Original article

Effect of Drying Methods on the Proximate Composition of *Clarias Lazera* (Cuvier and Valenciennes) in Sudan

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Abstract

The aim of this study is to compare the quality of solar tunnel and traditional sun and air dried fishes of *Clarias lazera* (Cuvier and Valenciennes) products in combination with salting and smoking as pre drying treatments. All experiments were carried out during the three seasons namely: summer, autumn and winter. Fish proximate composition including the determination of moisture, ash, oil and protein contents and caloric value were calculated. The levels of Na^{+}, K^{+}, Fe^{+2}, Ca^{+2}, Mg^{+2}, Cu^{+2} and P^{+2} minerals were estimated. In addition, estimation of total counts and identification of *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* spp. was carried out. The results showed significant effects of the interactions of seasons and drying methods on all the proximate constituents of the fresh treated samples ($P < 0.05$). In salted dried products almost all the proximate constituents were significantly affected by the drying methods ($P < 0.05$) except ether extract. The chemical constituents of smoked dried products were affected by the different drying methods ($P < 0.05$) except ash content.
The results have confirmed the concept of modernization and application of new technologies to replace the traditional techniques. In addition to the considerations of some hygiene measures leading to the promotion of the traditionally practiced fish preservation methods.

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Introduction

Fish is an important source of food and contributes to about 50% of total animal protein in the diets of many Africans FAO (2003). It provides a good source of protein and essential micronutrients and thus plays an important role in prevention of many human diseases (Williams and Poh-Sze, 2003). In addition, 5% of the populations in Africa depend wholly or partially on the fisheries sector, mostly artisanal fisheries, for their livelihood (FAO, 2001). Fish is highly susceptible to deterioration if kept without any preservative or processing measures. According to Ahmed (2008) post-harvest losses are either physical (weight) or quality (value) and are related too much physiological and microbial deterioration that degrade the fish (Ames, *et al*. 19994, Davies and Davies, 2009, Musa *et al*. 2010 and Dewi *et al*. 2011). It has been estimated that, in the high ambient temperatures of the tropics, fish spoils within 12-20 hours after being caught, depending on species and size. According to Ruckes (2003), post-harvest losses may reach 10-12 million tones per year. Hence to minimize these losses, landed catch should be processed to preserve fish catch by artisanal methods (FAO, 2001 and Oparaku and Ojike 2013).

Preservation methods such as canning and freezing are technologies that are hardly used in the artisanal sub-sector in the tropics, basically due to cost and non-availability of equipment and cold storage system (Eyabi, 1998). The methods commonly used are the traditional techniques such as salting/brining, sun-drying and smoking, which also increase fish availability to the consumers (Zakhia, 2002 and Abolagba and Osifo, 2004 and Azam *et al*. 2003).

Drying is regarded as a traditional and least expensive method of fish preservation. In Sudan, it is carried out by sun drying method, which is the most popular, primitive, low-cost and widely used as fish preservation method. It is of vital importance in the developing countries of the world. About eight million tons of fish (25 -30 %) of the present world catch for human consumption are dried, salted, smoked, or treated by some combination of these processes each year (Zakhia, 2002). However, the physical and organoleptic qualities of most of the traditional sun dried products available in the market are not satisfactory for human consumption (Reza *et al.* 2005 and Hasan 2006).

The objectives of present study are to introduce solar drying as a new technique in the field of fish preservation to minimize fish post harvest losses, and to assess and compare the quality of solar tunnel dried products of *Clarias lazera* with the traditional sun and air dried products in combination with salting smoking as pre drying treatments.

Materials and Methods

Fresh *Clarias lazera* (Arabic Garmout) fishes were obtained for the present study from Elmawrada fish market in Omdurman during 2014. The study was carried out during three seasons (summer, autumn and winter). Fish specimens were washed and weighed using a triple beam balance. Then they were eviscerated, washed and reweighed to detect loss in weight due to cleaning process. Representative control fresh fish specimens were taken randomly from the pooled sample. Then the fish sample was divided into three sub samples and treated as follows:

The first one was left without any treatment (fresh sample). The second was salted with 20 % NaCl solution for 3 hours (salted sample). The third was smoked in a steel smoker for 2 hours using Mesquite wood i.e. *Prosopis nudiflora* (smoked sample). Each sub sample was weighed before and after treatment in order to determine loss in weight due to salting or smoking processes. Then the samples were further divided into three portions according to the drying methods as follows: air drying (under shade); sun drying (under direct sun) and solar drying (using a solar tunnel dryer). The solar tunnel dryer is 14 meters in length, 1.2 meters width and 0.80 meters height. It consists of a solar cell, two fans, a seven meters heating up black plated surface and a seven meters drying surface where samples to be dried are placed.

Fresh and dried fish were analyzed to determine the crude protein, fat, moisture and ash content. Crude protein was determined using Kjeldahl techniques, fat content was determined by using Soxhelt extraction method and ash content was determined by incinerating 1g of sample at 600oC for six hours. Proximate analysis was based on standard methods described by (Pearson, 1976 and AOAC 2000). From the fat and protein contents fat: protein ratio was estimated, and the energy value was calculated using the formula recommended by (FAO, 1989). One way analysis of variance (ANOVA) and Duncan multiple range tests with significant level (0.05) were used for statistical data analysis.

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Results and Discussion

Fish processing helps to extend the storage life of fish and to give the product a form, which is attractive to consumers (Tawari, and Abowei, 2011). The investigations throughout this study concentrated on the comparison between the three drying methods namely air, sun and solar using a solar tunnel drier. Each of these methods was conducted in combination with salting, smoking or using fresh fish samples.

The proximate chemical composition of fresh samples of *C. lazera* is given in Table (1). All levels of the investigated parameters of the proximate constituents i.e. moisture %; ash %: fat%; protein; fat:protein and energy value kcal/100gm were within the ranges reported by many authors for Nile fish e.g. Mahmoud and Ali (1999), Omer (1984), Awouda (1988), Karrar (1997), Karrar, (2007), El-Bassir *et al.*, 2015 and El-Bassir *et al.*, 2015a, b.

Table (1): Proximate composition of fresh *Clarias lazera* in the three seasons

Parameters	Season		
	Summer	Autumn	Winter
Moisture %	75.61	75.37	75.99
Ash %	8.18	7.94	7.85
fat %	8.75	8.54	8.37
Protein %	76.80	76.21	76.84
Fat : Protein	0.1139	0.1120	0.1089
Energy Value kcal/100gm	406.861	402.447	403.604

Before the drying process, fish were cleaned then salted smoked or let without any treatment. During these steps some loss in weight was detected. The Weight loss percentage in *Clarias lazera* during predrying treatments in the three seasons is shown in figure (1).

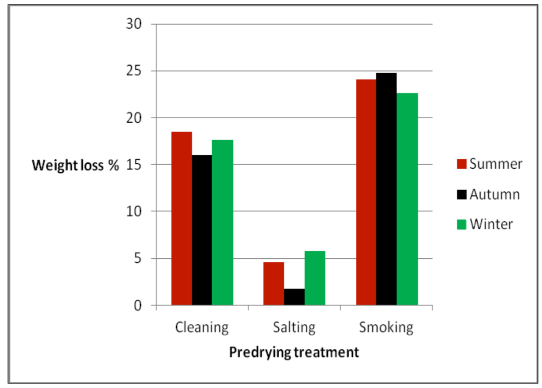

Fig. (1): Weight loss % in *C. lazera* during pre-drying treatments in the three seasons

Loss in fish weight during the drying process was detected daily in order to determine the drying time needed for each treatment as shown in figures (2-10). Then the total weight loss % was calculated for each treatment as given in figure (11). It was noticed from the results obtained from the statistical analysis of the data that, the total weight loss % during the drying process of fresh, salted and smoked *C. lazera* using the three different drying methods was significantly different among the three seasons ($p<0.05$). Variations due to the pre-drying treatments are justified by the losses in weight that took place due to the pre-drying processes, and the variations within the same treatment could be attributed to intrinsic variation within the same fish species (Dawson and Grimm, 1980 and Diakoku and Masui 1982).

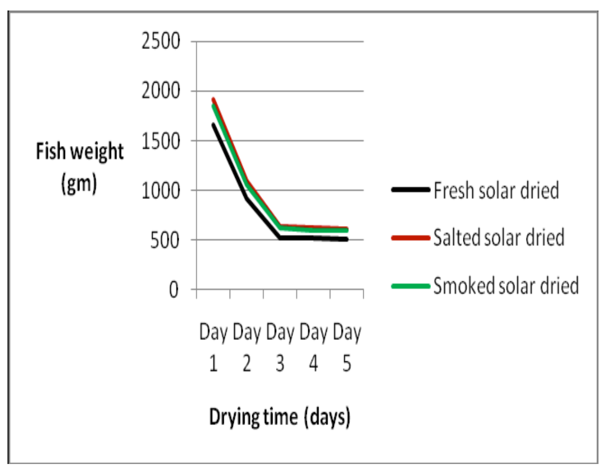

Fig. (2): Daily weight loss during solar drying of *C. lazera* in summer

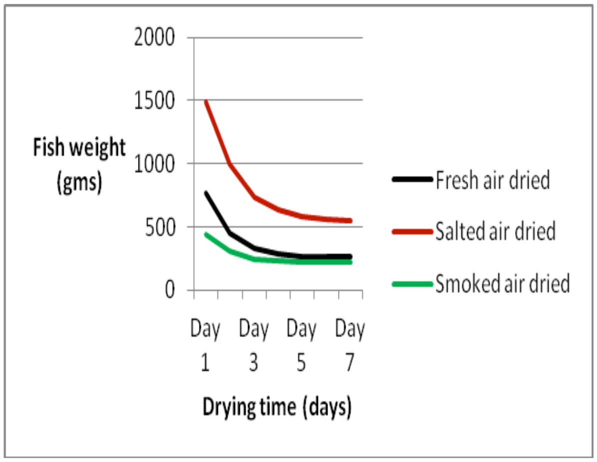

Fig. (3): Daily weight loss during sun drying of *C. lazera* in summer

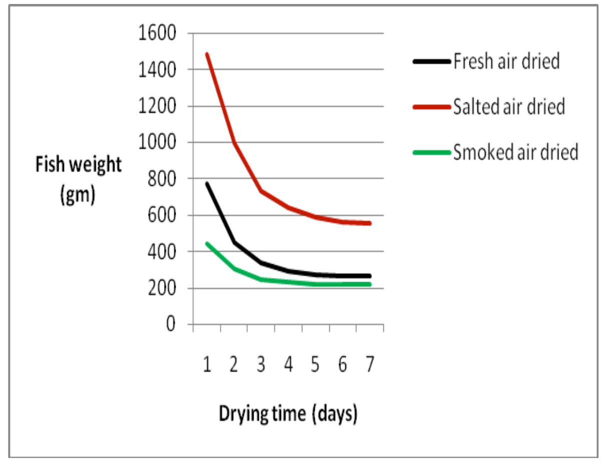

Fig. (4): Daily weight loss during air drying of *C. lazera* in summer.

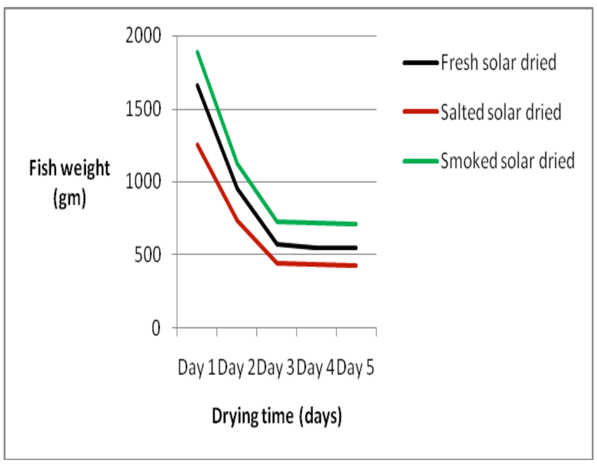

Fig. (5): Daily weight loss during solar drying of *C. lazera* in winter

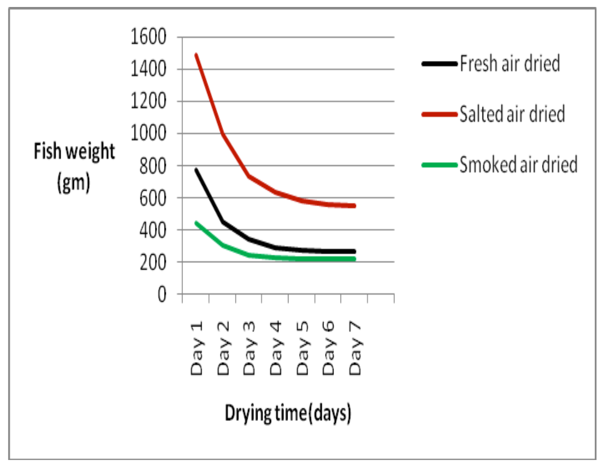

Fig. (6): Daily weight loss during sun drying of *C. lazera* in winter

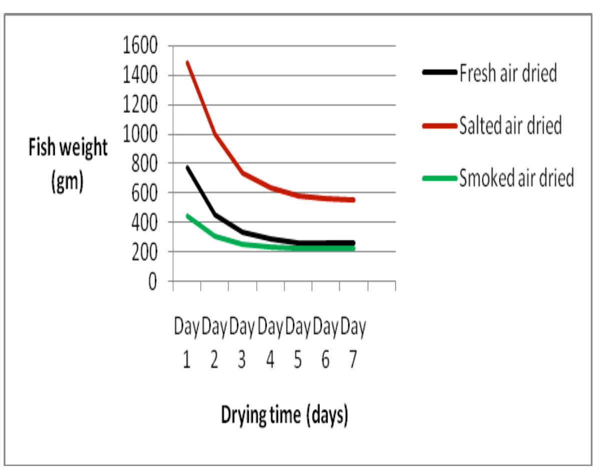

Fig. (7): Daily weight loss during air-drying of *C. lazera* in winter.

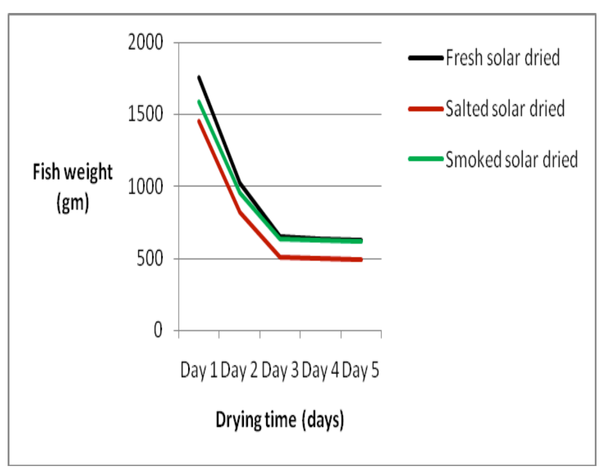

Fig. (8): Daily weight loss during solar drying of *C. lazera* in autumn

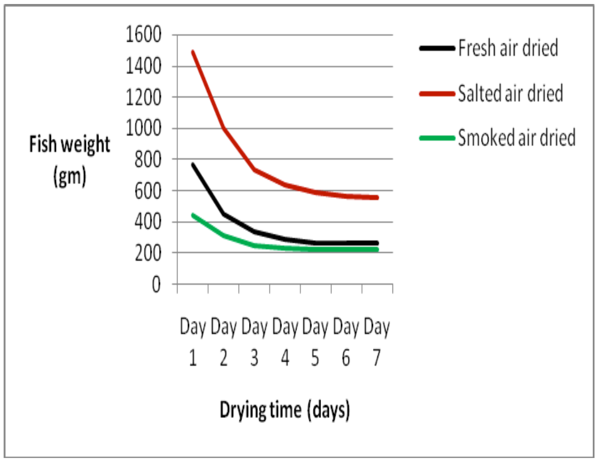

Fig. (9): Daily weight loss during sun drying of *C. lazera* in autumn

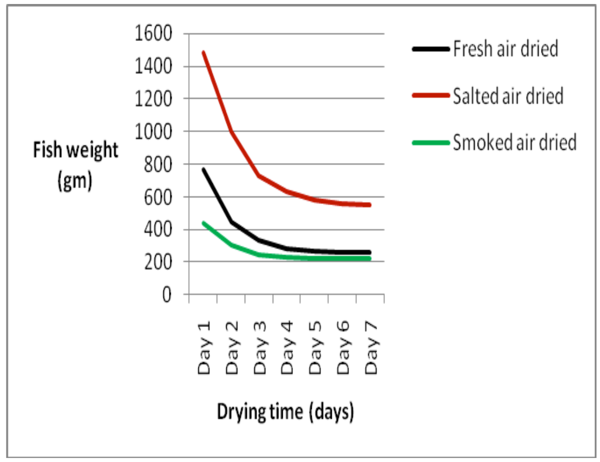

Fig. (10): Daily weight loss during air-drying of *C. lazera* in autumn.

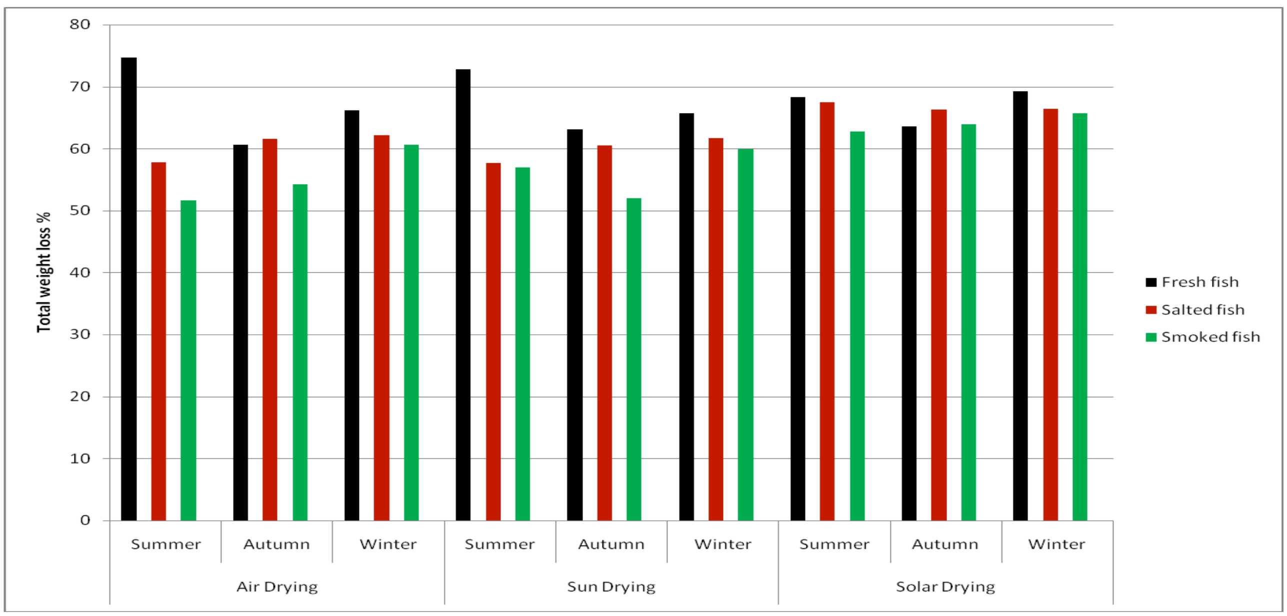

Fig. (11): Total weight loss % of fresh, salted and smoked dried *C. lazera* during three seasons

As soon as fish dies spoilage begins to set in. Spoilage is accompanied by various physical and chemical changes in the gills, eyes, slime and skin tissues (Eyo, 2001), and organoleptic parameters (Agbabiaka, et al. 2012). That affects the nutritional quality, consumer acceptability and commercial value of fish (Daramola, *et al.* 2007).

According to Bala and Mondol (2001), Traditionally practiced open sun drying renders fish into unhygienic products including a large wastage. Control drying is needed for longer shelf life and solar drying offers a just solution through low cost hygienic method. Solar fish drying is known to produce, better quality dried products compared to air and sun drying due to reduced insect infestation (Sablani, *et al*., 2002). It also decreases the number of bacteria existed in fresh fish due to the increase of temperature inside the drier (Babiker, *et al*., 2014). The solar tunnel dried fish products were found to be of better organoleptic and keeping quality (Manjarekar and Mohamed, 2010).

The proximate chemical composition of the dried samples was determined and the effect of the different comparison parameters was studied, the results are presented in tables (2, 3 and 4). In studying the effect of the interactions of the drying methods, seasons and predrying treatments on the proximate composition of *C. lazera*, it was observed that, all the studied parameters are significantly affected (P <0.05) in the fresh treated samples. With the exception of fat content %. , all the parameters tested in the present study were not affected the salting process.

The smoked samples showed significant differences in all parameters (P < 0.05) except the % of ash content (P > 0.05) All the findings of the proximate composition of the air, sun and solar dried products, in combination with the different pre-drying treatment during the different seasons of *C. lazera* were] in accordance with the results obtained for dried fish products by some researchers (Mmopelwa, 1990, Ikeme, 1991 and FAO 1992).

Table (2): Effect of drying method on proximate composition of dried fresh *C. lazera* during three seasons

Drying method	Air			Sun			Solar			P value
Season	Summer	Autumn	Winter	Summer	Autumn	Winter	Summer	Autumn	Winter	
Moisture %	7.80^{bc} ±1.30	7.74^{bc} ±2.15	7.76^{bc} ± 2.25	6.08^{ab} ± 0.16	8.50^{c} ± 1.65	7.17^{abc} ± 1.11	5.03^{a} ±1.98	5.98^{ab} ± 0.34	5.98^{ab} ± 1.44	0.016
Ash %	16.78^{c} ± 0.51	15.84^{bc} ± 1.82	15.25^{abc} ± 0.62	13.92^{ab} ± 2.23	15.24^{abc} ± 1.98	15.90^{bc} ± 0.91	13.50^{a} ± 1.57	13.80^{ab} ±1.34	14.49^{ab} ± 1.15	0.014
Ether Extract %	17.32^{bc} ±0.72	17.11^{bc} ± 1.62	16.46^{ab} ± 0.53	17.49^{bc} ± 1.27	17.34^{bc} ± 1.03	15.06^{a} ± 1.56	16.30^{ab} ± 1.84	18.30^{c} ± 1.29	15.36^{a} ± 0.53	0.004
Protein %	66.56^{ab} ±1.55	65.75^{a} ± 2.27	66.98^{ab} ± 1.31	67.71^{abc} ± 1.77	66.11^{a} ± 2.32	66.75^{ab} ± 0.55	69.86^{c} ± 1.07	68.37^{bc} ± 1.37	69.25^{c} ± 0.91	0.001
Fat : Protein Ratio	0.260^{bc} ± 0.012	0.261^{bc} ± .018	0.246^{abc} ± 0.008	0.259^{bc} ± 0.013	0.262^{c} ± 0.011	0.226^{a} ± 0.012	0.233^{ab} ± 0.017	0.268^{c} ± .007	0.222^{a} ± 0.013	0.002
Energy Value Kcal/100gm	440.45^{bc}±9.49	435.14^{ab} ± 8.36	434.50^{ab} ± 8.48	446.89^{bc} ± 9.45	438.69^{b} ± 17.82	420.87^{a} ± 15.44	445.33^{bc} ± 16.51	457.01^{c} ± 14.52	434.28^{ab} ± 14.73	0.006

* Means with similar superscript (in a row) are not statistically significantly different (P >0.05), those with different superscript are statistically significantly different (P <0.05).

Table (3): Effect of drying method on proximate composition of dried salted *C. lazera* during three seasons

Drying method	Air			Sun			Solar			P value
Season	Summer	Autumn	Winter	Summer	Autumn	Winter	Summer	Autumn	Winter	
Moisture %	8.87^{c} ± 1.63	7.96^{bc} ± 1.67	8.91^{c} ± 2.16	5.66^{a} ± 1.24	8.79^{c} ± 1.71	9.59^{c} ± 0.78	5.89^{bc} ± 1.04	5.89^{bc} ± 1.99	5.82^{bc} ± 1.65	0.000
Ash %	14.62^{a} ± 1.09	17.67^{d} ± 0.81	17.45^{cd} ± 0.69	14.95^{ab} ± 1.39	15.15^{ab} ± 1.49	16.05^{abcd} ± 0.56	15.99^{abc} ± 1.24	16.56^{bcd} ± 1.24	17.48^{cd} ±1.45	0.000
Ether Extract %	16.07^{a} ± 1.23	16.41^{a} ±0.40	15.54^{a} ± 1.04	16.41^{a} ± 2.16	15.67^{a} ± 0.40	17.02^{a} ± 1.01	16.62^{a} ± 0.78	16.98^{a} ± 1.26	15.38^{a} ± 0.94	0.226
Protein %	67.99^{ab} ± 1.82	69.57^{bcd} ± 0.91	66.42^{a} ± 1.85	67.77^{ab} ± 1.50	68.56^{b} ± 1.51	69.19^{bc} ± 0.57	70.77^{cd} ± 0.91	70.48^{cd} ± 1.03	71.11^{d} ± 0.87	0.000
Fat : Protein Ratio	0.237^{ab} ± 0.012	0.236^{ab} ± 0.013	0.233^{ab} ± 0.014	0.243^{ab} ± 0.005	0.228^{ab} ±0.014	0.246^{b} ± 0.014	0.234^{ab} ± 0.014	0.241^{ab} ± 0.009	0.216^{a} ± 0.014	0.036
Energy Value Kcal/100gm	435.21^{ab} ± 7.60	445.06^{bc} ± 5.52	423.79^{a} ± 16.19	437.41^{ab} ± 16.02	434.08^{ab} ± 6.61	448.90^{bc} ± 10.18	452.11^{b} ± 7.99	454.34^{b} ± 9.29	442.43^{bc} ± 7.39	0.001

* Means with similar superscript (in a row) are not statistically significantly different (P >0.05), those with different superscript are statistically significantly different (P <0.05).

Table (4): Effect of drying method on proximate composition of dried smoked *Clarias lazera* during three seasons

Drying method	Air			Sun			Solar			P value
Season	Summer	Autumn	Winter	Summer	Autumn	Winter	Summer	Autumn	Winter	
Moisture %	$6.25^{ab} \pm 0.22$	$7.96^{b} \pm 2.08$	$8.08^{b} \pm 2.03$	$6.69^{ab} \pm 1.28$	$6.00^{ab} \pm 2.02$	$7.59^{b} \pm 2.16$	$4.91^{a} \pm 1.56$	$5.10^{a} \pm 0.56$	$5.01^{a} \pm 1.44$	0.010
Ash %	$15.13^{ab} \pm 1.77$	$14.21^{a} \pm 1.93$	$16.18^{ab} \pm 1.86$	$17.09^{b} \pm 1.19$	$14.83^{ab} \pm 0.60$	$16.22^{ab} \pm 1.58$	$14.71^{a} \pm 1.53$	$14.56^{a} \pm 1.92$	$14.67^{a} \pm 1.72$	0.107
Ether Extract %	$15.83^{a} \pm 1.64$	$17.84^{cd} \pm 1.05$	$15.36^{a} \pm 1.24$	$16.17^{abc} \pm 1.18$	$17.74^{cd} \pm 0.56$	$16.36^{abc} \pm 1.80$	$17.65^{bcd} \pm 1.49$	$18.65^{d} \pm 0.94$	$15.98^{ab} \pm 0.47$	0.001
Protein %	$67.04^{b} \pm 1.89$	$68.76^{cd} \pm 0.56$	$67.56^{bc} \pm 1.76$	$64.67^{a} \pm 1.03$	$65.98^{ab} \pm 1.05$	$66.59^{b} \pm 1.37$	$70.43^{e} \pm 0.73$	$69.46^{de} \pm 0.73$	$70.78^{e} \pm 1.09$	0.000
Fat : Protein Ratio	$0.236^{ab} \pm 0.006$	$0.259^{bc} \pm 0.005$	$0.227^{a} \pm 0.006$	$0.249^{abc} \pm 0.007$	$0.268^{c} \pm 0.009$	$0.245^{abc} \pm 0.017$	$0.250^{abc} \pm 0.013$	$0.268^{c} \pm 0.014$	$0.225^{a} \pm 0.015$	0.004
Energy Value Kcal/100gm	$429.06^{ab} \pm 14.87$	$454.54^{def} \pm 9.27$	$427.05^{ab} \pm 16.54$	$421.95^{a} \pm 12.43$	$441.74^{bcd} \pm 3.98$	$431.98^{abc} \pm 17.53$	$459.98^{ef} \pm 11.40$	$464.78^{f} \pm 8.36$	$446.39^{cde} \pm 6.12$	0.000

* Means with similar superscript (in a row) are not statistically significantly different (p>0.05), those with different superscript are statistically significantly different ($P < 0.05$).

Conclusions

- The results of this study have confirmed the necessity of modernization and application of new technologies to replace the traditional methodologies and techniques based on the nutritive value of the dried fish products.
- The nutritive value of the solar dried fish products was significantly higher than the other two drying methods throughout the three study seasons.
- Sun drying and air-drying are simple, effective, and cheep methods for fish preservation that can keep a suitable range of nutritive value for the consumer.
- Salting and smoking as pretreatments for drying are very effective and showed a significant result on the dried products nutritive value.

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