method is faster and safer than the sunshine method, because they are exposed to air velocity and relative humidity of the surrounding environment suitable equipment for 30 minutes to several months for drying.

The nutritional composition of fish varies greatly from one species and individual to another, depending on age, feed intake, sex and sexual changes connected with spawning, the environment and season. Also, the fish belongs to high protein, minerals and low lipid category. They contain lower caloric content per unit of protein than lipid and they are an ideal source of animal protein for use in controlling diets (Silva and Chamul, 2000).

Methods of drying and smoking fish vary between different countries and within the same country depending on the species of fish used and the type of product desired. The processor may use unsalted fish products ranging from less than 2% to over 20%. The fish may be dehydrated to various degrees with moisture levels in the final product

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ranging from about 10% to 60%. Processing temperatures may range from less than 5^0C to up to 120^0C and processing times from half an hour to several months. The fish may be dried only or smoked only or there may be a combination of smoking and drying. In some countries the fish is boiled before being smoked and/or dried. Adding to this complexity, the fish species used as raw material may be fresh water or marine species and may range from very lean to fatty fishes and its condition from fresh to stale. This variation makes it difficult to arrive at general conclusions regarding processing effects of smoking and drying on protein quality and the proximate compositions of the final products. The different processing and drying methods have different effects on nutritional composition of fish. This is because heating, freezing and exposure to high concentration of salt lead to chemical and physical changes and therefore digestibility is increased, due to protein denaturation, but the content of thermolabile compounds and polyunsaturated fatty acids is often reduced (Eves *et al.,* 1993; Tao *et al.,* 2008; Eyo, 2001).

Dried fish product is used as a means of prolonging shelf –life after capture. As spoilage is a metabolic process, it causes food to be undesirable or unacceptable for human consumption during changes in sensory and nutritional characteristics (Doyle, 2007).

The Hilsa, *Tenulosa ilisha* (Hamilton 1822), belonging to the family Clupeidae, is locally known as 'ilish; and 'sbour' in Bangladesh and Kuwait, respectively. Hilsa has wide range of distribution and occurs in marine, estuarine and riverine environments. Hilsa is largely an anadromous species, capable of withstanding a wide range of salinity and capable of migrating great distances upstream. Hilsa migrates to freshwater for spawning. Juveniles develop and grow in freshwater, but soon migrate to Sea where they spend most of their life (Al-Baz and Grove, 1995). Many studies on the biology and population dynamics of *T. ilisha* have been done in India, Pakistan and Bay of Bengal (Gupta *et al.,* 1989).

Hilsa feeds on plankton, mainly by filtering, but apparently also by grubbing on muddy bottom. The movement of hilsa towards the river mouth or estuary, where in the fish spend time to acclimatize and accumulate fat before proceeding to the upstream for spawning migration. In addition to food, other factors such as species, size, reproductive status as well as the environmental characteristics can influence the proximate composition. This species are very popular among fish farmers and consumers. They command a very high commercial value not only in Yanam but also in Indian and Global markets (Piggot *et al.,* 1990).

Hilsa has two periods of spawning - one minor during spring warming from February to May and another major spawning that coincides with the heavy monsoon during July to October (Boblme, 2010). It is one of the most important target species in the drift gillnet and fixed stake-net fishery in Kuwait (Al-Baz and Grove, 1995). Hilsa is observed as the national fish of Bangladesh, due to its popularity and economic importance. It is marketed and consumed all over Bangladesh (Kleih *et al.,* 2003). Fishing of hilsa takes place mainly during the monsoon season (June-August) when the adult fish migrates up the rivers for spawning (Majumdar *et al.,* 2005).

The availability of hilsa in the markets in India is high during August to September and we chose to collect the samples during the month of November. As it is Anadromous in nature (an uncommon phenomenon in tropical waters), occurs in the estuaries, brackish water lakes and fresh water rivers of the western division of the indo-pacific region. It grows and lives in sea and upstream to the rivers for breeding purpose. It migrates up to 1200 km in land through rivers in the Indian sub-continent for spawning. The *Tenulosa ilisha* caught from Godavari region was found to be 30 cm where asymptomatic length of *T. ilisha* was found to be 52.5 and 52.7, as estimated by Allen (1966) in Canada. The length of T. ilisha from Bay of Bengal ranged from 58 and 68 cm, this trend of larger growth is seen in the cooler parts of the temperature range countries (Van der Knapp, 1987).

The length composition of *T. ilisha* ranged from 14 to 57 cm, with majority of the fish landed in the market ranging from 35 to 45 cm. fish from 14-22 cm, 16-31 cm and 30-57 cm are caught by mullet (locally known as maid) gill-net, fixed stake-net (hadrah) and *T. ilisha* (sbour) driff-net, respectively. Small *T. ilisha* fish (14-22 cm) caught as a by catch. The length range 14-30 cm was not fully sampled by mullet gill-net (Al-Baz and Grove, 1995). The length range 14-30 cm was not fully sampled by mullet gill-net (Al-Baz and Grove, 1995).

Fish lipids are the main sources of polyunsaturated fatty acids (PUFAs) which play important roles in cardiovascular system to reduce the risk of heart attack, especially Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA). Lipids and fatty acids also play a significant role in membrane biochemistry and have direct effect on the membrane-mediated process in human such as osmoregulation, nutrient assimilation and transport (Ibrahim *et al.,* 2004).

Cooking process will induces water loss in the food, that in turn increases its lipid content in most cases and only some fat is lost in the case of oiliest fish. Lipid and vitamins are the major nutrients in *T. ilisha* and their levels helps to define the nutritional status of the particular organism (Osibona *et al.,* 2006). A vitamin is an organic compound and an essential nutrient that an organism requires in limited amounts. But the lipid levels and fatty acid content in the same species depending on the age, size, maturity, season, food availability, and freshness of the fishes, geographical variation, salinity and water temperature (Piggot *et al.,* 1990). The main characteristic of traditionally sundried fishes are loss of freshness is one of the major reason which affect the lipid content of dry fishes (Jeyasanta and Patterson, 2013).

The purpose of this study is to investigate the effectiveness of smoking with four traditional methods using rice bran, sawdust, melon husk and electric oven (as control) to make the fish as a quick but a ready food item that will contain the essential amount of nutrients and in a good quality. The study was also intended to compare the proximate composition of total lipid and vitamins such as Ascorbic acid, Folic acid, Vitamin B6 and Niacenamide in *T. ilisha* and also address the nutritional importance of this species.

MATERIALS AND METHODS

Sample collection and preparation

Fresh mature hilsa *T. ilisha* originating from the Bay of Bengal were collected from a local fish market in Yanam, Puducherry (Figure 1) in the month of November 2016. The length composition of *T. ilisha* ranged from 14 to 57 cm, with majority of the fish landed in the market ranging from 35 to 45 cm (Al-Baz and Grove, 1995).

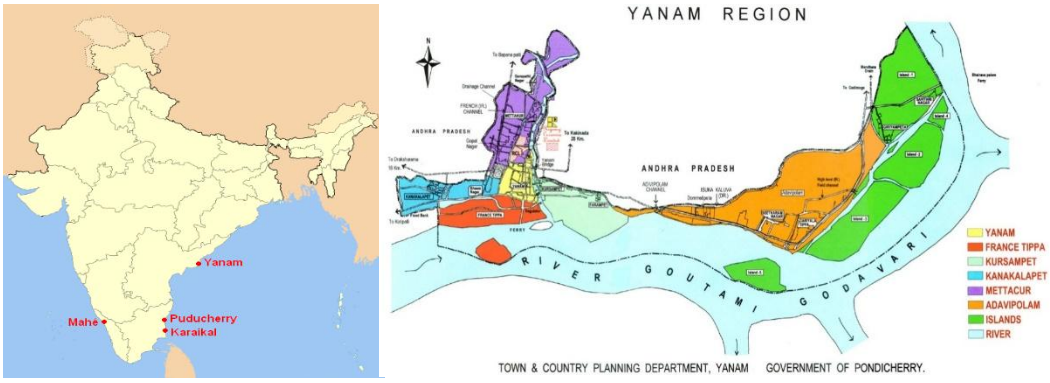


Figure 1. The study area, Yanam, Puducherry.

The collected fish samples were washed properly with fresh water to remove all dirt's and slime. Fish were measured individually for their standard length and weight and the mean values are shown in the Table 1. The fishes were dried in an electric oven at about 60°C for 24 h using it as control while the other three fishes were smoked in a smoking kiln using sawdust, melon husk and rice bran respectively. The fish samples were placed on the mesh in the kiln after weighing. The burning wood was adjusted continuously to maintain the required temperature in the chamber during the smoking period.

The fish smoking kiln was operated by wood chips and rice-husk into the heat chamber, preheating for some minutes and then loading the fish samples on to removable wire mesh trays in its central chamber for the smoke-drying process. Smoking was done approximately for 4 hours. During the smoking fish samples were turned upside down in the middle period, to make the samples smooth and steady in texture and appearance. The smoke-dried fishes showed characteristic attractive golden brown colour and acceptable texture with smoky flavor, which was followed by cooling for 20-30 minutes at ambient temperature to make fish muscle compressed and facilitate to prevent breaking of smoked products.

The dried samples were blended separately into fine powder using Kenwood food blender. The portion was put in a plastic container and kept it in a refrigerator at about 4°C to reduce microbial infestation for prior to use.

Proximate composition analysis

The proximate composition of fish samples were analyzed in triplicate following standard procedures (AOAC, 2005). All chemicals used were of analytical grade and supplied by Sigma Co. (USA). Each analysis was carried out in triplicates.

Lipid analysis

Total lipid content was estimated by using Folch method (Folch *et al.*, 1956). 2 gm of sample was homogenized in a potter Elvehjem type of homogenizer with 25 ml of chloroform: methanol (2:1) mixture, tightly covered with aluminum foil and kept at room temperature for 48 hours. It was then filtered by using Whatman no.1 filter paper and filtered extract was taken in a pre-weighed beaker and oven dried, beaker was weighed with lipids and the difference in weight was taken as total lipid content and percentage was calculated as follows

$$\% \text{ of lipid} = \frac{\text{Weight of lipid (mg)}}{\text{Weight of sample (mg)}} \times 100.$$

Vitamin C Analysis – HPLC

Vitamin C was extracted according to a modification of a published method (Babarinde *et al.*, 2009(. B6 (pyridoxine), Vitamin B3 (Niacenamide) and Vitamin B9 (folate) were determined according to the Finglas and Foulks (1984).

Vitamin C

The sample (10g) was blended and homogenized with an extracting solution containing metaphosporic acid (0.3M) and acetic acid (1.4M). The mixture was placed in a conical flask and agitated at 10,000 rpm for 15 min. The mixture was then filtered through a Whatman No.4 filter, and samples were extracted in triplicate. The ascorbic acid standard was prepared by dissolving 100 mg of L-ascorbic acid in a metaphosporic acid (0.3M)/acetic acid (1.4M) solution at a final concentration of 0.1 mg/ml. The calibration line was converted to a linear range based on four measured concentration levels.

Vitamin B3, B6 and B9 extraction

The samples were weighed and put in to a flask (250 ml). Then, 30 ml 0.1 of M Hcl were added and the flask was closed with cotton and then with Aluminium foil then put into an autoclave. After the step, the pH of each sample was adjusted to 6.5 and 4.5 with sodium acetate and HCl and volume was made up with distilled water, and filtered with a normal filter paper. If there was turbidity, this was centrifuged for 10 minutes at 6000 rpm. If turbidity persisted, the sample was filtered by using a filter of a 0.45 micrometer pore size. The samples were then ready for measurement. Quantification Of all water soluble vitamins were performed on an Agilent HPLC system. Chromatographic separation was achieved on an RP-HPLC column through isocratic delivery of a mobile phase (A/B 33/67; A: 0.1M potassium acetate, pH=4.9, B: acetonitrile: water (50:50) at flow rate of 1ml/min. UV absorbance was recorded at 254 nm at room temperature.

HPLC conditions

A column oven was used. This had heating and cooling. Column: C18 omnisphere 5,250 4.6 mm, wave length: 280 nm B3, B6, B9, flowing rate: 1 ml/ minute, injection volume was 20 *l*, mobile phase: 1000 ml phosphate solvent + 250 ml methanol mixture, pressure: 150 – 160 bar, running time 22 minutes.

Vitamin C was extracted according to a modification of a published method (Babarinde *et al.*, 2009). The sample (10g) was blended and homogenized with an extracting solution containing metaphosporic acid (0.3M) and acetic acid (1.4M). The mixture was placed in a conical flask and agitated at 10,000 rpm for 15 min. The mixture was then filtered through a Whatman No.4 filter, and samples were extracted in triplicate. The ascorbic acid standard was prepared by dissolving 100 mg of $_L$-ascorbic acid in a metaphosporic acid (0.3M)/acetic acid (1.4M) solution at a final concentration of 0.1 mg/ml. The calibration line was converted to a linear range based on four measured concentration levels.

Quantification of ascorbic acid content was performed on an Agilent HPLC system. Chromatographic separation was achieved on an RP-HPLC column through isocratic delivery of a mobile phase (A/B 33/67; A: 0.1M potassium acetate, pH=4.9, B: acetonitrile: water [50:50]) at flow rate of 1ml/min. UV absorbance was recorded at 254nm at room temperature.

Statistical analysis

Proximate composition analysis was replicated three times (n=3). The data were presented in duplicate and results were representative of the mean ± standard deviations.

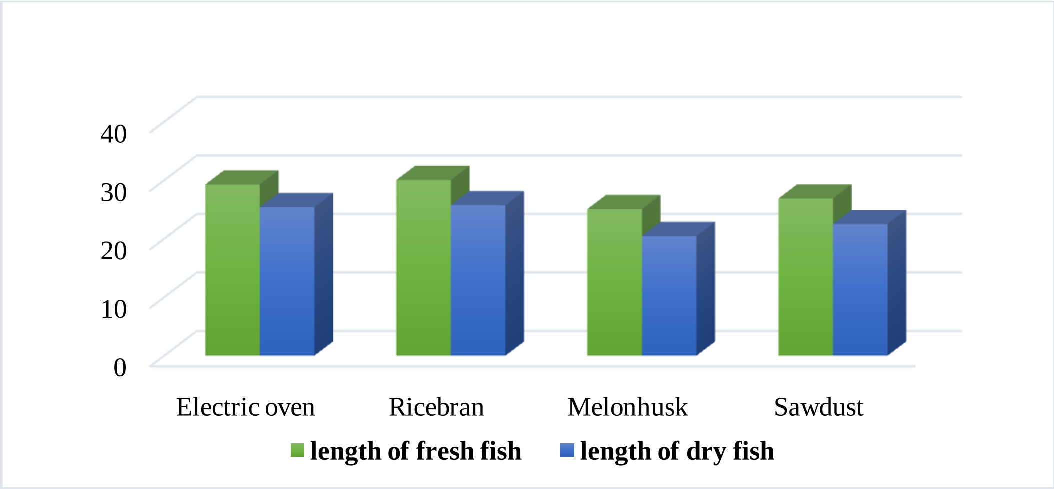
RESULTS

The length and weight decreased after smoke-drying when compared with fresh fish and the mean ± SD values are shown in Figure 2. The fish smoke-dried with electric oven and control had a mean length 25.38±0.1 (within the range of 25.01-25.08), and other three smoke-dried fish such as ricebran 25.73±0.2 (at the range of 25.07-26.08), Melon husk 20.45±0.006 (within the range 20.38-20.56) and Sawdust 22.49±0.2 (with range 22.12-23.20). However, the weight is also decreased after smoke-drying in four methods when compared with fresh fish the Figure 3 values are shown as follows with their ranges below. They are 126.1±0.2 (125.5-126.8) using electric oven as control 158.3±0.7 (157.5-159.5) using ricebran, 70.5±0.3 (69.8-71.2) using melonhusk and 77.4±0.8 (76.2-78.5) using sawdust respectively.

Lipid content of the traditionally smoke-dried fish with four different methods shows the mean (±SD) values with their ranges. The highest lipid content was present in hilsa which was smoke-dried with melon husk (16.47±0.01) when compared with other three sources like electricoven (11.55±0.03) as control, Ricebran (6.56±0.01) and sawdust (15.23±0.01) in Figure 4.

The analysis on water soluble vitamins in *Tenulosa ilisha* revealed the presence of folic acid and vitamin B6 (pyridoxine) in all smoke-drying methods. Folic acid increased considerably in ricebran and vitamin B6 increased in sawdust smoke-drying method. Ascorbic acid was present only in melon husk drying method. However, Niacenamide was absent in all drying methods.

The result on the analysis of water soluble vitamins such as Ascorbic acid, Niacenamide, Folic acid and Pyridoxine using HPLC is shown in Table 1 and Figure 5-9. Ascorbic acid was present only in melonhusk (1.78%) whereas absent in all three methods. The results on folic acid and pyridoxine revealed their retention without much loss. Interestingly, folic acid reduced from 1.03% (electric oven as control) to 0.22% in sawdust. However, vitamin B6 increased from 0.19% to 0.47% (electric oven and sawdust) respectively.



F igure 2. Comparison of mean length of fresh and smoke-dried *Tenulosa ilisha.*

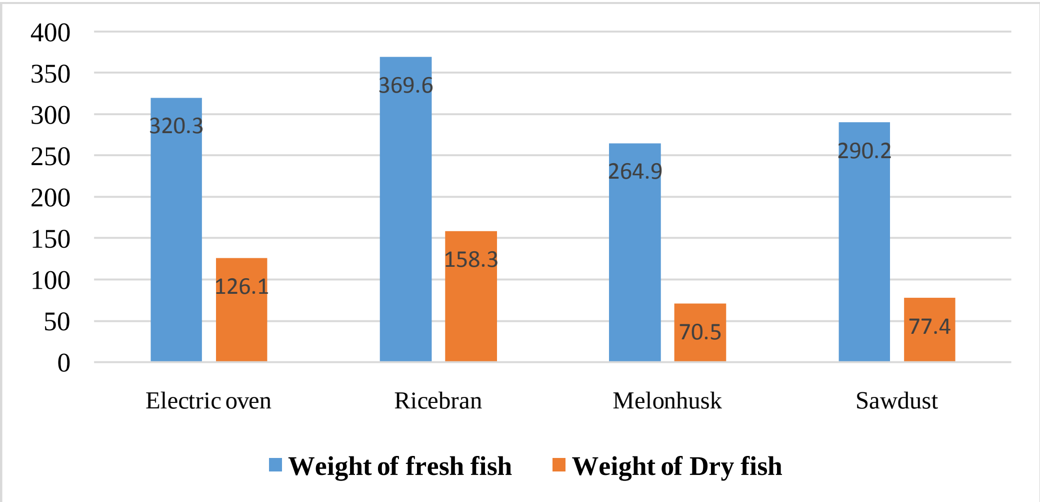


Figure 3. Mean weight of *Tenulosa ilisha* exposed to smoke-drying.

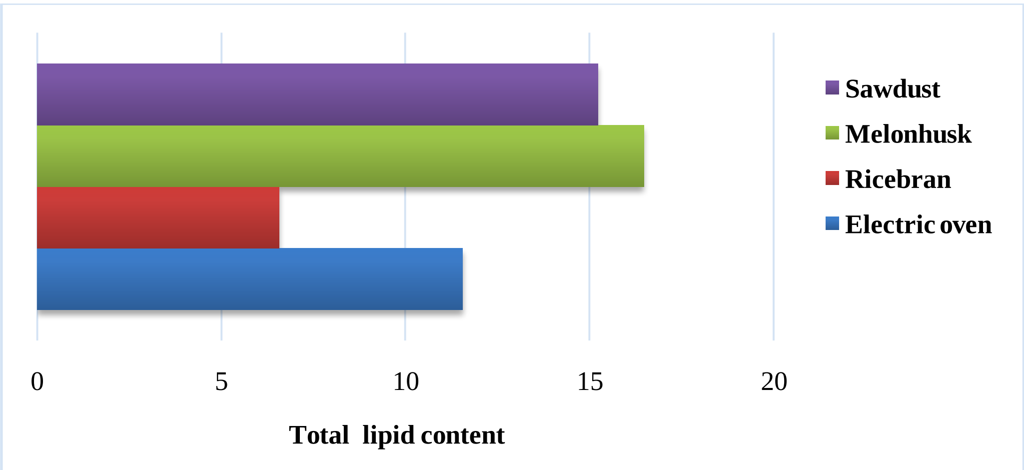


Figure 4. Total lipid composition of *Tenulosa ilisha* smoked with different sources of heat.

Table 1. Proximate composition (%) [a] of *Tenulosa ilisha* smoked with different methods.

Parameters in (%)	Smoke-drying methods				Mean	SD [b]
	Electricoven	Ricebran	Melonhusk	Sawdust		
Lipid	11.55±0.03	6.56±0.01	16.47±0.01	15.23±0.01	12.45	14.84
Ascorbicacid (Vit-C)	0.00	0.00	1.78±0.05	0.00	0.44	0.59
Niacenamide (Vit-B3)	0.00	0.00	0.00	0.00	0.00	0.00
Folic acid (vit-B9)	1.03±0.001	0.65±0.01	0.35±0.01	0.22±0.002	0.56	0.09
Pyridoxine (Vit-B6)	0.19±0.001	0.28±0.009	0.34±0.01	0.47±0.01	0.32	0.01

[a]Each value represents the mean ± standard deviation of triplicate.

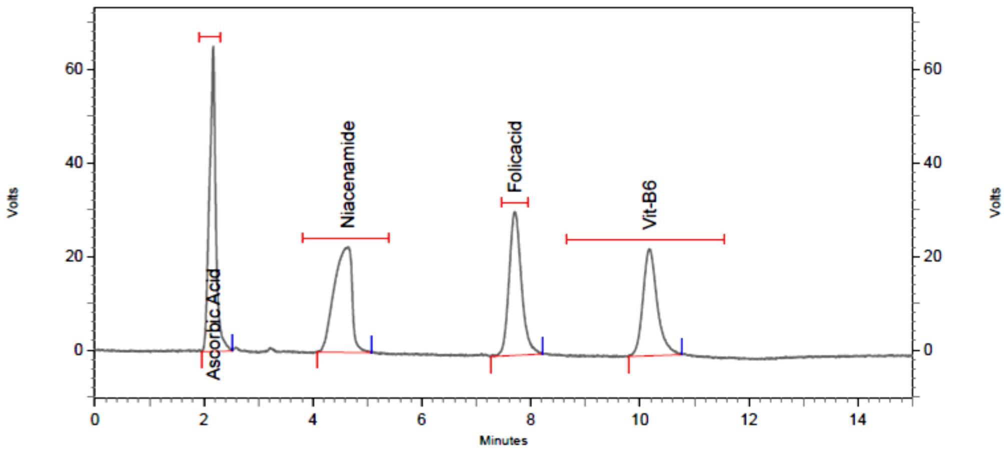


Figure 5. Chromatogram of standards for vitamins.

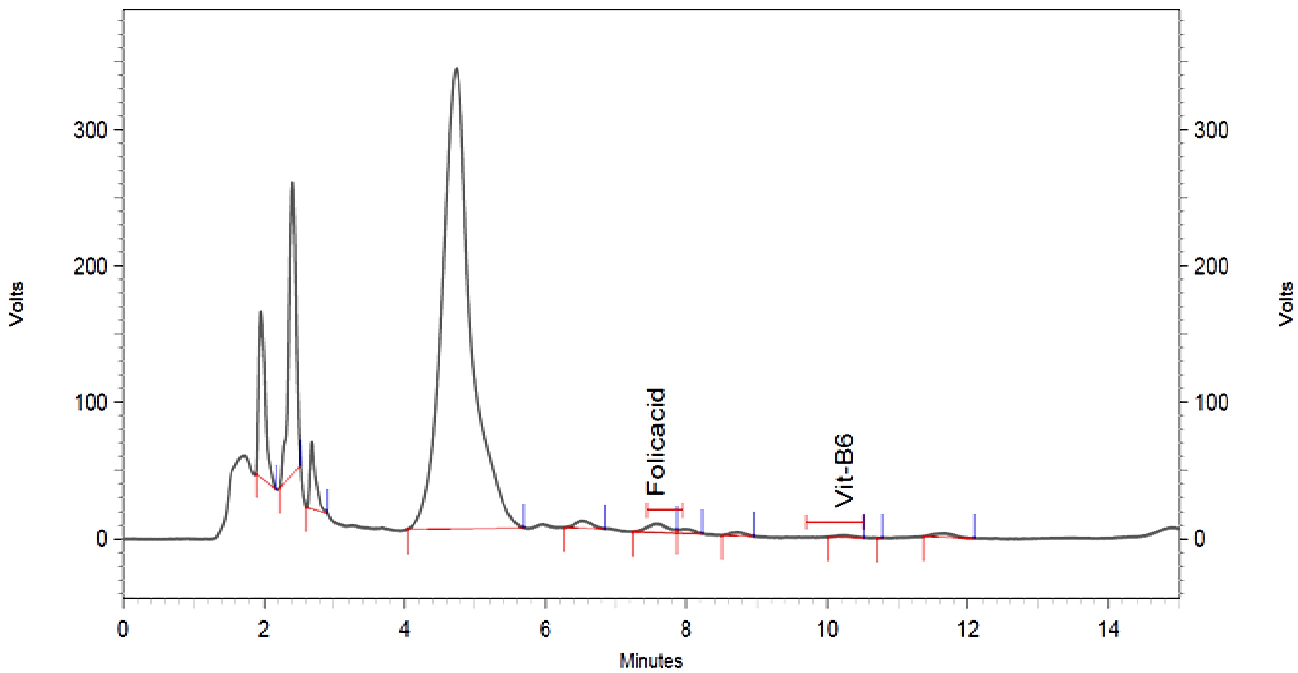


Figure 6. Chromatogram of *Hilsa ilisha* smoked with electric oven.

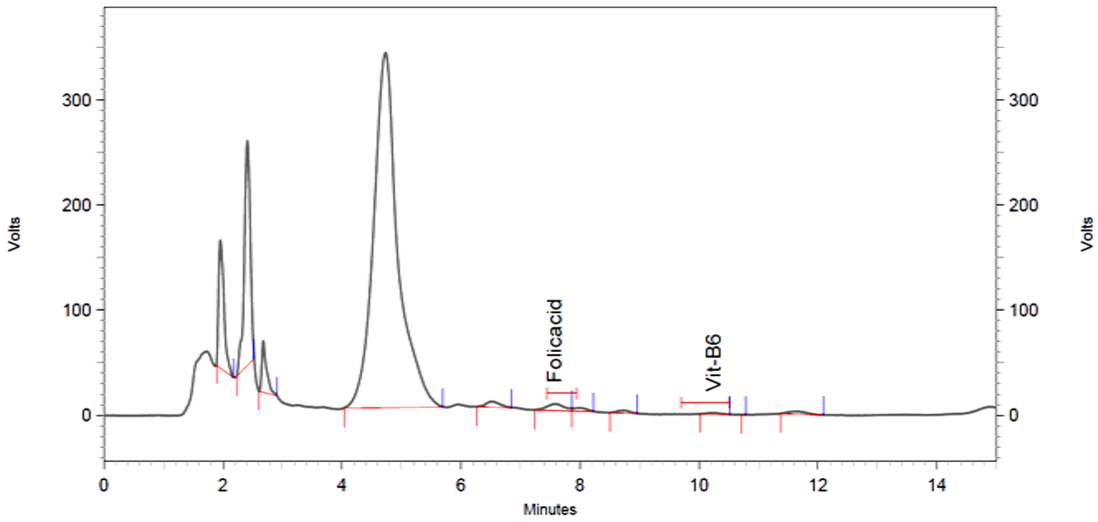


Figure 7. Chromatogram of *Hilsa ilisha* smoked with Ricebran.

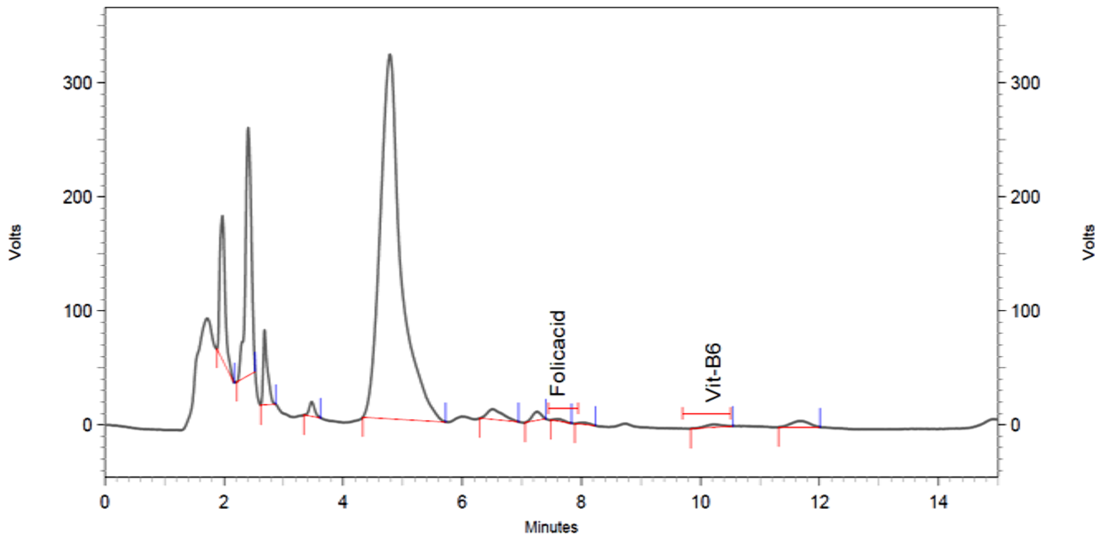


Figure 8. Chromatogram of *Hilsa ilisha* smoked with Melon husk.

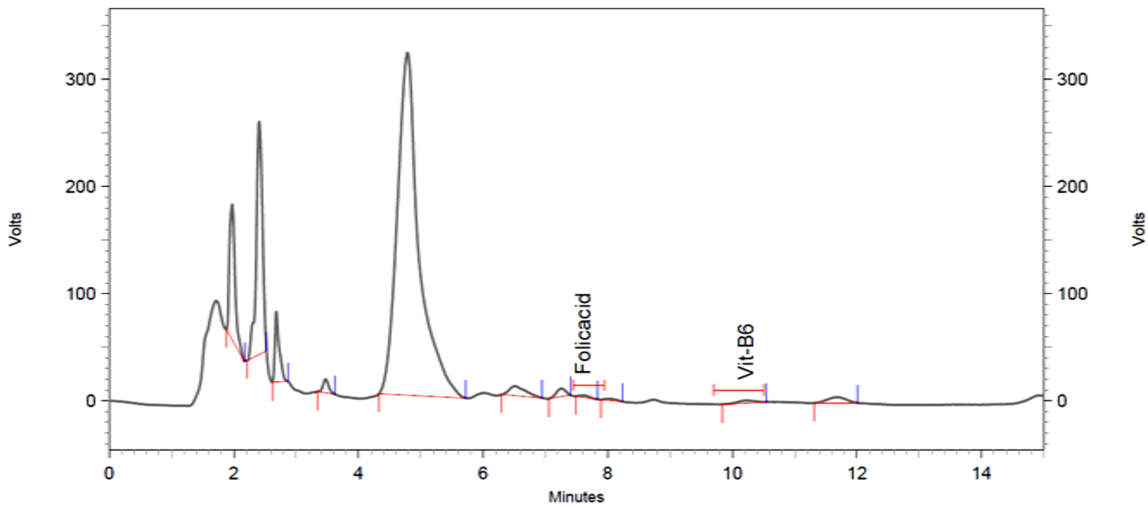


Figure 9. Chromatogram of *Hilsa ilisha* smoked with Sawdust.

DISCUSSION

The *T. ilisha* caught from Godavari region was found to be 30 cm, where asymptomatic length of *T. ilisha* was found to be 52.5 and 52.7, as estimated by Allen (1966) in Canada. The length of *T. ilisha* from Bay of Bengal ranged from 58 and 68 cm, this trend of larger growth is seen in the cooler parts of the temperature range countries (Van der Knapp 1987). The length composition of *T. ilisha* ranged from 14 to 57 cm, with majority of the fish landed in the market ranging from 35 to 45 cm. fish from 14-22 cm, 16-31 cm and 30-57 cm are caught by mullet (locally known as maid) gill-net, fixed stake-net (hadrah) and *T. ilisha* (sbour) driff-net, respectively. Small *T. ilisha* fish (14-22 cm) caught as a by catch. The length range 14-30 cm was not fully sampled by mullet gill-net (Al-Baz and Grove, 1995).

Dry fish yards are located in very remote rural locations, characterized by lack of infrastructure facilities and poor sanitary conditions responsible for deterioration of dried fish. Scientific knowledge of the quality and safety of dried fishery products produced in most developing countries is poorly developed. Several studies have attempted to determine the effect of different processing methods and processing conditions and storage temperature on the quality of dried fish products (Chukwu, 2009).

Smoke-drying method acts as an indicator of the susceptibility of a product to undergo microbial spoilage, different methods of smoke-drying of *T. ilisha* reduces 25% of microbes and 15% on the growth of mould will cease and thereby increase its shelf life (Glucas, 1982). The proximate composition of fish species are greatly varies during the catching season due to physiological reasons and changes of environmental conditions (Boran *et al*., 2011). Several studies have been carried out on the nutritional composition of fishes (Ayyapan *et al.,* 1976) estimated lipid content of miscellaneous edible fish from shrimp trawlers and reported that most of the species had high lipid contents.

Lipids are considered to be the most important constituent of fish as a reserve energy source (Pal *et al.,* 2011).

The lipid contents were lower in dried samples than the fresh fish and this variation could be the result of evaporation of moisture content with lipids. The fat content may be reduced with the evaporation of moisture and increase during heat treatment (Immaculate *et al.,* 2012). Similarly, in the present study the melonhusk drying revealed significant increase in lipid than other methods because melon peels absorbs most of the oil without evaporating and penetration of citric acid from the melon husk into the hilsa after water is partially lost by evaporation (Saguy and Dana, 2003).

The fat content in fresh hilsa was between 18.01±0.31 and 18.96±0.43% which is in agreement with Majumdar *et al*. (2005), who stated that fat content in fresh hilsa varies from 14-25%. Majumdar and Basu (2009) found lipid (as % of muscle) as 9.41 respectively.

The moisture content seems to be an exact indicator of the susceptibility of a product to undergo microbial spoilage. It has been reported that a fish well dried or moisture content reduced to 25% will not be affected by microbes and if further dried to 15%, the growth of mould will cease and thereby it increase the shelf life (Glucas, 1982).

Lipid and vitamins are the major nutrients in fish (*T. ilisha*) and their levels help to define the nutritional status of the particular organism (Osibona *et al.,* 2006). But the lipid levels and fatty acid content in the same species depending on the age, size, maturity, season, food availability, and freshness of the fishes, geographical variation, salinity and water temperature (Piggot *et al*., 1990).

The main characteristic of traditionally sundried fishes are loss of freshness is one of the major reason which affect the lipid content of dry fishes (Jeyasanta and Patterson, 2013). Fishes damage through bacterial spoilage ammonia generated from amino acid decomposition thus reducing the quality of the available nutrition and the present study agreed with this. Traditional drying is often rudimentary and good hygiene is rarely practiced. During the rainy season, when humidity levels are high, sufficient drying cannot be achieved using traditional methods. In such conditions, stored dried fish will re-absorb moisture and become susceptible to bacteria, fungal and insect attack (Azam, 2002).

Lipids displayed dissimilar percentages in hilsa in the given four methods. According to (Okuzumi *et al.,* 2000) lipids are highly efficient as source of energy and they contain twice the energy of carbohydrates and proteins. As general rule, they act as major food reserve along with protein and are subject to periodic fluctuations and environmental variables like temperature.

After drying there was a significant decrease in lipid content. Smoking in melon dried samples retained higher lipid content (16.47%) than rice bran (6.56%), electric oven (11.55%) and saw dust (15.23%). This trend is in agreement with those obtained by Tao and Linchun, 2008. This result indicates that the fat loss phenomenon was more intensive in the rice bran than smoking in melon husk and electric oven. Lipids may exude with moisture evaporation during electric oven drying and that seems to enhance the phenomenon of lipid loss (Ogbonnaya Chukwu and Saba, 2009). The present result is an agreement with Immaculate *et al.* (2012) revealing that increasing lipid content during heat treatment.

The pattern of changes in lipid content is governed by the rate of fat metabolism, maturity stage, environmental temperature, food availability, stress and other factors. The higher lipid content present in *Hilsa* from Yanam Godavari related to their foods. Similar observations were also reported in Bluefin sea bream and silver pomfret (Hossain *et al* 2012) and in *Hilsa*. Pal *et al.* (2011) reported that the EPA and DHA levels were highest in Godavari hilsa than in brackish water and marine hilsa. The taste and flavour of many fish depends on their food and feeding habits. The unique taste of hilsa is believed to be attributed to the environment where it lives or to the feed it takes. Hilsa of fresh water origin is tastier than those of the sea. Godavari hilsa is found to be tastier than marine *Hilsa* in the Indian waters of Bay of Bengal (Rao *et al.*, 2012).

This result is also attributed towards the minimal loss of moisture. Interestingly, ascorbic acid is present only in melonhusk smoke-drying method (1.90%), revealing the suitability of melonhusk which adds flavour and protects from the destruction of vitamin C. As stated by Ogbonnaya Chukwu and Saba (2009), vitamin C is less effected in catfishes by smoke-drying methods as it improves iron absorption and resistance of infection also. As expected the melonhusk smoke-drying method is more suitable for longer shelf life with increase market value.

It is assumed that vitamin C is absent in control electric oven method whereas it is present in melon husk smoke-drying method. The present study reveals that the melonhusk had a direct influence on enhancing the presence of vitamin C. Niacin is relatively stable vitamin, resistant to the effects of acid, heat and oxidation. Niacin has been said to be a stable vitamin. Niacin content of African catfish was found to be 1.13 mg/100g and cuttlefish 1.1 mg/100 g contrastingly the present study reveals the absence of niacin in all four methods of drying. This is due to the differential heat treatments stabilizes insignificance of niacin.

Vitamin B6 and folic acid are present in all four drying methods revealing their heat stable characteristics future. Niacin and B complex vitamins provides basic building blocks for growth and also enhance immune system in fishes (Rao *et al,* 2012).

CONCLUSION

The present study reveals that different smoke-drying methods such as Electric oven, ricebran, melonhusk and sawdust of *T. ilisha* have a significant role on the proximate composition of lipid and water soluble vitamins. It was observed that the hygienically smoke-dried samples using Melon husk had comparatively good nutritional value. Melonhusk enhances antibacterial activity, a very good antioxidant and gives an acceptable relishable smoke flavour for the fish.

ACKNOWLEDGEMENT

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