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RESEARCH PAPER

A Comparative Study on Quality of Dried Anchovy (*Stelophorus heterolobus*) Using Open Sun Rack and Solar Tent Drying Methods

Bereket Abraha[1,2,*], Melake Samuel[1], Abdu Mohammud[1], Habte-Michael Habte-Tsion[3,4], Habtamu Admassu[2], Nabil Qaid M. Al-Hajj[2]

[1] Massawa College of Marine Science and Technology, Department of Marine Biotechnology, P.O.Box: 170, Massawa, ERITREA
[2] School of Food science and Technology, Jiangnan University, Wuxi 214122, PR China
[3] Wuxi Fisheries College, Nanjing Agricultural University, 69 Xue Jia Li (Binhu Nanquan town), Wuxi 214081, Jiangsu, PR China
[4] Kentucky State University, Division of Aquaculture, College of Agriculture, Food Science and Sustainable Systems (CAFSSS), 103 Athletic Rd., Frankfort, KY 40601, USA

* Corresponding Author: Tel.: +86-186-1667226; Fax: +86-510-85809610;
E-mail: bereketmft@yahoo.com

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Abstract

The open sun rack and solar tent drier were evaluated for their drying effectiveness to evaluate the quality of *Stelophorus heterolobus.* The highest mean temperature in the solar tent drier was found to be 45^{0}c, with relative humidity 42%, while in the open sun rack drying was 35^{0}c, with relative humidity 47% at an air speed of 1.8 meter per second. The average moisture, crude protein, total lipids, free fatty acid, peroxide, total volatile basic nitrogen and ash content of the solar tent dried products were 7.5 %, 79.32%, 3.74%, 0.50%, 14.66% , 19.65% and 9.90%, and for open sun rack were7.7% 75.32%, 3.20%, 0.54%, 13.66%, 21.80% and 9.20%, respectively. Total plate count (TPC) of 3.2 × 10^{3}cfu/g and 5.7 ×10^{3}cfu/g was found within the average level for solar tent and open sun rack driers respectively.The quality of the fish products dried in the solar tent drier was superior compared to that of open sun rack-dried products. It took only three days for the fish to be dried in the solar tent drier compared with the open sun rack dried fish products which took five days to dry.

Keywords: Fish (Stelophorous heterolobus), proximate composition, microbial loads, organoleptic characteristics, traditional drying methods.

Introduction

Fish represents a valuable source of protein and nutrients in the diet of many people and its importance in contributing to food security is rising significantly. Retaining the nutritional value of fish, preserving the benefits of its rich composition and avoiding costly and debilitating effect of fish-borne illnesses are important. Many different techniques can be used to preserve fish quality and to increase shelf life. One of these techniques is based on temperature control and encompasses a wide array of techniques used to decrease or increase the fish temperature to levels where metabolic activities catalyzed by autolysis or microbial enzymes are reduced or completely stopped (FAO, 2009).

In many parts of the world, especially African countries, there is no access to refrigeration or ice. In the absence of cold storage, placing a stress on the physical, chemical and biological processes that lead to spoilage can slow deterioration of freshly caught fish. By reducing the moisture content of the fish through drying could ensure in a stable source of protein that can be transported to communities with limited access to fresh fish. Drying of fish has been practiced by many societies for centuries, but these methods are not well known and not practiced in Eritrea.

Eritrean Red Sea has not yet being exploited and possesses diverse marine resources. The Maximum Sustainable Yield of marine fish resource of Eritrean Red Sea is estimated 80,000 metric tons per year and small pelagic has been estimated around 50,000 metric tons per year (Araya & Krishnan, 2012). The fish landings activities were very good in the past (1950s); catches of more than 20,000 metric tons per year were reported in 1950-71, whereby 80% consisted of small pelagic, sardines and anchovy were processed into fishmeal. At this time also small pelagic fish, anchovy, mackerel and sardines were sun dried for animal feed. Even though Eritrea has plenty of marine resources, fish consumption is estimated at 0.5-1kg per person per year, which is very low (IFAD, 2010).

Anchovies are small pelagic fish start to appear in the catches in late September or early October. The season ends around March/April but schools are said to be spotted until May, as reported in 1971. Sardine (*Harengula punctata*) and anchovy (*Stelephorus heterolobus*) resources have been estimated at about 50,000 metric tons per year from the Red Sea of Eritrea from 1993 to 2008 (Pasience, 2009; FAO, 2015). Anchovies are highly nutritious food and particularly valuable for providing protein of high quality, better than those of meat and egg. However, they are the most perishable of all the foods because their suitable medium for growth of micro-organisms after death (Kader, 2005). Thus the problem of spoilage could be solved and the shelf life can be extended by preservation using solar drying techniques. Sun drying is one of the traditional simple and economical methods employed to preserve fish, particularly small pelagic fish (Relekar, Joshi, Gobe, & Kulkarni, 2014). Some limitations of sun drying can be improved raising the drying fish rack off the ground on wooden frames which allows air to circulate in all the directions, that facilitates water evaporation from both sides (Sankat & Mujiaffar, 2004). Solar drying is an improved method of sun drying. It minimizes or stops some of the limitations of open sun drying (FAO, 1981; Relekar *et al.,* 2014). Solar drying differs from open sun drying in a structure, often very simple in construction, which is used to enhance effect of the insulation (Yu, Siaw, & Idrus, 1982). This is due to the truth that solar tent dryer is an enclosed structure that traps heat inside the tent and make efficient use of the heat which is entrapped inside the tent during the day by the help of some rocky black stones that absorb heat (Doe, Ahmed, Muslemuddin, & Sachithhanathan, 1977). The end product has a long shelf life, providing a source of protein, vitamins and minerals when the fresh fish themselves may not be available in offseason (Sankat & Mujiaffar, 2004). For getting better quality dried fish, it is very essential to use improved method of fish drying. Indeed, the present study focused to determine and compare quality of dried anchovy by solar tent and open sun rack drying methods and to adopt improved method to get better quality of dried anchovies. This type of drier is practiced for the first time in Eritrea which could be very useful to solve the afro- mentioned problems and enhance utilization of the resource in an effective way. Moreover anchovies are used as animal feed although the people are suffering from nutrition of fishery products. Despite the huge resource, the utilization is very low and these problems have great impacts on the effective utilization of the resources.

The main objective of the present study was to determine and to compare quality of anchovies (*Stelophorus heterolobus*) by assessing the proximate composition, chemical, microbial and sensory attributes of dried anchovies under open sun rack and solar tent drying methods.

Materials and Methods

Sample Collection and Preparation

The experimental fish was anchovy, *Stolephorus heterolobus*, collected from Eritrean Red Sea (Rassdarma-Southern part around Asseb) on18/03/2016 using beach purse seine net and kept in fish boxes using ice for four days, ice was replaced only once and transported to the laboratory of Massawa College of Marine Science and Technology. The fish samples were washed with potable water properly and beheaded. The beheaded fish were placed on the solar tent dryer and open sun rack drying. The temperature, humidity, wind speed were measured using thermometer (LCD portable multi-system thermometer, No. 201211253516 Hutaib Enterprise, India), hygrometer (Lutran HT-3003, Taspei, Taiwan), vane anemometer (KM-8022, No. VA 120708245, Kusma-mecor, India) respectively. At the end of the drying period, dried fish were collected and packaged polyethylene bag after 1day, 3 days and 5 days and kept under refrigeration for further analysis.

Construction of Solar Tent and Open Sun Rack Dryers

The solar tent drier was constructed in Massawa college of marine science and technology (Figure 1a). It consists of a plastic polythene sheet stretched over a wooden frame work (1 m wide by 1.5 m long by 1.5 m high) with side and top vent (0.3 m by 0.3m). The fish rack (0.5 m by 0.5 m) was placed with wire mesh under and underneath black rocks, which can be used as a heat collector and transmitter area. The transparent plastic on the front side was wrapped around a stick at the bottom. In this way the plastic can be rolled up or let down to allow air into the tent and to regulate the temperature a bit. The air entering is heated in the tent and absorbs moisture when it flows pass the fish on the rack. The humid air can leave the tent through both air outlets in the top of the tent. Open Sun drying rack was constructed by a wooden frame of 0.5 m by 0.5 m and was constructed from chicken wire mesh that was placed directly under the sun for maximum heat utilization from the sun.

Setting-up the Dryers

The two dryers were set-up side by side and exposed to the sun (Figure 1b). The tent was positioned facing the direction of the prevailing wind, to allow air readily into the tent, since the drying process is a combination of air movement. A black igneous rocks were used that generate heat and black polythene was spread out on the base of the solar tent drier. Drying rack was fixed rigidly inside the tent and open sun drying rack was outside of the

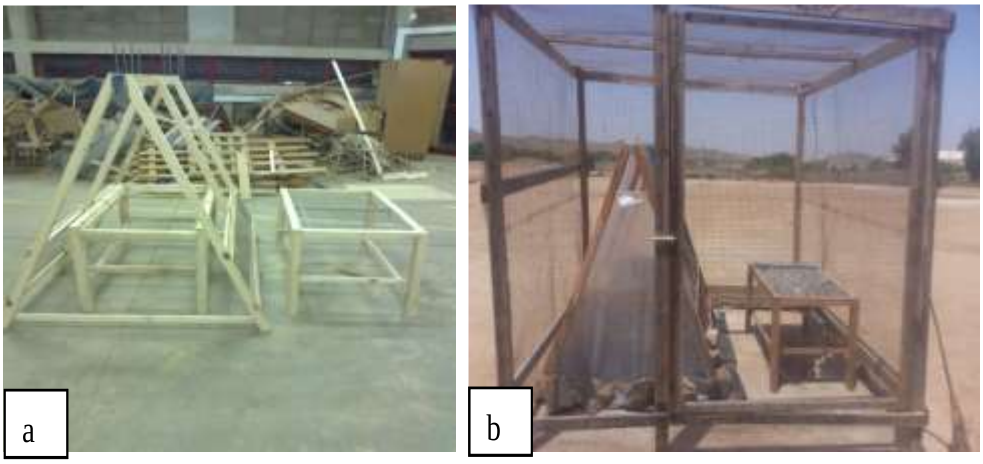

Figure 1. Construction of solar tent and open sun rack dryers (a) and drying of studied fish (b).

environment and heat. The dryers were set-up 30 minutes before fish were put inside.

Quality Evaluation

Quality of dried fish (*Stolephorus heterolobus)* were subjected to proximate composition, microbiological and organoleptic analysis.

Proximate Composition Analysis

Proximate analyses were carried out on the fresh and dried fish, on day 1, 3 and 5 respectively in Eritrean Standard Institution (Asmara) and Quality Control Laboratories (Massawa). For fresh fish, the proximate composition was determined from the body muscle tissues whereas, dried one's, it was carried out from dried flesh. The analysis were done according the method of Association of Official Analytical Chemistry (AOAC, 2000). The following parameters were measured: crude protein (Kjeldahl method), ash (muffle furnace), crude fat (Soxhlet method), moisture content(thermostatically controlled forced air oven, 105ºc for 8 hours), free fatty acids (FFA) value, peroxide value (PV) and total volatile basic nitrogen (TVB-N). The analysis were carried in triplicate and the average values were calculated and expressed as mean ± SD in triplicate observation.

Protein Content

Crude protein was determined using the micro-Kjeldahl method (AOAC, 2000). About 0.5 g powder laver sample was used to analyze protein of commercial laver. The total protein was calculated by multiplying the nitrogen content a sample with a conversion factor of 6.25. Data was expressed in grams per kilogram of dry weight sample.

Ash Content

Ash content was determined by complete igniting of the sample (5 gram) in a muffle furnace at a temperature of 550 °C for 6 hours and ash was calculated in percentage as:

$$Ash(\%) = \frac{(\text{weight of crucible} + \text{ash}) - \text{weight of empty crucible}}{\text{weight of sample}}$$

Fat Content

Lipid content was determined by extracting required quantity of samples with analytical grade n-hexane for 8 hours in a ground joint Soxhlet apparatus. The oil obtained by evaporation of the solvent on a steam bath was weighed in a sensitive balance and percent lipid was calculated and the extracted fat was used for the determination of free fatty acid and peroxide value. The fat content was calculated in percentage using the following formula:

$$Fat(\%) = \frac{(\text{Weight of flask} + \text{fat}) - \text{Weight of empty flask}}{\text{weight of sample}}\ x\ 100$$

Moisture Content

Residual moisture was determined gravimetrically by heating the sample at 105 ^{0}C for 8 hours in hot air drying oven until a constant weight has achieved. The moisture content was stated as percentage by dry weight of sample.

Determination of acid value or free fatty acids (FFA)

Two gram of fish oil dissolved in 15 ml of neutral fat solvent and few drops of 1% phenolphthalein indicator was added. The mixture was titrated against 0.1 N NaOH until faint pink colour persisted for at least 30 seconds in the fume hood. The free fatty acids were calculated and expressed as percentage of oleic acid by the formula:

$$FFA(\%) = \frac{\text{Volume of alkali x normality of alkali x 28.2 x weight of empty flask}}{\text{weight of fish oil}}$$

Peroxide Value

Primary oxidation products in fish, hydro peroxides, were determined by peroxide value measurement. Peroxide values of fresh and dried fish oils were measured by titration of liberated iodine with standardized sodium thiosulphate solution according to the AOAC official method (2000).

Total Volatile Basic Nitrogen (TVB-N)

The total volatile basic nitrogen was determined by Conway's micro-diffusion analysis (Osman, Suriah, & Law, 2001). In the procedure, the trichloro acetic acid (TCA) extract prepared sample was treated with potassium carbonate, ammonia liberated and absorbed by boric acid. The quantity of ammonia absorbed was volumetrically determined by titrating the ammonium borate against standard sulphuric acid. The TVB-N content was calculated and expressed as milligram nitrogen per 100 g sample.

Microbiological Analysis

Microbiological analyses were carried out to determine the Total Plate Count and fungal growth of fresh and dried anchovies under the aforementioned methods by the test method of International Organization of Standardization 4833 (ISO, 1991).

Organoleptic Assessment

Samples of solar tent and open sun rack dried *Stolephorus heterolobus* were subjected to organoleptic assessments. Organoleptic characteristic like colour, odour, flavour, texture (mouth-feel) and general acceptability were evaluated using Hedonic scale grading based on the method of (Doe & Olley, 1990) by 12 panelists randomly selected from the department of marine food technology and Eri-fish fish processing plant and trained for two weeks. The fresh fish was evaluated after washed, while the dried raw fish assessed directly after collected from the trays and after boiling, the dry fish was first socked in water for 5 minutes and boiled 15 minutes and then evaluated by the taste panelists. The assessors scored for color, odor, texture, flavor, and appearance. An overall acceptability score was given to fresh, boiled and unboiled fish using nine point hedonic scale where nine (9) was like extremely, while one (1) was dislike extremely.

Data Analysis

The statistical analyses were performed using statistical program (SPSS 18.0) for Windows. All analytical determinations were performed in triplicate and the mean values were reported. All data were statistically compared by one way variance analysis (ANOVA) and comparisons between means were performed using T- test. Difference between mean were reported at a significant level, P≤0.05. Descriptive analysis were also used in organoleptic analysis.

Results

The proximate and biochemical analysis of the fresh and dried *Stolephorus heterolobus* by the open sun rack and solar tent driers are presented in Table 1. In this study significant difference was observed between the two drying methods, which was 3 days for the solar tent and 5 days for open sun rack drying methods resulted differences in the analysed parameters (P≤0.05), but there was no significant difference (P≥0.05) among the days of drying. All the proximate and biochemical composition, except moisture content were increased with drying time in both driers. The drying time was shorter in solar tent drier compared to open sun rack drier. Increase in temperature resulted in shorter drying time. The drying time was three days in solar tent drier and five days in open sun rack drier. The moisture content obtained from the solar tent drier decreased more than in the open sun rack drier which showed significant difference (P≤0.05). The contents of ash, fat and

Table 1. The average values of Proximate Composition, Peroxide Value, Free Fatty Acid, and Total Volatile Base Nitrogen, of Fresh and dried *Stolephorus heterolobus*

Parameters	Drying day						
	0	1		3		5	
	fresh	OSRD	STD	OSRD	STD	OSRD	STD
Moisture(%) ± SD	81.00±0.76	9.00±0.68	7.90±0.58	8.80±0.25	7.60±0.11	7.70±0.35	7.50±0.22
Ash (%) ± SD	1.90±0.60	8.60±0.55	9.40±0.66	8.70±0.70	9.50±0.07	9.20±0.89	9.90±0.60
Fat (%) ± SD	1.62±0.10	3.08±0.12	3.10±0.10	3.32±0.15	3.63±0.09	3.32±0.17	3.74±0.50
Crud protein (%) ± SD	19.32±0.43	60.20±0.99	63.00±0.45	72.38±0.97	79.17±0.65	75.25±0.41	78.82±0.35
FFA AEX (%) ± SD	1.33±0.09	1.63±0.12	1.39±0.10	1.70±0.20	1.45±0.11	1.74±0.22	2.05±0.06
PV AEX (%) ± SD	4.73±0.52	15.21±0.30	14.20±0.07	14.30±0.08	14.98±0.06	13.43±0.19	14.66±0.15
TVB-N (%)± SD	19.15±0.26	20.02±0.16	19.39±0.01	20.37±0.19	19.45±0.08	25.01±0.24	20.12±0.20

*Values represent the mean ± standard deviation of fish for each drying method.
*STD: Solar tent drier
*OSRD: Open sun rack drier
*SD: Standard deviation

protein were significantly higher in the solar tent drier compared to the open sun rack.

The microbial analysis of total plate count and fungal growth of fresh and dried *Stolephorus heterolobus* is presented in Table 2. In microbial analysis even though result obtained was below the limit there was significant difference (P≤0.05) between two dryers, more appreciable results were obtained in solar tend drier than open sun rack dryer. The sensory evaluation of fresh, dried, boiled and unboiled *Stolephorus heterolobus* is presented in Table 3 and 4. The result showed that although the appearance, color, texture, flavor and odour of the two dryers were in good condition throughout the experiment, but dried products from solar tent drier were more excellent than open sun rack drier. Moreover, no discoloration was observed in the two drying methods.

Discussion

The result of proximate analysis of the fresh *Stolephorus heterolobus* shown a high values in the moisture content than the dried products and a significant increase in protein, fat and ash contents in dried products compared to fresh fish sample due to reduction of moisture content. The findings of this study is similar with the findings of Ochieng, Oduor, and Nyale (2015) who reported chemical and nutritional quality of dried sardine (*Spratellomorpha bianalis*) and Immaculate, Sidujia, and Jamila (2012) who studied the biochemical and microbial qualities of *Sardinella fimbiata*. Proximate composition of fish differs with species, season, fishing area, body size, environmental factors and nutritional status (Sankar & Ramachandra, 2001). This study is in close approximation to that of reported by Kumar, Sing, and Danish (2013) for the chemical composition of *Laeogonius*. The total volatile basic nitrogen (TVB-N) is mainly contributed by ammonia in the muscle produced by deamination of muscle protein (Chaijan, Benjakul, Vissanguan, & Faustman, 2006). In this study the content of nitrogenous substance as TVB-N in fresh *Stolephorus heterolobus* was found below the levels suggested by different researchers for different fish and fish products. A value of 35 mg/100 g of TVB-N has been suggested as border line by (Ghaly, 2010).

The proximate composition of crude protein, lipid, and ash of dried fish increased, while moisture content decreased in both drying methods from the first to the fifth day of the drying process. The highest crude protein, fat, ash content was recorded in solar tent dryer with the average temperature 45ºC and relative humidity 42% at an air speed of 1.06 meter per second, while in the open rack sun drying with the average temperature 35ºC and relative humidity 47% at an air speed of 1.8 meter per second. The low humidity recorded in solar tent drier was because of its consistent high temperature, thus humidity was the strongest factor for fish drying within the driers in this study. There was no significant difference among the

Table 2. The average values of Total plate count and Fungal growth of fresh and dried *Stolephorus heterolobu*

Parameters	Drying day						
	0	1		3		5	
	fresh	OSRD	STD	OSRD	STD	OSRD	STD
Total plate count (cfu/g) ±SD	$1.2*10^5$±0.90	$6.6*10^4$±0.70	$2.2*10^4$±0.52	$9.5*10^3$±0.45	$8.4*10^3$±0.33	$5.7*10^3$±0.25	$3.2*10^3$±0.17
Fungal growth (cfu/g) ±SD	$1.2*10^1$±0.01	$8.6*10^2$±0.63	$6.9*10^2$±0.30	$7.1*10^2$±0.50	$2.2*10^2$±0.22	$5.5*10^2$±0.38	$1.2*10^2$±0.10

*Values represent the mean ± standard deviation of fish for each drying method.
*STD: Solar tent drier
*OSRD: Open sun rack drier
*SD: Standard deviation

Table 3. The mean value of fresh and dried un boiled fish of organoleptic indices

Parameters	Drying day						
	0	1		3		5	
	fresh	OSRD	STD	OSRD	STD	OSRD	STD
Appearance	7.63±0.74	7.11±1.36	7.33±0.72	6.89±1.61	7.11±1.05	6.67±1.87	7.55±0.52
Colour	8.25±1.64	6.77±1.71	7.11±1.05	6.67±2.12	7.22±0.97	6.33±2.12	7.28±1.14
Odour	7.75±0.88	6.44±1.74	7.33±0.70	6.50±1.87	7.44±0.72	7.00±0.86	7.22±0.83
Texture	7.38±0.91	7.22±1.39	7.17±1.65	6.94±1.62	7.55±1.01	7.33±1.22	7.78±0.66
Overall Acceptability	7.88±0.64	7.22±0.97	7.44±0.88	6.88±1.71	7.12±1.00	6.78±1.56	7.44±0.68

*Values represent the mean ± standard deviation of fish for each drying method.
*STD: Solar tent drier
*OSRD: Open sun rack drier

Table 4. The mean value of fresh and dried boiled fish of organoleptic indices

Parameters	Drying day						
	0	1		3		5	
	fresh	OSRD	STD	OSRD	STD	OSRD	STD
Appearance	8.63±0.51	7.11±1.53	7.50±0.93	7.67±1.00	7.00±1.73	7.22±0.83	7.44±2.06
Colour	8.41±0.46	7.22±0.97	7.06±1.37	7.00±1.50	6.78±2.10	6.89±0.78	7.44±1.81
Odour	8.25±0.37	6.89±2.08	6.78±1.39	6.89±1.67	6.44±2.12	7.00±0.70	7.00±2.02
Texture	8.72±0.45	6.89±1.26	6.78±1.64	6.94±1.62	7.11±0.92	6.89±0.60	7.11±1.61
Flavor	8.44±0.49	7.11±1.26	6.56±1.50	6.56±1.30	7.44±0.72	7.11±1.05	7.67±0.70
Overall Acceptability	8.38±0.44	7.44±0.72	6.78±1.30	6.88±1.71	7.33±0.70	7.22±0.44	7.72±0.96

*Values represent the mean ± standard deviation of fish for each drying method.
*STD: Solar tent drier
*OSRD: Open sun rack drier

days of each experiment in solar tent drier as well as in open sun rack drier in the crud protein, ash, fat, FFA and PV but a significant difference was observed between the driers in the aforementioned parameters. We found inverse relationship between the moisture and fat, curd protein and ash content. This result is related to the result found by Nurullah *et al*. (2006), who studied on small indigenous fish species (*Amblypharyngodon mola, Osteobrama cotJ'ocotio, Barbides sarana, Pseudotropius atherinoides, Mystus vitatus, and Gudusia chapra)* dried by solar tunnel and traditional sun drying methods. Increase in protein was observed due to reduction in moisture content causing aggregation of protein, minerals, fat, FFA and PV (Ninawe & Rathnakumar, 2008). There was no protein nitrogen lost observed in solar tent dryer, since the activity of enzymes and microorganism prevented by the high temperature created and low water content of dried sample, so that the protein content increased with the reduced moisture content when compared with the fish dried in open sun rack dryer. The high temperature and low relative humidity created in the solar tent drier, evaporated more moisture content from the sample, and increased protein content significantly, which was recorded 79.17% on dry weight basis after 3 days of drying. These results were similar to those reported by Chukwu and Shaba (2009) and Sultana, Islam, and Kamal (2009). Chukwu and Shaba (2009) reported that dried fish nutrients were more in cat fish (*Clarias gariepinus*) dried in oven than dried by smoking. Sultana *et al*. (2009) studied in silver jiaw fish (*Johnius argentatus*) and Bombay duck (*Harpodon nehereus*) to evaluate drying performance of rotating and solar tunnel dryer and reported that drying rate was faster in solar tunnel dryer than open air drying and lower than rotating dryer due to high temperature and low relative humidity resulted high quality of dried fish products .

In the present study, peroxide value increased throughout the drying time, but the increase was only within narrow limits. Peroxide value is commonly used to assess rancidity development. A rancid taste often becomes noticeable at peroxide value of 10 – 20% (Oparaku, Obialo, & Effiong, 2010; Enamul *et al*., 2013). Peroxide value was low in both the solar tent and open sun dried products. This is due to the activity of fish muscle enzyme and microorganisms were reduced to a minimum level through evaporation of water content of the dried products. The result shows lower peroxide value in the dried products using solar tent dryer compared to that open sun rack dryer. Fish may show off odour and taste rancid when PV is above 20 mill moles of oxygen per kg of fat (Connell, 1976). The free fatty acid values found in this study were below the acceptable limit and no rancidity was observed, due to low water content, mould and enzymes activities. This result is in agreement with the findings of previous study (Immaculate *et al*., 2012).

In the proximate analysis of open sun rack and solar tent dried fish low levels of moisture were achieved for products from solar tent dryer than in the open sun rack dried products. A significant difference in moisture content was observed between the driers. This was because of the high rate of drying associated with solar tent drying and great significant difference on the temperature of the drying methods. The percentage moisture content both in the sun and solar tent dried fish products were not high enough to cause the fish to spoil because of the good weather at the time of drying. These results were agreed with those reported by Enamul *et al*. (2013) and Ochieng *et al*. (2015) who studied on drying of bombay duck and silver pomfert fish using solar tunnel and traditional sun drying methods and who studied on drying of sardine (*Spratellomorpha bianalis*) dried using solar raised rack and traditional ground drying processing on net respectively. These studies indicate that a well dried fish or reduced moisture content to 25% is well enough to inhibit microbial growth and if further dried to a moisture content of 15%, the growth of mould will stop and prolongs the shelf life (Ogongo *et al*., 2015; Rahman, Siddique, Barman, & Riar, 2016; Immaculate *et al*., 2012).

Percentage fat recorded were higher in the solar tent dried products than in open sun rack dried fish products, a significant difference in fat content was observed between the two driers. The fat content in solar tent was higher than that in open sun rack dried products. No oxidation of fat was observed in both drying methods, even though fat content and PV values had direct relationship. The difference could be attributed to the differences in their moisture contents. Fat content of solar tent dried products was 3.69% (3rd day), relatively higher than the open sun rack dried products 3.32% (5th day) in dry weight basis. This result is in agreement with the result found by Nurullah *et al*. (2006) who reported that fat and protein contents of the solar tunnel drier products were much higher than the traditional sun dried products. Fat and moisture content for any species fluctuates depending on season and location of catch, size, spawning cycles, and drying methods (Nurullah *et al*., 2006; Islam *et al*., 2013). This loss in moisture content is reflected as an increase in the other constituents of the proximate composition. The ash content of the experimental fish dried products increased throughout the drying time in both driers, and indicated that the dried products are good source of mineral contents. However, the values obtained in solar tent drier were higher than open sun rack drier. This high value could be resulted due to low moisture content and the bones and head of the dried fish. However, solar tent drier had higher temperature and low relative humidity that can help the dried products to have lower moisture content and higher ash content compared to the products dried in open sun rack. This finding agree with Dewi (2002).

The quantity of bacteria in foods serves as a universal indicator of cleanliness. Evaluation of total bacterial count is widely used to measure the bacterial quality of fish. The border for total plate count (TPC) is 1 x 10^5cfu/g in the dried product **(**Relekar *et al*., 2014). In the present study, low TPC and fungal growth was found in fish dried in both two drying methods. Low moisture content and hygienic conditions attributed to low TPC and fungal growth. The results of microbial analysis reveal that the total plate count and total fungal count were higher in open sun rack dried anchovy when compared to the solar tent drier dried samples. Thus, solar tent dryer can concentrate solar radiation with the result that elevated temperature, which increase drying rate, in turn, lower relative humidity makes unfavorable to the activities of microbes and moulds. Moreover, high internal temperature and shelter protect the entry of pests into the dryer and can be lethal to those already entered. Bacteria infestation was observed in open sun rack drying method during the first day of the experiment, this was due to little rain happed on that day, and the samples were kept for 1 day in a room gives favorable condition for bacterial and fungal growth. The infestation has stopped in the next day after exposed in to sun light. Moreover during the experiment trails period, it was observed clearly that there was no a signs of loses due to the contaminations by insects infestation and dust in both the methods except in the open sun rack drying in the first day there was bacteria infestation and effect of dust, while the solar tent method samples looked pure and clear, and there was no any signs of contaminations by insect infestation or dust. These results are in accordance with the earlier findings (Rillo, Magal, Migual, & Diloy, 1998), studied the microbial quality of commercially available dried mackerel of Philippines and reported presence of microbes. In this study, microbial load in the samples from solar dryer was less due to clean and safe practice followed.

In the present study, drying time was found to be different in the two drying methods. Solar tent drier required less time (5 days). The reason behind was circulation of hot air within solar tent drier, which increased internal drier temperature and reduced drying time. However, open sun rack drier required 5 days for drying fish since it was placed in an open air so there was no creation of hot air as it was in a solar tent drier. This finding is in agreement with (Curran, 1985), observed that three days were required for fish drying in solar tent drier. Also he reported that fish dried on sloping rack-required 4 days for reducing moisture up to 20%. Table (3 and 4) describes the organoleptic indices of fresh, dried boiled and dried unboiled fish, the results show that there was no significant difference between appearance, colour, odor, texture and flavour at level, while in the general acceptability, the method of STD score was higher than the OSRD. None of the dried boiled products in these two drying systems had a value of less than 6.56 10 point hedonic sale measurement. In the mean time, unboiled dried products solar tent a value of 7.11 and open sun rack a value of 6.44 on the 10 point hedonic sale measurement. The color, texture and odor of dried fish were evaluated from both driers in boiled and unboiled conditions. Although, the color, odor and texture of fish dried in the solar tent dryer was having high levels of acceptability and obtained high scores by the taste panelists compared to the open sun rack dryer, the texture of unboiled dried fish was firm, dry, good in color, very pleasant odor and freshly appearance in both driers. The flavor of dried fish from both driers was evaluated in a dried boiled form, fish dried in 3rd day using solar tent dryer was found to be relatively higher in value (7.33 on the 10 point hedonic scale measurement) and showed higher level of acceptability, while fish dried using open sun rack scored lower value (6.8 on the10 point hedonic scale measurement). The organoleptic evaluation showed that the appearance of the two dryers were in good condition throughout the experiment. Also, no discoloration was observed in the driers. This results agrees with (Blight, Shaw, & Woyewoda, 1988) studies showed the dark colour and rancid odour of cured fish is an indication of deteriorated quality. The result of statistical analysis conducted using one-way analysis of variance indicated that drying had no effect on the organoleptic properties. Appearance, Flavour and colour appeared to be the three most important characteristics that influenced panel's preference for products. Colour, flavour, texture, odour and over all acceptability of sun and solar tent dried fish were acceptable by panelists; but solar tent dried was superior in quality than open sun rack dried. From the results it was observed that solar dried products provided fish with better organoleptic qualities. It is evident that the thermal energy generated helped in drying up the fish products. This heat was then transfer to the air by contact between the air and absorber and similar analysis was reported by Lawand (1966). This resulted in the higher temperature and thereby increased drying rate and also high quality of the solar tent dried products. This result is in agreement with the studies of (Relekar *et al*., 2014) who thought the consumers may have strong opinions, they usually find it difficult to explain in detail why they prefer one product to another, and the results may be difficult to interpret. The finding in agreement with studies of (Adam & Sidahmed, 2012) which showed that descriptive sensory analysis carried out by trained sensory panels provides accurate and detailed description of the sensory properties of the products under study. From this study the solar tent dryer has proven to be more efficient and reliable form of fish preservation using the ambient solar energy. The products were of good quality compare to open sun rack drying in terms of proximate composition, microbial, organoleptic analyses and hygienic.

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