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Preface
By Mohamed El-Tahir Ali

1. Introduction

According to data published by FAO, 15% of the world's supply of animal proteins is derived from fish. The demand for fish as food is systematically increasing but at the same time marine resources are close to the limits of exploitation. However, aquaculture which supplies the market with both marine and freshwater fish, is fast developing.

Until recently, freshwater fish processing was carried out mainly in kitchens at home, in restaurants and in catering centers. Occasionally, fishmonger shops and small fish processing plants produced semi-products in rudimentary conditions and placed them on the market. However, changing requirements and habits of customers created the need for an increased market supply of ready-to-cook (e.g., fillets, chunks) or ready-to-serve dishes.

However, mechanization of the processing lines is very costly, especially for small plants processing freshwater fish. In these cases, mechanization of freshwater fish processing would be limited to that equipment needed to maintain the market and meet the basic sanitary requirements imposed by the competent authorities. In addition to infrastructure and the necessary machines - for example, ice generators, washers, smoking equipment, freezers and cold stores - small processing plants could, within reason, also acquire simple, inexpensive machines which often only perform one operation. Bykowski, P.; Dutkiewicz, D.-*FAO Fisheries Circular*. No. 905.

2. Fish as Raw Material for Processing

2.1. Nutritive and Technological Values of Fish

The manufacturing potential of the raw material as food depends on two features - the nutritive and the technological value.

2.1.1 Nutritive Value

The nutritive value of dishes prepared from fish and from animal meat is comparable, but in some cases fish-based meals are advisable. In such an evaluation, many parameters, such as energetic value, quality and content of protein components, vitamins and mineral compound content should be examined.

The composition of amino-acid proteins in fish meat is similar to that of a hen's egg. Consumption of fish together with products of plant origin which are poor in some amino-acids (lysine, threonine), enables not only a complete utilization of plant protein, but also improves the content of a diet.

The biological value of freshwater fish fats is lower than that of marine fish because the former contain fewer unsaturated aliphatic acids. Fish meat is valuable as a source of vitamins and mineral substances. It contains especially the trace metals such as: selenium, molybdenum, cobalt, whose value is emphasized by physiologists (Bykowski, P.; Dutkiewicz, D.-*FAO Fisheries Circular*. No. 905).

2.1.2 Technological Value

The technological value generally depends on two parameters: the yield of preliminary processing and the quality features of fish meat and by-products. The yield of edible parts of the fish depends, first, on the species and constitution and also on age and consequently size and maturity.

Plate 1: Traditional Manual Processing of Small- Sized Fishes on Shore of Fishing Site (Gebel Aulia)

Yield is affected by the ratio between edible and inedible parts of the fish and this is a decisive factor with regard to the technological value of the fish. This ratio depends on the species. It is most favorable in the Salmonidae family, amounting to approximately 75% of the weight. For most fish species this parameter ranges from 50 to 60%. In the case of perch and most of the Cyprinidae family the yield is less than 50%.

Evaluation of the technological value of fish should take account of its possible utilization for different products, considering the sensory properties such as: flavor, texture, appearance, size and bone content. These parameters are decisive as to consumer's interest and thus the market demand.

Fish with high bone content are not so popular as a product for consumption. Therefore, the technological value of cat fishes is lower than that of Nile-perch (*Lates niloticus*) and *Bagrus* spp. The taste of fish depends mainly on the quality of their water habitat and on their food. It is known that fish (for example, *Clarias*) living in dirty and muddy ponds, has an unpleasant flavor. The flavor of wild *Tilapia* from rivers is better than that of fish from aquaculture.

Fish are classified according to size, larger individuals usually being preferred to small fish. This is also connected with bone content: e.g., *Tilapia* weighing over 500 g is more popular with best market value and of high demand.

The sanitary and hygienic condition of fish and fish meat also influences the technological value. This relates to the presence of parasites and pathogenic micro-organisms.

However, the main role in evaluating technological value and usefulness is played by a set of features termed freshness. These features change during storage after the death of the fish and the intensity of the changes depends on the species, fishing conditions and storage conditions immediately after capture (Bykowski, P.; Dutkiewicz, D.-*FAO Fisheries Circular*. No. 9

Plate 2: Fillets from Commercial Fresh Fish-Catches (Processed manualy) .

Plate 3: Chunks (Faried) from Commercial First Grade Fish (*Bagrus* Sp.)- Produced Manually on Shore.

2.2. Post Mortem Changes and Fish Quality Assurance Methods

On the death of the fish, processes of physical and chemical change caused by enzymes and micro-organisms begin to occur. The complete decay of the fish is the final result of those changes.

Post-mortem changes which take place in fish tissue occur in the following phases:

- Slime is formed in certain cells of fish skin and the process becomes very active just after fish death. Some fish, for example cat fishes secrete more slime than scaly fishes, for comparison, *Bagrus* spp and Nile perch.
- Rigor mortis is a result of complicated biochemical reactions which cause muscle fibres to shorten and tighten and finally the fish becomes stiff. *Rigor mortis* has many technological consequences
- Autolysis, a complicated biochemical process starts on the death of the fish, leading to a decomposition of basic compounds of tissues which takes place under the influence of enzymes
- Microbiological Spoilage, the muscle tissue of live fish is generally sterile but bacteria thrive in the alimentary tract and on the skin and from there they penetrate into the muscles; for example, through the blood vessels. This process is further favored by structural changes in the tissue as a result of *rigor mortis* and autolysis.

The duration of each phase can change or phases can overlap. This depends on storage conditions, especially the temperature which greatly influences these processes.

Plate 4: Mishandling and Improper Landing of Fish Catch (Tilapia Sp.) on mud.

Plate 5: Spoiled Fish from Commercial Fish Landing, at Fish Market (as result of improper handling)

2.3. Indicators of Fish Freshness

Freshwater fish, as other fish species, are raw material which fast deteriorates. This implies that both the producer and the consumer are very often exposed to the risk of buying fish which is not fresh or has even deteriorated. Knowledge of the average shelf life for individual fish species - depending on storage conditions - is a basic principle applied in the food - and the fish - industry. Effective, objective and repeatable methods for evaluation of raw material freshness should be specified, but attempts so far are only now showing positive results. Thus, sensory analysis is the main method of evaluating fish freshness. It enables differences in texture, flavor and taste to be determined and subsequently the usefulness of the raw material. Sensory properties change during storage from the desired very high standard, through neutral or average and finally to undesirable or disgusting. It is generally assumed that prior to disappearance of desirable features the fish is considered to be fresh, while the appearance of undesirable or disgusting features disqualifies the raw material. The most difficult step is to determine an intermediate state in which the fish is not entirely fresh. Sensory analysis is thus carried out on raw fish and cooked fish. Flavor, appearance and state of abdominal cavity (for not eviscerated fish) are the main indicators of quality in the case of raw fish. For cooked fish, smell is the most important indicator. Bykowski, P.; Dutkiewicz, D.-*FAO Fisheries Circular*. No. 905. Huss, H.H. (1988).

3. Fish Processing

In small freshwater fish processing plants only limited preservation methods are used as compared with marine fish processing establishments. The main methods of freshwater fish processing and technological examples are:

3.1.Chilling and Storage of Chilled Products

Decreasing the temperature of the fish to about 0° C slows down the microbiological, chemical and biochemical decomposition processes and extends fish stability. Thus when the raw material is cooled quickly, just after capture and kept at low temperature during transport, processing and distribution, it meets the basic processing requirements. Its usefulness is extended and at the same time fish quality is maintained.

In modern fish processing plants, especially the small ones, flake ice generators dominate as flake ice ensures major contact surface with fish and its production cost is low. The effectiveness of temperature exchange depends on the thickness of the layers of fish and the distribution of ice. For example, an 80 mm layer of fish requires two hours to decrease the temperature from 17° C to 10° C when exposed to double-sided cooling and about 24 hours when exposed to one-sided cooling.

To evaluate optimal conditions for fast cooling of fish, many parameters (degree of ice granulation, temperature of the fish and the environment), which influence the activity of the process, should be known.

Greater amounts of ice do not shorten the process. It was ascertained that use of 25% ice in relation to the amount of fish causes temperature to drop to 5° C after 3.3 hours, for 50% ice - cooling down to 1° C takes 6 hours, but for 75% ice - 2.25 hours.

Plate 6: Chilling by ice of commercial Fish Landings

3.2. Freezing and Refrigerated Storage

Even when the most effective chilling methods and further chilled storage of raw fish and fish products are applied, shelf life is limited. Freezing is needed to extend shelf life for long periods. This can be achieved by changing two parameters: first, a considerable decrease in temperature and second, by freezing the water in the fish tissue. During the freezing process the majority of micro-organisms are inactivated and only psychotropic bacteria can develop in such conditions and to a limited degree. A temperature of about -10° C is a limit for growth of such micro-organisms. Some molds and yeasts multiply very slowly at -15 to -18° C.

Fish should be frozen rapidly in order to produce the highest quality frozen products. Quick freezing implies a fast change from cryoscopic temperature to -5° C. During this period (about 2 hours) the main changes take place in fish tissue. A faster freezing process is linked to the formation of smaller ice crystals which damage the cellular membranes to a lesser degree, especially if freezing takes place before *rigor mortis* sets in.

In small fish processing plants there are usually two kinds of freezing equipment: chamber freezers and contact-plate freezers. Chamber freezers can be used in small plants; but high energy consumption and their large size are the main disadvantage. Contact freezers are far less common in fish processing plants with low daily production.

Even properly frozen fish has limited storage life. Low temperatures inhibit processes of microbiological decomposition but do not protect against fat oxidation and loss of water. The stability of frozen fish depends on the initial quality of the raw material, the rancidity, the drying process and the storage temperature. Bykowski, P.; Dutkiewicz, D.-*FAO Fisheries Circular*. No. 905.

3.3. Smoking of Fish

There are two methods of fish smoking: hot and cold, which give very different products. The difference lies in stability and sensory properties which in turn depend on a degree of fish dryness and saturation with smoke components. FAO Fisheries report no. (88) 43 pp.

Smoke is produced by a not complete burning of some type of wood and is a mixture of more than a hundred chemical components. The chemical composition of smoke depends on the type of wood and traditionally citrus tree wood is used.

The hot-smoking process includes the preliminary processing of raw material, brining, drying to a certain loss of water content, the actual smoking process and thermal treatment at temperatures above 30° C, usually 70-80° C.

The cold-smoking process involves no thermal treatment and the entire process is carried out at temperatures below 30° C.

Drying is carried out in order to reduce the water content in fish tissue to a level which ensures product stability and texture. Usually 25-30% weight loss takes place during hot-smoking and 40-45% during cold-smoking.

3.4. Drying of Fish

Drying means extraction of water from a substance, usually by heating. During drying, there are two things of primary importance, the heat transfer that causes the evaporation of water and the mass transfer of the evaporated water through the substance and subsequently the removal of moisture away from the surface of the substance itself. FAO Fish. Tech. Pap. No. (160): 52 p.

3.4.1. Types Of Processes Employed in the Drying of Fish:

I. Air or contact drying, where heat is transferred to the fish from heated air or a heated surface, utilizes the air movement above the fish to carry away the moisture. In most parts of the world, fish drying is still largely carried out in the open air, using the energy of the sun (solar drying) to evaporate the water and air currents to carry away the vapour.

   Artificial or mechanical drying will give better control and thus better quality and uniform product but at a price of higher cost in equipment and operation.

   Simple mechanical driers have been designed over the years and the ones in practice are tunnels/boxes with fans and heaters with air and temperature controls (Axtell and Bush, 1991; Clucas and Ward, 1996).

II. Vacuum drying, where advantage is taken of the greater evaporation rate of water from the fish at reduced pressure, utilizes conduction by contact with heated surfaces or radiation to evaporate the water which is removed by the vacuum pump.

III. Freeze drying relies upon the attainment of very low pressures by highly efficient vacuum pumps in a sealed chamber containing the fish.

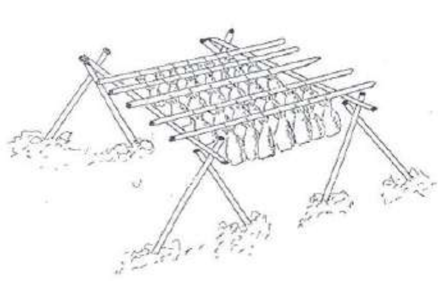

figure (2): Rack for sun drying of fish

3.4.2 Sudanese dried fish (kejeik):

Drying was most commonly used for preserving fish in the Sudan; kejeik was produced in large quantities in the southern Sudan by the Nilotic tribes and also in the Northern parts of the country along the White, Blue Nile and the Atbara River (Dirar, 1993). kejeik bounni (dark colored product) is made from Garmut (*Clarias* Sp), Nauk (*Heterotis niloticu*s), Humar_el_hout (*Auchenoglanis* Sp). The lower grade product is kejeik abiad; from: Igil (*Lates niloticus*), Bayad or Kabaros (*Bagrus* Sp), Dabs (*Labeo* Sp) and others (Omer, 1984). Kejeik, also called korki and Hout, is a product obtained by sun drying large fish. The fish were first asymmetrically split along their dorsal axes before drying (as in Plate).

Plate7: Sudanese dried fish (kejeik-white).

Plate 8: Sudanese dried fish (kejeik -black).

3.5 Fish Salting (Solar and Wet - Salting):

Salting is probably one of the earliest preservation techniques; today it is an important preservation technique in some parts of the world. Several factors account for the preservative properties of salt (NaCl). High salt concentrations around the fish result in the osmotic transfer of water out of and salt transfer into the fish. The high salt content prevents growth of the normal spoilage micro flora on the fish.

3.5.1 Wet And Dry Salting

The salting process employed depends mainly on the size of the fish. Small fish can be salted whole (no gutting) as the skin is a poor barrier to salt penetration in this situation. Bigger fish must be gutted and perhaps split open to encourage salt penetration because the thicker skin (and scales) is a major barrier to penetration.

Salt can be applied directly to the fish ('dry' salting)and the brine formed by extraction of water from the fish (due to osmotic pressure) is allowed to drain off.

In the 'wet' process the fish is immersed in a brine (pickle) solution. In reality, the processes overlap, whereby a 'dry' salt system becomes 'wet' if the brine formed is not drained off.

- **Brining** is a light pre-treatment applied before another, more severe, process such as smoking.
- **Pickling** involves long-term storage in strong brine, giving a stable product.
- **Kench curing** is applied to white fish which are split open and dry salted with the brine allowed to drain off. The resulting dry, brittle product has a long shelf life.

3.5.2 Types of Salt Used:

- **Solar** salts produced by evaporation of sea/brackish waters from improvised lagoons, under the sun and wind, are the cheapest and energy-saving option but are the least pure and salt crystal size will not be uniform. Manual removal of the salt will lead to contamination by sand and soil from the lagoon bed.
- **Brine-evaporated** salts are produced by evaporation of brines from deep mines and tend to be less contaminated than solar salt. However, the application of heat for evaporation makes the process less energy efficient than solar salt production.
- **Rock** salt is mined and purity varies from 80 to 89% depending on the source.
- **Manufactured** salt can be produced from any of the above grades with appropriate purification up to 99.9%. The crystal size can be better controlled by crystallization from saturated solution but the greater processing is accompanied by greater energy use.

Plate 9: Fresh Fish (*Alestes* and *Hydrocynus* Spp.). Wet Salted for Fermented Fish (Fessiekh)

Preparation, 

Plate 10: Fermented Fish (Fessiekh). Prepared and Landed on Shore for Marketing

Plate 11: Commercially Packed and Presented" Fessiekh" at Market, Ready for Direct Sale.

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1
CHAPTER

Body Characteristics Sensory Evaluation Parameters

Obany Okuki Deng Lual and Sara Gibreel Abakar

1.1. Body Characteristics

The filleting yield of the studied fish species was a reflection of their anatomy i.e. species with large heads and skeleton relative to musculature give lower filleting yield than those with smaller heads and skeletons (Eyo, 1989; Ali *et al.*., 1996).

Generally, the percentage of body components of inedible parts (skin, skeleton, viscera and head) of the fresh water fishes was in most cases, higher than the edible parts (fillet). Since these inedible body components (head, skeleton, skin and viscera) are usually discarded except for a few considerations where heads and skeletons are eaten, the purchaser may thus suffer economic loss. Therefore, the use of such inedible parts for manufacture of fish silage or fish meal in different fisheries sectors is suggested.

Zaitsev *et al.* (1969) conducted studies on fish curing and processing. They mentioned that the food value of fish is normally estimated only approximately according to amount of edible material (flesh) and its content of the basic nutrient (fat and protein). Babiker (1981) studied the reclassification according to nutritional merit of about 50 species belonging to 23 genera of the Nile fish. He found also that a high relative proportion of tissue fat is indicative of high energy yield from the tissue; but from a nutritional point of view an overabundance of fat is negative feature.

The body components (fillet, head, skeleton, viscera and skin), edible and non- edible portions of fish; studied by different authors in different areas for different species in Sudan are represented in - following (table 1).

Table 1.1: Summary of Mean Values of Body Components of Different Freshwaters Fishes of Sudan

Param - Spp	Total Wt. (gm)	S.L (cm)	Fillet (%)	Viscera (%)	Head (%)	Skeleton (%)	Skin (%)	Edible Parts (%)	Inedible (%)	Author	Area
Bagrus bayad	1228.5±0.12	46.10 ±1.39	46.86 ±0.23	4.48±1.38	25.00±0.28	20.00±0.70	-	-	49.54±0.95	Adam, suileman, H.M 1996	Lake Nubia
Bagrus docmac	1848.1±1.68	41.46 ±0.62	45.90 ±0.33	6.62±0,29	27.83±0.64	15.67±0.81	-	-	50.21±0.77		
Barbus bynni	1221.4±0.10	38.90 ±0.25	44.80 ±0,09	7.37 ±0.32	13.04±1.21	21.96±1.38	9.65±1.04	-	52.02±0.21		
Labeo coubie	957.3 ±0.28	32.20 ±0,80	43.31 ±0.21	11.40±1.15	14.17±1.07	18.38±0.11	9.14±1.00	-	53.05±0.09		
Synodontis spp	641.7±1.35	28.±1.39	40.80 ±0.74	11.39±1.15	33.55±1.36	14.05±1.42	-	-	58.99±1.86		

Paramet. Spp	Mean weight (gm)	Mean standard length (cm)	% Weight of fillet	% viscera	% head	% skeleton	% skin	% In edible)	No. of determination	Author	Area
B.bayad	1231.83± 304.2	46.87± 6.5	48.31	4.5	24.99	20.49	-	49.98	15	JokGaiPakaGeuerjok December 1996	Lake Nubia
B.docmac	2065.91±874.4	49.64± 3.87	47.53	6.30	28.67	15.49	-	50.46	15		
B.bynni	1217.8±368.35	36.04± 2.92	47.16	6.43	13.14	21.02	10.62	51.21	30		
L.coubie	948.47±399	32.5± 4.1	45.03	11.08	16.35	17.03	8.81	53.27	30		
Synodontis	653.07±13.38	28.57± 0.35	40.23	11.18	32.47	13.55	-	57.2	30		

Paramet. Spp	Total Wt.(gm)	S.L (cm)	Fillet Av /(g)	Viscera Av / (g)	Head Av /(g)	Skeleton Av /(g)	Skin Av / (g)	Edible	Inedible Av/ (g)	Author	Area
t-O. niloticus	930 ± 21.60	29.75 ± 0.50	282.5 ± 17.09	65 ± 5.77	252.56. ± 46	212.5 ± 19.37	92.5± 2.89	-	56.98 ± 1.5	Adam. H.M.Y 2011	White Nile
Labeo. niloticus	1210 ± 106.15	39.5 ± 1.29	470 ± 47.61	132.5± 34.03	121.25 ± 11.09	330 ± 13.54	112.5± 6.46	-	48.28± 0.53		
C. Lazera	977.5 ± 71.82	45 ± 0.82	398.75 ± 38.38	101.2± 13.15	283.75 ± 11.09	83.75± 4.79	53.57± 4.79	-	45 ± 1.26		
Where: Av = Average, SD = Standard deviation Spp = species, g = gram											
spp	Weight% ±SD	S.L (cm)	fillet %± SD	viscera % ± SD	Head % ±SD	Skeleton % ±SD	Skin %±SD				
% O. niloticus	930 ± 21.60	29.75± .50	33.39±.2.05	10.33 ±0.6	14.16± 0.67	32.84± 1.85	9.95 ± 0.44	-	66.71%		
Labeo niloticu	1210 ± 106.15	39.5±1.29	38.82± 1.29	10.85±1.97	10.06± 0.93	27.37± 1.51	9.32 ± 0.42	-	61.17%		
C. lazera	977.5 ± 71.82	45± .82	46± 1.32	6.99 ± 0.5	29.09 ±1.16	8.58 ± 0.41	5.52 ± 0.58	-	52.45%		

Gymnarchus niloticus Parameters	Body weight (Kg)			SE	LS	Author	Area
	1	2	3				
Heads %	16.62	16.50	15.82	0.15	NS	Omer atta al –manan Algani Alkhidir September 2011	Khartoum state- White Nile
Internal organ%	7.84	7.42	6.84	0.17	*		
Skin %	6.88	6.29	6.15	0.15	NS		
Fillet %	46.70	47.34	48.15	0.14	NS		
Bones %	7.96	8.38	9.82	0.14	*		
Total fins %	2.31	1.25	1.18	0.06	*		
Fat %	8.54	10.06	10.16	0.18	*		

Recently in Sudan, the demand of Tilapia (*Oreochromis niloticus*), Dabs (*Labeo niloticus*) and catfish (*Clarias lazera*) consumption increased continuously because, these fishes are of low price, but of high nutritional food value. It was noticed that *Bagrus bayad*, B. *docmac and Clarias lazera* have the highest edible meat percentage 48.31%, 47.53%, 46.75%, followed by *Labeo niloticus* 38.82% and *Oreochromis niloticus* (33.39%) and there were significant differences ($p < 0.05$) among the other species (as in- above-table 1).

On the other hand, *Synodontis* sp. had high inedible parts (head, skeleton and viscera) that recorded 58.99% and 57.2% whereas *B. bayad*, *Clarias* and *L. niloticus* recorded relatively less inedible parts (46.98 - 49. 54%), 45.0% and 48.28%. These inedible parts are often discarded except for a few considerations where head, skeleton and gonads are used as by-products and sometimes used as diet for low-income people. The fillet percentage was highest in *Clarias lazera*. 46.75% compared to *Oreochromis niloticus* which was 33.39%. The highest filleting yield of *Clarias* sp. is due to its low skin (5.5%), skeleton (8.58%) and viscera (6.99%), while the lowest filleting yield of *O. niloticus* is due to high percentage of head and skeleton which were 32.84 % and 14.16% respectively. The least variable component of carcass was the skeleton which was more or less uniform, except for *O. niloticus* and *Labeo niloticus* which recorded a higher percentage skeleton of 32.84% and 27.37% respectively. *Synodontis* spp and *B. docmac* possessed large heads (33.55%, 32.47 and 27.83%, 28.67% respectively) which had effect of lowering the filleting yield. Also, there were some attributes, which were responsible for decreasing the filleting yield such as skeleton and skin in the case of *Barbus bynni, Bagrus bayad, L. niloticus* and *Oreochromis niloticus* which recorded (21.96 – 21.02 %), (20.00 – 20.49%), 27.37% and 32.84% for skeleton respectively. While for skin of these species *Barbus bynni, Lates niloticus* and *Oreochromis niloticus* were (9.65 – 10.62%), 9.32% and 9.95% respectively.

Ali *et al.*, (1996) studied body characteristics; yield assessment and proximate chemical composition of commercial fish species namely *Lates niloticus, O. niloticus, Sarotheradon galilaeous*, *Labeo niloticus* and *Labeo horie*. The results of body characteristics and yield indices revealed clearly percentage decrease in the order of fillets, heads, skeletons, viscera and skin for *Tilapia* spp. Compared to order of fillets, skeletons, viscera, head and skin for *Labeo* spp.

Osman (1995) studied the body structure, yield indices and physical analysis of *Labeo niloticus* from commercial landings. She found that the percent of body structure and yield indices were decreased in the order of fillet, skeleton, head, skin and viscera.

Adam (1996) found that fillet percentage ranged between 40 and 46%. He also found that all species were organoleptically acceptable to the panelist**s.**

Mac (1996) studied body weight characteristics and chemical composition of some fish species from lake Nubia, he found that body weight characteristics had clearly shown that the percentage of viscera, skeleton, head and fillet differ significantly ($p<0.01$ or $p<0.05$) among the treatments.

Jock, (1996), in his study on the percentage of fillet, head, viscera and skeleton of four different fish species (*Bagrus bayad*, *Bagrus docmac Barbus bynni* and *Synodontis* spp) at Nubia Lake, was as follows 46.86%, 5%, 4.48% and 20% - 45.90%, 27.83%, 5%&15.67% - 44.80%,13.04%, 7.37% and 21.36% 43.3%, 14.17%, 11.40% and 18.43% respectively.

Siham, (1999) showed that the percentages of head, viscera, skin, skeleton and fillet of *Protopterus aethiopicus, Malapaterurus electricus* and *Tetraodon fahaka* bought from Elmorada fish market were as follows 16.59%, 10.88%, 28.99%,10.26% and 29.2 - 19.26%, 17.9%, 16.02%, 13.35% and 27.29% - 5%, 24.58%, 13.76%, 21.66%, 6.61% and 30.56% respectively.

Mac (1992) carried out the meat quality, yield and nutritional value determination of *Oreochromis* *niloticus* and *Sarotherodon galilaeous*. He found that the body characteristics of these species have the decreasing order of fillets, skeleton, head, viscera and skin. In a similar study , the body weight characteristics and filleting yield indices revealed clearly a percentage decrease in the order: fillet, head, skeleton and viscera for *B. bayad, B. docmac* and *Synodontis* sp. while the percentage decrease order for *Barbus bynni* and *Labeo coubie* was: fillet, skeleton head, viscera and skin. These results were in agreement with Eyo (1989), obanu and Ikeme (1988) and Ali *et al..*, (1996).

The terms fillet and edible portion are difficult to define exactly since the portion eaten varied from one country to another, but generally, the fillet yield of each species is expressed as the total weight of boneless, skinless fillet divided by the total weight of the whole fish (Gall *et al.*, 1983). Weis. (1953) reported that the edible fraction of the different fish species varies widely between 30% and 50% of total weight.

Finne. G *et al.* (1980) Gulf of Mexico, finfish species varied from a maximum of 31.3% to a minimum of 20.0% in yield and composition.

Babiker (1981) studying some Nile fish found that the edible portion of the fish ranged between 50% - 60%.

Clement and Lovel. (1994) recorded that the fillet yield of *Oreochromis niloticus* and *Ictalurus punctatus* ranged between 25.0 and 30.9%. The fillet yield was found to vary from one species to another and was related to the specific anatomical make – up of the species and that the size of each individual did not greatly influence fillet yield (Gall *et al..*, 1983).

1.2 Sensory Evaluation Parameters

Sensory evaluation of food, according to Huss, (1994); Meilgaard *et al.* (1991); is defined as the scientific means of quantifying and interpreting the variations in food characteristics (odour, flavour, tactile, appearance) by using human senses of smell, taste, touch and sight. Studies have shown that assessment of food freshness/ characteristics using sensory methods are capable of giving objective and / reliable results when assessments are done under controlled conditions. Generally, trained and experienced taste panel is essential to obtain accurate and reproducible result (Connell, 2001; Alejandra *et al..*, (1992).

Little work has been done in Sudan concerning sensory evaluation of fish products. The organoleptic test was carried out for the treated samples to evaluate the mean value of color, texture; flavor and juiciness depending on the personal preference score are in -following- (Table 1-2)

Table 1.2: Mean organoleptic scores for fresh water fishes

Treatm. Species		Salt conc.	Color	Texture	Flavor	Juiciness	Overall Acceptability	Author	Area
Bagrus bayad			5.8a	5.6a	5.9a	5.8b	5.85	Adam suileman, H. M, 1996	Lake Niba
Bagrus docmac		-	6.2a	6.1a	5.7a	5.9b	5.97		
Barbus bynni		-	5.3a	5.2a	5.6a	5.2b	5.31		
Labeo coube		-	5.9a	5.5a	5.5a	5.4b	5.57		
Synodontis sp.		-	5.7a	5.7a	5.2a	5.4b	5.62		
Clarias sp		-	5.0a	5.7a	5.4a	5.1b	5.43		
SE		-	0.47	0.48	0.42	0.49	0.43		
Hydrocynus sp.	S	20%	6.2	6.4	6.6	6.4	6.4	Hassan yagub, 2011	White Nile
	W		5.8	6.2	6.0	6.4	6.1		
	S	25%	5.8	6.6	6.8	7.0	6.6		
	W		6.8	6.2	6.6	6.2	6.5		
	S	33%	6.0 6.4	5.8	6.6	6.4	6.2		
	W			6.4	6.4	5.0	6.1		

Labeo sp	S W	20%	6.2 6.2	7.0 6.0	7.4 6.0	7.4 7.2	7 6.4		
	S W	25%	6.0 6.8	6.2 5.8	6.4 6.8	6.2 6.8	6.2 6.6		
	S W	33%	6.2 6.8	5.6 6.0	6.4 6.6	6.2 6.0	6.1 6.4		
Schilbe sp	S W	20%	5.8 6.2	6.2 6.4	6.8 5.8	6.4 6.4	6.3 6.2		
	S W	25%	6.2 6.4	6.8 6.0	7.0 6.4	7.0 6.2	6.8 6.3		
	S W	33%	6.2 6.2	6.0 6.2	6.4 6.6	5.4 6.0	6.0 6.3		

Where: conc. = concentration W= wniter. S= summer.

Fresh (n=10)	Smoke (saw Dust)	Color M±SD	Odor M±SD	Taste M±SD	Tex ture M±SD	Appear ance M±SD	Overall acceptability M±SD	Fawzi, A. M.A (2010)	Khartoum state (almorda market umdroman)
		4.1±2.0	4.7±1.15	4.8±1.9	4.6±1.8	4.0±1.3	4.5±1.6		
	Smoke (fire wood)	4.6±1.42	5.9±1.52	5.30±1.4	6.6±1.8	5.7±1.3	5.6±1.5		
	Smoke (fire wood)	5.4±1.42	5.5±1.50	4.6±1.6	5.4±1.4	4.3±2.1	5.0±1.6		

Parameters Species		**Body Weight (Kg)**					Omer Atta AlmananAlganiAlkhidi r 2001	El Mourada Market Khartoum State
		1	**2**	**3**	**SE**	**LS**		
Gymnarchus niloticus	**Color**	5.67	5.99	5.42	0.12	NS		
	Tenderness	5.61	5.93	5.68	0.01	NS		
	Flavor	5.40	5.62	5.37	0.09	NS		
	Juiciness	5.46	5.78	5.71	0.09	NS		
Parameter Species		**Treatment**			S.E	- -	AlhadiAlmoniemElminshawi October 2007	Khartoum State
		A	B	C				
Color	*Bagrus* Sp.	5.42[a]	5.81[a]	6.13[a]	±1.91			
	Clarias Sp.	5.90[a]	5.75[a]	6.15[a]				
Texture	*Bagrus* Sp.	5.62[a]	5.99[a]	5.66[a]	±2.55			
	Clarias Sp.	4..95[a]	5.75[a]	6.05[a]				
Flavor	*Bagrus* Sp.	5.87[a]	5.80[a]	5.72[a]	±2.25			
	Clarias Sp.	5.40[a]	5.45[a]	5.90[a]				
Tenderness	*Bagrus* Sp.	5.51	5.39	5.58	±2.57			
	Clarias Sp.	5.10	5.25	6.05				
Juiciness	*Bagrus* Sp.	5.11	5.31	5.65	±2.55			
	Clarias Sp.	5.50	5.65	6.20				
Personal preference	*Bagrus* Sp.	5.45	5.71	5.63	±2.74			
	Clarias Sp.	4.75	5.40	5.80				

Note: each result is mean ± standard deviation of panelist response on a scale of 8 = excellent, 7= very good, 6= good, 5= fairly good, 4= fair, 3=poor, 2= very poor and 1 = extremely poor for overall acceptability. S= summer, W=winter

Adam, Sulieman, H.M, (1996) showed that no significant difference ($P>0.05$) in the parameters of color, texture and flavor for all samples. However, for the parameter of juiciness there was a significant difference observed ($P<0.05$). This might be due to the effect of water holding capacity and the cooking method. The juiciness was considered to be related to water holding capacity as it was preferred by the panelists. The overall acceptability scores obtained during this study would closely be related to the overall preference of the consumer for the samples. Remarks made by individual panelists of the organoleptic test showed that *B. docmac* (5.97) was the most preferred one among the studied fishes. This might be attributed to its good color (6.2) and texture (6.1), while *Barbus bynni* scored the lowest marks due to fewer score of color (5.3) and texture (5.2). The organoleptic test was carried out on treated fish samples to evaluate the color, texture, flavor and juiciness. These parameters depend completely on the personal preference score.

Fawzi, A. M. A: he reported that the fresh fish smoked using firewood (5.6) were found to be better in terms of overall acceptability when compared with sawdust smoked products (4.5). Dried fish smoked using firewood were also found to be better in terms of overall acceptability (5.0) fairly good when compared with fish smoked with sawdust (4.5). Also, these results were in agreement with Clifford *et al.* (1980), who observed that the texture, toughness and dryness of smoked fish were greatly influenced by the panelist's preference.

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2
CHAPTER

Physical Characteristics

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2.1. Physical Characteristics of Fresh Fish:

Hamm (1972) attributed the variation in water holding capacity (WHC) to many factors such as species of fish, physiological condition, seasonal variation, age and stage of sexual maturity. The results revealed clearly that muscles (flesh) with high WHC were juicy and obtained high organoleptic scores than muscles with low WHC a result that confirmed the findings of Hamm, (1972), Tibin, (1980), Osman, (1995) and Huss, (1988).

The following tables show the results of physical characteristics of fishes i.e. PH, WHC, color, cooking loss and shrinkage percentages, which were studied by different authors in the Sudan.

Table 2.1: Mean physical Characteristics for Fresh Fishes

Parameter Species	Treatment	PH %	WHC %	Lightness %	Redness %	yellowness %	Area	authors
Clarias sp	Summer	7.10	1.66	38.30	18.77	12.87	Khartoum State	Elminshawi, A. A. (2007)
	Winter	7.30	1.19	44.53	23.97	13.10		
Bagrus sp	Summer	7.13	0.91	52.37	8.80	10.77		
	Winter	7.30	1.52	48.97	10.77	8.67		
Gymnarchus sp	Summer	N. A	0.61	43.03	24.23	7.03		
	Winter	N. A	0.51	44.70	4.60	13.17		
B. bayad		7.06	2.62				Lake Nubia	Sulieman, H. M. A. (1996)
B. docmac		7.09	3.35					
Barbus bynni		7.08	1.75					
Labeo coubie		7.04	1.77					
Synodontis		7.03	1.59					

Elminshawi. (2007). Reported that the value of PH and WHC were significantly different, while the best WHC was in the *Gymnarchus* sp in winter, also he mentioned that the *Clarias* sp was of the lightest clour (Redness) in winter, while the highest value was recorded for *Gymnarchus* in winter and yellowness highest values was in *Gymnarchus* sp in winter. Sulieman (1996). Mentioned that there is non-significant difference in PH value of Bagridae family, *Labeo coubie* and *Synodontis*, but there is significant difference in their water holding capacity.

2.2 Physical Characteristics of Fish By-Product for Human Consumpostion:

Tibin (1980) reported that heat causes the protein in muscle fibers to coagulate and the flesh becomes firmer, which resulted in some shrinkage and a lot of weight lost. The cooking losses materials are composed of drip losses, evaporation and material that accumulated in aluminum foil. Factors behind the losses of cooking were the internal temperature of meat, cooking time, method of cooking and PH of flesh. Similar findings were reported by Osman (1995) on flesh of *Labeo niloticus* where the losses were found to be 20

Table 2.2: Mean Values for PH, WHC and Color Percentages of Fish by-product for human consumption.

Parameter / species	Treatment	PH	WHC %	Lightness %	Redness %	yellowness %	Cocking loss %	Shrinkage %	area	authors
Gymnarchus	BW1		1.06				15.75	10.75	Elmawrada fish market	Alkhidir, O. A. A. (2011)
	BW2		0.93				13.20	8.98		
	BW3		0.92				8.10	8.90		
	ST0D		1.41				17.32	11.34		
	ST2D		1.06				13.31	10.22		
	ST4D		0.81				10.35	8.79		
	ST6D		0.59				8.41	7.81		
	Control		1.21				15.84	10.92		
	Bread		0.73				8.86	8.17		
Clarias sp	FF	6.91±.003	4.66±.203	36.10±.088	17.5±.057	10.10±.033			Elmourda fish market	Sourkaty, M. M. A. A. (2012)
	MFun	6.45±.008	2.913±.20	36.266±.08	13.6±.057	8.66±0.33				
	MFw	6.41±.005	2.81±.158	33.16±.088	11.7±.058	8.96±0.034				
	FBun	6.0±0.003	0.00±0.00	35.06±.033	12.66±.08	9.70±0.057				
	FBw	5.92±.010	.366±.057	34.43±.088	12.76±.08	10.20±.057				
Labeosp	FF			49.34	10.94	8.68			White Nile	Elobiad, A. O. (2003).
	DTSo			50.70	9.88	19.78				
	DTSu			50.41	10.67	18.35				
	DTt5d			49.61	10.54	18.76				
	DTi7d			51.50	10.01	19.37				
	Salted			52.33	9.57	19.86				
	Not salt			48.78	10.98	18.27				

Key: BW (1, 2, 3) = body weight in kg. ST (0, 2, 4, 6) D = storage time in days. FF = fresh fish, MFun = minced fish unwashed fillet, MFw = minced fish washed, FB (un & w) = (fish burger unwashed & washed). DT (So & Su) = drying type (by solar or sun), DT (t5d & t7d) = drying time (time 5 days & time 7 days)

Alkhidir (2011), studied the WHC, cooking loss and shrinkage for different sizes of *Gymnarchus* sp, his study showed a slight decrease in values of the three physical features with increase in size and storage period. While Sourkaty, (2012) studied the PH, WHC and colors of *Clarias* sp fresh fish, Minced and Burger, his study revealed there is non-significant difference in PH & WHC, but the WHC for both Mince and Burger fish showed a significant different from Alkhidir (2011)and this may be attributed to different treatment and the effect of washed and unwashed fish. Elobiad (2003) studied the colors of *Labeo* sp dried under solar or sun and also he studied the effect of storage period on dried fish, his finding showed a significant difference of Sourkaty (2012)and the increasing in the percentage of colors attributed to the effect of smoking.

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3

CHAPTER

Chemical Composition

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3.1. Chemical Composition of Unprocessed Fish:

Many evidences on benefits of fish consumption due to Omega-3 fatty acids present in salt water fish have been reported. However, despite the lack of information on the health benefits from long-term intake of fish and shellfish, there is no obvious drawback on opportunity to enjoy health living, prolonged life and good diet of fish species (Sefa- dededh *et al.*, 1992). Today even more people are turning to fish as health alternative to red meat. Fish fat is characteristically high in poly-unsaturated fatty acids, making them important in diets for people requiring keeping low level of cholesterol in their blood (Clucas and Ward, 1996).

Fish meat contains significantly low lipids and higher water than beef or chicken and is favored over other white or red meats (Nestel, 2000). The nutritional value of fish meats comprises the contents of moisture, protein, vitamins and minerals plus the caloric value of the fish (Steffens, 2006). Fish as a rich source of protein needs to be introduced locally into Sudanese diet, so as to reduce the burden of high cost of red meat pertaining in this country's market. Yet in Sudan with its large fisheries resources, little is known about nutritional value of the fishes that are normally utilized either fresh or preserved dried, salted or smoked Elagba *et al.* (2010).

3.1.1. Chemical Composition of Fresh Fish:

The parts such as flesh, head and viscera separated from fish frames show variation in proximate composition, the same species fish show variation from organ to organ. The flesh separated from frames is compositionally same as any food fish with protein content ranging between 15-18%. The head contained considerable amount of flesh with protein content of 15-17%, but showed higher fat and lower moisture content. Mahmoud, (1977) studied the meat quality of some common Nile fishes, he reported that the proximate composition of fish species were in the range of 63. 29 - 75.19%, 14.99 - 22.01%, 0.36 - 2.50%and 0.45 - 1.94% for moisture, protein, fat and ash respectively.

The tables below determine the proximate percentages of chemical composition of fishes i.e. moisture, protein, fat, ash and dry matter that were observed by many authors in different treatments.

Table 3.1.1: Mean value and their standard error for some chemical percentages of fresh fishes from different waters of Sudan.

Param. / Species	Treatment		Moisture %	Protein %	Fat %	Ash %	Dry matter %	area	authors
Clarias sp	Fresh FS		75.35^{a}	18.04^{a}	1.19^{a}	1.01^{a}	26.64^{a}	Khartoum State	Elminshawi, A. A. (2007)
	Fresh FW		77.71^{af}	18.77^{b}	1.51^{d}	0.77^{a}	22.28^{df}		
Bagrus sp	Fresh FS		74.20^{b}	17.93^{a}	1.13^{a}	1.00^{a}	25.86^{df}		
	Fresh FW		80.51^{c}	18.34^{c}	1.52^{dc}	0.70^{a}	19.50^{b}		
Gymnarchus sp	Fresh FS		74.61^{c}	17.90^{a}	1.11^{a}	1.12^{a}	25.50^{c}		
	Fresh FW		77.07^{af}	18.00^{a}	1.68^{f}	0.94^{a}	22.93^{f}		
B. bayad	Fresh fish		80.41^{c}	18.08^{a}	1.99^{b}	0.93^{d}		Lake Nubian of the Sudan	Erjok, J. G. M. P. (1996)
B. docmac			81.9^{c}	19.64^{a}	1.77^{b}	1.02^{d}			
B. bynni			79.63^{c}	19.57^{a}	2.56^{b}	1.01^{d}			
L. coubie			81.51^{cc}	17.89^{a}	1.95^{b}	1.12d			
Synodontis			79.38^{c}	19.37^{a}	2.56^{b}	1.02^{d}			
B. bayad	Fresh fish	M	80.28±0.82)^{a}	17.4±0.98)^{a}	2.2±0.85)^{a}	.74±0.22)^{a}			
		F	80.36±0.82)^{a}	17.0±0.98)^{a}	1.17±0.85)^{a}	.96±0.22)^{a}			
B. docmac		M	79.45±.12)^{ab}	18.4±1.96)^{ab}	(3.22±1.69)^{ab}	.95±0.1)^{ab}			
		F	(80.0 ±0.12)^{ab}	(15.8±1.96)^{ab}	(2.0±1.69)^{ab}	(1.01±0.1)^{ab}			
B. bynni		M	(78.1±3.65)^{bc}	(19.3±3.33)^{bc}	(2.0±1.43)^{bc}	0.89±0.27)^{bc}			
		F	(75.3±3.65)^{bc}	(20.1±3.33)^{bc}	(1.91±1.43)^{bc}	(1.22±27)^{bc}			
Synodontis		M	(78.9±0.72)^{abc}	(15.8±2.23)^{abc}	(1.74±2.18)^{abc}	(1.01±0)abc			
		F	(79.6±0.72)^{abc}	(18.9±2.23)^{abc}	(2.3±2.18)^{abc}	(1.02±0)^{abc}			
Shillbaia	fresh		(76.50±0.60)^{b}	(32.00± 0.50)^{b}	(7.90± 0.10)^{a}	(4.30±0.10)^{b}	(23.6±..6)^{b}	Elmourada	Elfaki, M. O.
Kawara			(77.04±0.60)^{a}	(32.50± 0.70)^{a}	(7.60± 0.10)^{b}	4.10±0.10)^{c}	(22.9±.7)^{c}		
Hemaela			(72.90± 0.80)^{c}	(31.00±0.50)^{c}	(7.20± 0.10)^{c}	4.60±0.10)^{a}	27.2±.9)^{a}		
Siganus sp	G-A		5.94±0.97^{a}	81.58±0.97^{a}	7.99±0.65^{a}	7.32±0.13^{a}		Red Sea	Habiballa, S. Y.M.
	G-B		5.52±0.52^{a}	76.39±0.91^{b}	8.21±0.79^{a}	7.52±0.11^{a}			
	G-C		6.33±0.61^{a}	83.45±1.00^{b}	8.89±0.73^{a}	7.29±0.14^{a}			
	G-D		6.30±0.69^{a}	75.04±1.46^{a}	8.61±065^{a}	6.88±1.46^{a}			

Key:
Fresh FS & FW = fresh fish summer & fresh fish winter, M= male, F= female. G (A, B, C & D)= group (A, B, C&D)

Table (3.1.1) shows the studies investigation of moisture, protein, fat, ash and dry matter, of fishes in different seasons of the year, ranged between (81.9% -72.2%), (32.50% - 15.8%), (7.9% - 1.1%), (4.60% - 0.70%) and (26.6 – 19.5) respectively. We can observe that during winter all the chemical with exception to the ash are at higher level for *Clarias* sp and *Gymnarchus* sp (Elminshawi, 2007). While (Erjok, 1996). Studied the Bagridae family he revealed there is non-significant difference in chemical composition of the fishes except the percentage of protein of *B. bynni* i.e. (20.1±3.33) which is significantly different from the other results, but it is accompanied with finding of Mahmoud (1977). For Shillbaia and *Alestes* sp there are non-significant differences, except the percentage of dry matter, Hemaela is showing a significant difference than the other two species (Elfaki, 2010). On the other hand Elfaki, (2010) found high percentage value of protein i.e. {(32.00± 0.50)^{b,} (32.50± 0.70)^{a} and (31.00 ± 0.50)^{c} for Shilbaia, Kawara and Hemaela} respectively, but unfortunately he didn't mentioned any reason for his results. The value of moisture content appear very low in the results of Habiballa (2007) for (*Siganus rivulatus*) i. e. (5.94 ± 0.997, 5.52 ± 0.52, 6.33± 0.61 and 6.30 ± 0.69) for four groups of his treatments in which he observed the infection of *Siganus* sp with Helminthes.

3.1.2. Chemical Composition of Fish Treated by Irradiation:

Table 3.1.2: Shows the chemical composition of fish treated by irradiation:

Para. / Spp.	Treatment	Moisture %	Protein %	Fat %	Ash %	Area	Authors
Bagrus& Tilapia sp	ID0D	78.99±1.30	19.11±0.88	1.71±0.31	1.39±0.33	Elmawrda fish market	Abdalla, T. A. (2007)
	ID1D	79.33±1.01	19.34±0.60	1.86±0.51	1.34±0.27		
	ID3D	78.88±1.88	19.02±0.98	2.02±0.82	1.31±0.29		
	ID6D	79.31±1.97	18.38±0.67	1.75±0.47	1.28±0.26		
	ISP0D	78.58±1.49	18.83±0.75	1.71±0.47	1.36±0.33		
	ISP3D	78.29±1.40	19.49±0.73	2.03±0.72	1.36±0.33		
	ISP5D	80.29±1.40	18.58±0.85	1.76±0.41	1.28±0.27		
	ISBa	79.24±1.67	18.82±0.82	1.89±0.66	1.27±0.29		
	ISTi	79.01±1.49	19.11±0.88	1.78±0.43	1.39±0.27		

Key: ID (0, 1, 3 & 6) D = irradiation dose (0, 1, 3& 6) days, ISP (0, 3 & 5) D = irradiation storage period (0, 3 & 5) days, ISBa = irradiation storage of *Bagrus* sp, ISTi = irradiation storage of *Tilapia* sp.

Abdalla (2007). Studied the drying of *Bagrus* and *Tilapia* spp. with irradiation using different doses and storage periods of time for both species, but her results revealed that there is non-significant difference in the chemical composition contents for the different treatments.

3.2. Chemical Composition of Chilled Fish:

Use of ice for preserving fish and fishery products has proved to be an effective handling method (Shawyer and Pizzali, 2003), it is a technique used to decrease the fish temperature to levels where metabolic activities and microbial enzymes completely stopped or reduced (Ababouch, 2005)and it can slow down the process of deterioration and prolong the shelf life of fish as food (Graham *et al.*., 1992). The design, size, insulation and management of cold stores are key factors for fish quality and energy saving (Ababouch, 2005). The quality of the final product determines the usefulness and commercial viability of the processing method applied. Quality is concerned with the degree of contamination with undesirable materials, nutritive value, degree of spoilage, damage, deterioration during processing, preservation, sale and the consumer satisfaction, on buying and eating (Connell, 1995). Undoubtedly one reason for the poor fish quality is lack of rapid transport, but with modern techniques for freezing storing and transporting very fresh fish, the consumer can receive fish that has a composition and flavor virtually unchanged from when caught (Torry, 2008).

Table (3.2): Mean value and their standard errors for some chemical parameters of chilled fishes.

Param. Sp	Treatment	Moisture %	Protein %	Fat %	Ash %	Dry matter %	area	authors
Tilapia nilotica	0 day	77.03± 0.09	31.05± 0.21	7.80± 0.14	1.550± .07		Jebel Awlia	Hassan , A. A.(2011)
	10 day	79.35± 0.21	28.30± 0.42	2.450± 0.07	1.25± 0.07			
	20 day	80.20± 0.00	27.05± 0.12	2.200± 0.14	1.15± 0.07			
	30 day	81.75± 0.35	24.70± 0.42	1.950± 0.07	0.90± 0.01			
Tilapia	10 d with hy	73.90± 2.0	21.30±5.0	2.00±0.05	0.60±0.05	26.10±2.0	Jabel Awlia , Elshagara	Hamid, S. H. A. (2007)
	10 d with v.f	73.50± 2.4	22.00±1.0	2.10±0.05	0.63± 2.5	26.30±2.5		
	Control	75.50±3.00	24.00±1.3	2.20±0.05	0.76±0.05	24.40±3.0		

	40 d with hy	73.5±1.2	23.0± 1.0	2.0± 0.1	00.7±0.10	26.5± 1.2		
	40 d with v.f	76.8± 2.4	22.0± 1.0	1.9± 0.2	0.7± 0.10	23.1± 0.4		
	Control	77.50± 1.0	22.30±0.5	2.00 ± 0.1	0.60±0.11	22.00±1.0		
Plectropomus areolatus	D0 1:1	67.59±1.78	69.95±1.05	4.23±0.13	5.51±0.90		Red Sea	Ahmadoon, H. G.(2010)
	D7 1:1	77.82±2.62	61.13±1.94	3.34±0.87	4.86±1.09			
	D14 1:1	79.97±1.23	54.06±1.98	3.54±0.38	4.18±0.74			
	D21 1:1	80.19±0.99	40.91±7.93	3.63±0.37	3.52±0.39			
	D28 1;1	80.64±0.89	40.16±6.16	3.05±0.81	4.11±0.96			
	D0 1:2	77.62±2.25	70.62±1.28	4.23±0.13	6.10±1.25			
	D7 1:2	77.73±1.22	60.13±1.62	3.79±0.22	4.47±0.20			
	D14 1:2	79.12±1.16	54.28±2.00	3.78±0.17	5.04±2.19			
	D21 1:2	79.88±0.65	41.54±4.46	3.37±0.25	4.57±0.68			
	D28 1:2	79.91±1.34	38.85±5.50	3.66±0.31	3.63±0.54			
Plectropomus areolatus	FIR 1:1	79.38±0.01	38.43±0.01	3.35±0.01	3.99±0.01		Red Sea	Ahmadoon, H. G. A. & Ali ,M. E. (2013)
	FIR 1:2	79.61±0.01	39.00±0.01	3.40±0.01	3.30±0.01			
	FZ S	79.38±0.01	33.78±0.01	3.00±0.01	3.09±0.01			
	FZL	81.65±0.01	38.43±0.01	3.35±0.01	3.99±0.01			
	FSW	79.75±0.01	46.45±0.01	3.95±0.01	4.74±0.01			
	FSS	79.38±0.01	38.43±0.01	3.35±0.01	3.99±0.33			
	FAP	79.38±0.01	37.16±0.01	3.35±0.01	3.99±0.01			
	FAS	79.41±0.01	38.43±0.01	3.45±0.01	4.09±0.01			

Key:
10 d with hy = 10 days with a hydrophila , 10 d with v.f = 10 days with *V. furnissii* , 40 d with hy = 40 days with a hydrophila , 40d with v.f = 40 days with *V. furnissii* , D (O,1,7,14,21&28) = day (0,1,etc…) , 1:1 & 1:2 = Rtio of fish to ice, FIR = fish ice ratio, FZS = fish size small, FZL = fish size large , FSW = fish season winter , FSS = fish season summer , FAP = fish area Port Sudan , FAS = fish area Sawakin.

During chilling the moisture percentage increasing with the increasing time of chilling, while the percentage of protein, fat and ash are decreasing with the increasing time of chilling of *Tilapia nilotica* Hassan *(*2011*)*. The chilled *Tilapia* fish infected with *Hydrophila* and *V. furnissii* sp have shown lower moisture content than the control ones but for protein, fat and ash there is non-significant difference between chilled fish even for 10 or 40 days and the control, while the dry matter of infected fish with *V. furnissii* chilled for forty days showed significant difference from the other samples Hamid (2007). On the other hand the percentage of chilled *Tilapia* for a wide variation time showed a significant difference in the percentage of the chemical parameters.

The moisture content of *Plectropomus areolatus* chilled in ratio of (1:1 & 1:2 fish to ice) at constant difference interval of time increased directly with the increasing period of time while the protein content has an inverse proportion with the increasing time of chilling, but there is non-significant difference in the contents of fat, ash and dry matter of *Plectropomus areolatus* chilled for different periods of time. *Plectropomus areolatus* chilled in (ratio of 1:1 & 1:2 fish to ice, small and large fish size, summer and winter or area Port Sudan and Sawakin; revealed there is non-significant difference in chemical contents (Ahmadoon (2010); Ahmadoon and Ali, M. E. (2013).

Chemical composition, bacteriological test and sensory evaluation of gutted and whole fish at days; 0, 7, 14, 21 and 28 were done on *Plectropomus areolatus* chilled in (ratio of 1:2 fish to ice. Chemical contents were decreased with progress of preservation period except moisture and pH, which increased in gutted and whole fish. A significant effect was produced from gutting at the end of preservation on acidity and protein; the change was more in whole fish; Ahmadoon (2015).

3.3. Chemical Composition of Fermented Fish (Fasseikh &Terkin):

The need for efficient processing of landed fishes for maximum yields with best quality should be emphasized (Ali *et al.*., 1996, Turan, *et al.*., 2007). Fermentation is considered an easy and low energy preservation method for meat that results in distinctive products that have an important part in the diet of people making them (Margy, 1992). Such fermented meats contribute both nutritional value and pleasure to meals. Dirar (1993) mentioned that, there are four major fermented fish products in Sudan (Fessiekh, Kejeik, Mindeshi and Terkin), the fifth, Batarikh, is prepared in the homes of a few families of Egyptian origin. The product is made by fermenting fish roe or milt and is better known in Egypt than in the Sudan.

Agab and Bashir (1987) found that the proximate composition of traditionally salted fermented fish of the Sudan were 18.12 – 28.5%, 20.7 - 45.5 %, 10.6 - 22.5% and 3.6 - 5.2% for protein, moisture, fat and ash respectively. Omer (1984) preliminary studies on the chemical composition of the flesh of *Hydrocynus forsskali*, (she) found that the proximate composition were in the range of 79.1%, 17.33%, 1.1- 1.45% and 1.28- 1.64% for moisture, protein, fat and ash, respectively.

Table 3.3: Determine the chemical composition of fermented fish:

Paramrter/Species	Treatment	Moisture %	Protein %	Fat %	Ash %	Area	Authors
Hydrocynus	Raw fase-	56.7±5.2	12.3±0.8	6.9±0.3	17.4±0.2	Khartoum	Ahmed, A. A. A. (2010)
	F+SP	65.1±4.4	12.5±1.04	6.9±0.2	17.6±0.15		
	F+HP	61.2±2.8	12.6±1.03	6.9±0.24	17.7±1.25		
Hydrocynus	F 0%S	70.9±1.2	24.2±0.21	3.8±0.95	1.2±0.95	Elmawrada fish market	Bakhiet, H. H.A.(2010)
	F15%S	60.3±0.77	21.7±0.49	3.4±0.35	10.5±0.70		
	F20%S	56.7±1.9	19.2±0.56	3.2±0.28	12.9±0.28		
	F25%S	52.2±0.19	17.6±0.35	1.9±1.0	14.1±0.14		
Labeo niloticus	S4D	61.30±0.99	17.40±.39	1.23±0.29	15.67±0.15	El mwrada fish market	Elhag, G. *et al.* (2012)
	S8D	61.26±0.97	15.57±0.37	1.23±0.51	14.30±0.76		
	S12D	45.21±0.8	15.93±0.32	1.0±0.40	13.43±0.62		
	S1M	61.72±0.29	14.63±0.14	1.36±0.11	13.63±0.19		
	S2M	58.22±0.25	11.92±0.33	0.90±0.23	12.54±0.18		
	S3M	47.72±0.31	11.23±0.13	0.73±0.50	12.55±0.24		
	S4M	41.33±0.15	11.03±0.35	0.46±0.50	13.70±0.34		
	S5M	33.06.±0.9	10.45±0.20	0.23±0.50	12.18±0.15		
Kas & Kawara	T J A	56.4±0.51	24.0±0.21	6.3±0.24	13.2±.31	J wlia W Halfa	Abu alhassan, O. (2011)
	TWH	39.2±1.01	30.7±0.614	11.8±0.26	19.1±0.49		
Hydrocynus	S 0 week	63.41±0.10	18.0±0.10	1.41±0.10	11.20±0.10	Local fish market	Ahmed, O. E. & Ali, M. E. & Ahmed, A. A
	S1month	56.82±0.10	16.21±0.10	1.20±0.38	12.22±0.10		
	S2month	38.42±0.10	15.72±0.10	1.0±0.10	13.0±0.38		
	S3month	25.71±0.10	14.51±0.10	0.83±0.11	13.12±0.10		
	S4month	22.90±0.10	13.23±0.10	0.71±0.10	13.51±0.10		

	S5month	20.00±0.10	12.51±1.08	0.51±0.10	13.83±0.11		
	S6month	19.31±0.10	11.68±1.06	0.41±0.10	13.98±0.10		
Key: F+SP = fasseikh with sweet pepper, F+HP = fasseikh with hot pepper. F (0, 15, 20, 25%) S = Fassiekh (0, 15, 20, 25%) of salt concentration. S (4, 8, 12) D =storage (4, 8, 12) days, S (1, 2, 3, 4, 5) M =storage for (1, 2, 3, 4, 5) months. TJA =Tilapia from Jabel awlia, TWH = Tilapia from Wadi Halfa. S (1,2,3,4,5,6) month = storage for (1,2,3,4,5,6) month.							

Elhag, *et al*. (2012). They observed that the chemical composition of fresh sample and salted fermented Debs (*Labeo sp*.), showed a decrease in moisture, ash, protein and ether extraction of all fermented fish during storage period. In a similar study carried by Abbey *et al*. (1994) reported a gradual decrease in moisture, fat and protein content in salted fermented products.

The moisture content of the treated samples varied between 61.30 ± 0.99 during 4 day of storage and decreased to 33.06 ± 0.29 on 5 months of the storage and it was 77.90 ± 0.374 in fresh samples. A significant difference ($p<0.05$) was observed between fresh and fermented salted samples. The moisture values of fermented fish in her study were close to values reported by Abdullhi (2000), Asiedu and Sanni *et al.* (2002) who obtained 77.8 % for naturally fermented" Enam Ne-Setaaky", a West African fermented fish. Ahmed, *et al.* (2010). reported that the moisture contents have recorded high value 70.21± 0.101%; similar results were obtained by various researchers, namely Abdullahi (2000) who worked on fresh water fish species: *Alestes nurse*, *A. macrolepidotus*, *Hydrocynus brevis* and *Hepsetus odoeand* Clucas (1981) who worked on *Hydrocynus vittatus.* The protein content was 20.20 ± 0.368% on wet basis; this is probably due to the high moisture content. These results agreed with those obtained by other investigators for common Nile fishes, (Mahmmoud, 1977; Iskander, 1982 and Ssali, 1988). Lipid content was 1.84 ± 0.113% on wet basis. It was obvious that *Hydrocynus forskalii* belongs to the category of low-fat fish classified by Ackman (1989) having fat content below 5%. Ash and fiber content were 1.9 ± 0.368% and 1.93 ± 0.110% respectively. These results are in accordance with those obtained by (Mahmmoud, 1977, Ssali, 1988). The moisture content changes were determined to be of significant difference ($p<0.05$) and decreased progressively during the six months storage period.

3.4. Chemical Composition of Dried-Smoked Fish:

Drying means extraction of water from a substance, usually by heating. During drying, there are two things of primary importance, the heat transfer that causes the evaporation of water and the mass transfer of the evaporated water through the substance and subsequently the removal of moisture away from the surface of the substance itself. The main purpose of drying is to prolong the presentation time of the product. The effect of smoking and frozen storage on the protein and fat content of five African fish species comprising, *Malapteurus electricus*, *Synodontis, clarias*, *Chrysichthys grodigitatus*, *Clarias gariepinus* and *Sarotherodon melanotheron* from lekki lagoon was evaluated. Frozen storage reduced both the percentage of protein and fat content in all the species while smoking reduced the percentage of protein content and simultaneously increasing the percentage of fat content. The most susceptible fish to protein loss during smoking and frozen storage was *Clarias gariepinus* (44.33% - 3.00%) and (44.35% - 28.54) respectively. *Sarotherodon melancheron* was the least susceptible to protein loss during smoking (29.33% -28.00) while *Chrysichthys grodigitalis* was the least susceptible to protein loss during frozen storage (27.50% - 24.50%). Smoking and storage lead to loss of nutrient quality in African fishes and fatty fishes were more susceptible to nutrient loss during processing (Saliu, 2004).

3.4.1 Chemical Composition of Sun Drying Fish (Kajeik):

Currently, seven fish products mostly produced in Sudan include: Alfesikh, dried fish Kejeik, indigenous Turkein, chilled fish, frozen fish, canned fish, smoked fish and fish waste. Dried fish from low-cost traditional industries and citizens exercised on the Blue Nile and White Niles, Dirar (1993). One of these home products is a dried black or brown Kejeik made from Garmut (mud-fish, *Clarias angullaris*, *C. lazera*); Nawk (thick-skinned fish, *Heterotis niloticus*) Humar el-hout (black spotted cat fish, *Heterotis bidarsalis*). Kejeik, which is also called Korki and hout, is a traditional food product obtained by sun drying of large fish. It is prepared along the White Nile, Blue Nile and the Atbara River. Kejeik is consumed in many parts of Sudan as a whole food or as a sauce. Kejeik is produced in the southern Sudan by the Nilotic tribes: the Dinka, Nure and Shulluk. Many subgroups of these large tribes live in the vast swampy area of the alongside the Nile, Dirar (1993).

Table 3.4.1: determine the chemical composition of sun drying fish (Kajeik):

Para. Sp	Treatment	Moisture %	Protein %	Fat %	Ash %	Dry Matter %	NFE %	Area	Authors
Clarias sp	Sun drying	5.5± 0.65	61.29±.63	7.96±.17	7.92±0.25	94.51±.55	17.46±1.0	Gedarif State	Elhassan,A. A. M .(2012)
Tilapia sp		7.63±0.47	61.04±.66	7.53±.15	7.44±0.15	92.48±.54	16.17±.97		
Tilapia sp	Untreated	76.3±0.8	34.4±0.5	7.5±0.2	4.6±0.3	23.7±0.8	29.9±1.3	Elmourda fish market	Adam, H. M. Y .(2011).
	treated	6.7±1.0	62.00±0.6	7.4±0.2	7.2±0.1	93.3±1.0	16.7±0.8		
Labeo sp	Untreated	74.9±0.9	32.2±0.06	8.4±0.3	4.8±0.2	25.0±0.9	29.3±1.6		
	treated	7.1±0.7	61.5±2.7	8.2±0.2	7.3±0.2	92.9±0.7	16.9±0.09		
Clarias sp	Untreated	76.5±.7	32.3±0.4	7.3±0.2	5.8±0.3	23.7±1.0	30.9±0.9		
	treated	7.1±0.5	61.5±0.7	7.3±0.2	7.9±0.2	94.5±0.5	17.8±0.9		
Clarias sp	Open air	5.95±0.07	52.65±.77	7.95±.07	8.1±0.14	94.05±.07	25.35±.49	Elmawrada market	Sulieman, H. M. A. *et al.*
	Plastic s	5.050.49±	59.0±0.28	6.8±0.14	8.85±0.07	94.95±0.9	20.45±.9		
	Rabbit w	4.55±0.63	61.75±.35	7.1±0.14	8.55±0.02	95.45±.36	18.05±.49		
Labeo sp	DTY by Solar	10.0[a]	50.99[a]	17.22	21.86[a]			White Nile	Elobiad, A. O. (2003).
	DTY by Sun	10.18[a]	50.57[a]	17.02[a]	22.36[a]				
	DTI in 5days	11.83[a]	50.71[a]	17.68[a]	20.98[b]				
	DTI in 7 days	8.35[b]	50.84[a]	16.56[a]	23.24[a]				
	Salted	9.16[b]	50.97[a]	14.30[b]	20.99a				
	Non salted	11.02[a]	49.58[b]	19.94[a]	19.23[b]				
Bagrus sp	SD of FFF	83.58		0.22	7.27	77.5			Babiker, A.O.
	SD of DF	83.04		0.23	30.67	57.19			

Key:
DTY =drying type, DTI =drying time, SD of FFF = solar drying of fresh fish flake, SD of DF = solar drying of dried fish

The result of chemical composition of Adam, (2012) is in agreement with Clucas and Ward (1996) who reported that flesh from healthy fish contains (70 – 80%) water. Results of Adam, (2012) study is also in agreement with Babiker and Dirar (1992) studies on the fermented and dried fish in Sudan on three fish species Dabs (*Labeo* sp), Bulti (*Tilapia* sp) and Garmout (*Clarias* sp). They mentioned that the chemical composition results showed that moisture contents were (9%, 7.1% and 7.7%), protein content (65%, 58.1% and 55.1 %,), fat content (11.3%, 18.2% and 17.6%) and ash content (18.5%, 22.9% and 12.6%)

respectively.

Elobid (2003) Compared the drying of *Labeo* sp in solar and under open sun, his results revealed that there is non-significant difference between the two methods, but when he dried for an extended period of time he found there is a significant difference in moisture contents and ash. On the other hand Babiker (2008), compared the fresh and dried flakes of *Bagrus* sp and his results have a significant difference in ash and dry matter.

3.4.2. Chemical Composition of Smoked Fish:

Ikeme, (1991) who studied characterization of traditional smoked dried fish in Nigeria. He found that the chemical composition showed 60 – 80% protein, 6 – 15% fat, 7 – 19% moisture and 5.4 – 15% ash.

Table 3.4.2: Show the chemical composition of smoked fish

Parameter sp	Treatment	Moisture %	Protein %	Fat %	Ash %	Dry Matter %	NFE %	Area	Authors
Clarias sp	Fresh x sd	89.55±0.64	26.2±0.49	7.8±0.1	4.0±0.14	10.5±0.64	51.5±2.1	Elmorda fish market	Ahmed, F. A. M. (2010)
Clarias sp	Fresh x fw	91.35±.49	22.9±0.91	5.2±0.1	3.70±0.14	8.65±0.49	59.7±0.63	Elmorda fish market	Ahmed, F. A. M. (2010)
Clarias sp	Drying x sd	14.85±1.9	21.3±0.35	5.7±0.2	3.9±0.07	85.2±1.6	65.2±0.42	Elmorda fish market	Ahmed, F. A. M. (2010)
Clarias sp	Drying x fw	10.45±.64	21.3±0.35	5.1±0.1	3.8±0.07	89.4±0.64	65.2±0.42	Elmorda fish market	Ahmed, F. A. M. (2010)
Eutropius niloticus	SSO salted	29.40	70.91	7.57	5.19			Elmawrada fish market	Ibaid, I. H. A. (2007).
Eutropius niloticus	SSP non-S	31.60	67.60	7.53	6.04			Elmawrada fish market	Ibaid, I. H. A. (2007).
Eutropius niloticus	SOA salted	21.93	5.16	5.40	3.83			Elmawrada fish market	Ibaid, I. H. A. (2007).
Eutropius niloticus	SOP non-S	22.83	6.06	5.90	3.60			Elmawrada fish market	Ibaid, I. H. A. (2007).
Eutropius niloticus	SSTD salted	20.66	5.41	6.00	3.77			Elmawrada fish market	Ibaid, I. H. A. (2007).
Eutropius niloticus	SSTD non-S	23.53	3.77	5.47	3.80			Elmawrada fish market	Ibaid, I. H. A. (2007).

Key:
Sd = saw dust, fw = firewood, S SO salted = smoked in steel oven salted, SSP non-S = smoked in steel oven non salted, SOA salted = smoked in open air salted, SOA non-S = smoked in open air non salted, SSTDs salted = smoked in shaded tent dryer, SSTDn non-Salted = smoked in shaded tent dryer,

Ahamed (2010) Revealed that there is a significant difference between the chemical composition of *Clarias* sp that is dried with firewood and sawdust for moisture, fat and dry matter contents, but there is non-significance in protein contents and ash. Also Ibaid, (2007) Compared the drying of *Eutropius* sp using three different treatments i.e. steel oven, open air dryer and shaded tent dryer. Her result of smoking with steel oven dryer showed a significant difference from the other two methods.

3.5 Chemical Composition of Fish By-Products

3.5.1 Processed for Human Consumption:

Fish industry has been developing processed or minced fish products such as fish burgers, fingers and sausages, which add cooking convenience to nutritional benefits, Mohammed, S. R. *et al.*. (2007). Fish flesh can be used as raw material for sausage production because muscle protein can form gel and act as an emulsifying agent, Yada, R. Y. *et al*. (1994). Fish sausage is a product in which fish flesh is mixed with additives, stuffed into suitable casings and heat processed. The sausage butter has decisive influence on quality factors of the finals products, such as texture, flavor, appearance and nutritive value. A sausage butter of constants composition also guarantees a predetermined uniformity of the final products throughout the production. This in turn, provides economic advantage to the processor and continued satisfaction to customer, Karms. (1977).

Table 3.5.1: Show the mean percentage of chemical composition of fish by-product for human consumption.

Param. Spp	treatment	Moisture %	Protein %	Fat %	Ash %	Dry matter %	area	authors
Clarias sp	Burger A	69.00[a]	16.60[a]	3.30[a]	4.03[a]	31.00[a]	Khartoum State	Elminshawi, A. A. (2007)
	Burger B	66.17[a]	15.90[a]	3.10[a]	3.33[a]	33.67[a]		
	Burger C	66.17[a]	14.97[a]	2.83[a]	4.33[a]	34.00[a]		
Bagrus sp	Burger A	68.67[a]	16.76[a]	3.40[a]	5.33[a]	31.33[a]		
	Burger B	69.33[a]	15.60[a]	3.00[a]	4.40[a]	30.67[a]		
	Burger C	69.83[a]	15.77[a]	2.33[a]	3.83[a]	30.17[a]		
Gymnarcus sp	Finger 1kg	78.88[a]	17.76	0.77[b]	0.91[b]			Alkhidir, O. A. A. (2011)
	Finger 2kg	77.18[b]	18.44	0.99[a]	0.93[ab]			
	Finger 3kg	76.70[b]	18.81	1.08[a]	0.98[a]			
Labeo sp	S*Sausage	72.77	21.66	2.06	1.51			Abdelmajid, R. M. M.(2008)
	S* Burger	73.41	22.37	1.85	1.54			
	S* Koffta	72.85	22.83	2.01	1.46			
	S* minced	73.85	21.88	2.15	1.41			
	A* Sausage	72.98	18.88	4.79	1.31			
	A* Burger	72.65	19.86	3.86	1.41			
	A* Koffta	72.79	19.60	3.72	1.31			
	A* Mince	75.86	20.88	1.81	0.89			
	A A* sausage	73.41	18.88	4.68	1.25			
	AA* burger	73.52	19.68	3.31	1.38			
	W* Sausage	72.91	22.26	2.08	1.28			
	W* Burger	73.37	22.61	2.08	1.31			
	W* Koffta	72.88	22.85	2.10	1.43			
	W* mince	74.12	22.00	2.21	1.20			
Tetradoan fahaka	S* Burger	71.66	22.34	2.17	1.58			
	S* Koffta	71.79	22.75	2.17	1.56			
	S* mince	72.69	22.83	2.23	1.26			
	S* ausage	73.88	18.88	3.98	1.28			
	A* Burger	73.86	19.71	3.32	1.36			
	A* Koffta	73.79	19.68	3.41	1.31			
	A* Mince	76.12	20.67	2.01	0.85			
	AA* sausage	74.53	18.88	4.12	1.26			
	AA* burger	73.88	19.68	3.72	1.28			
	W* Sausage	72.31	22.36	2.18	1.23			
	W* Burger	72.19	22.78	2.18	1.28			
	W* Koffta	72.38	22.81	2.17	1.34			

	W* mince	73.85	21.84	2.27	1.20			
Clarias sp	Mince un	80.8±0.112	9.29±.04	3.55±.68	5.9±.72	19.2±.11	Elmourda fish market	Sourkaty, M. M. A. A. (2012)
	Mince wa	83.35±.328	6.07±.41	4.93±0.0	5.64±.44	16.64±.57		
	Burger un	67.54±.419	20.34±.51	5.14±.586	7.31±.32	32.45±.42		
	Burger wa	69.14±.109	13.97±.78	8.78±.450	7.38±.45	30.86±.11		
Clarias	Mince	71.91±.284	16.93±1.0	1.93±0.33	2.5±0.18		JebalAwlia	Ahmed, E. O. & *et al.* (2011)
Tetraodon		72.73±0.19	18.61±0.9	1.31±0.30	2.78±.25			
Clarias +Tilapia		70.0±0.347	18.93±1.3	2.17±0.26	3.23±1.5			
Key: Burger A→ binders (soya bean2%, starch 6%), B→ binders (skimmed milk2%, starch 6%), C→ binders (skimmed milk2%, starch 6%), S* = Summer, A* = Autumn, A&A* = Autumn & African, W* = winter, un = unwashed, wa = washed								

Elminshawi (2007) reported that the chemical contents of burger made of *Clarias* fish using different binders of both soya bean and skimmed milk revealed there is non-significant difference in their chemical contents, while the burger made of *Bagrus sp* with the same binders revealed non-significant difference in moisture, protein, fat and dry matter, but the only significant difference is on the ash contents. If we compare the chemical composition of burger made of *Clarias* and that made of *Bagrus* we find there is a significant difference on ash content of the burger using different types of binders.

The finger fish made of *Gymnarchus sp* showed there is non-significant difference in chemical composition of finger fish, Elkhidire (2011) and if we compare the chemical content of burger made of *Clarias* and *Bagrus sps* with the finger fish made of *Gymnarchus sp* we will find that the finger fish has high chemical content than the burgers made from both *Clarias* and *Bagrus sps*.

On the other hand the sausage, burger, koffta and mince made from *Labeo* sp showed a significant difference in moisture content of mince during winter and autumn, but the protein and ash content showed a significant difference in the four types of processed fish, while there is non-significant difference among ash contents as shown by Abdelmajid (2008). The sausage, burger, koffta and mince made of *Tetradon sp* showed a significant difference in moisture, protein and fat contents, but there is non-significant difference in ash contents, Abdelmajid (2008). While Sourkaty, (2012) from Elmawrada fish market, observed that the chemical composition of mince and burger made of *Clarias sp* washed or unwashed has a significant difference in their chemical contents

3.5.2 Chemical Composition of By-Product (Fish Meal):

Table 3.10: show the chemical composition of fish meal:

Param. spp	treatment	Protein %	Fat %	Ash %	Dry matter %	authors
Fish meal	Co inoad	63.26±4.16	9.72±2.25	25.02±1.38	86.16±3.51	Ibrahim, R. A.E. (1998)
	Co inpd	67.06±3.82	12.16±0.69	24.06±2.24	90.19±2.89	
	Rs in oad	54.21±7.71	15.73±1.33	29.49±0.52	89.80±0.44	
	Rs in pd	61.32±4.77	15.7±0.57	23.02±5.16	92.48±0.34	
Key: Co in oad = cooked in open air dryer, Co in pd = cooked in polythene dryer, Rs in oad = raw salted in open air dryer, Rspd = raw salted in polythene dryer.						

Ibrahim (1998); compared the chemical composition of fish meal cooked in open air dryer and polythene dryer, her results showed a significant difference in the contents with the exception of ash which showed non-significant difference, while when she added salt in both methods found a significance difference in her results with the exception of fat content which have a non-significant difference in each methods.

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4

CHAPTER

Microbial

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Fish are soft tissues and in aquatic environment they are extremely susceptible to microbial contamination. Many of them potential spoilers, present in the surface slime, on the gills and intestines of live fish, although the flesh itself is normally sterile. Bacterial growth and invasion on the fish are prevented by the body's natural defense system during life, but after death the defense system breaks down and the bacteria multiply and invade the flesh. Microbial actions play a large part in the spoilage of fish (Eyo, A.A. 2001).

Abu Gideiri, (1973) stated that in the Sudan the importance of fish in the diet seem to follow a markedly regional pattern. Handling and post-harvest treatment of fish in Sudan show a wide spectrum as regards chose, consumption and ways of utilization, people consume fresh fish or presented in one way or another (smoked, salted or dried).

Fish preservation methods include, salting, drying, chilling, smoking and freezing. Post-harvest losses of fish catch on processing include material, as well as value and nutritional losses. Preservative methods must be applied to the fish even on the fishing boat. The need for efficient processing of landed fishes for maximum yields with best quality should be emphasized (Ali *et al.*., 1996, Turan *et al.*., 2007).

Sudan has the presence of a number of large water reservoirs, which contain a huge wealth of fish of several types and the estimated wealth was about 110 thousand tons of fish. The main sources of fish in Sudan are the Blue Nile, White Nile, River Nile, lake reservoirs behind dams and irrigation canals as well as the red sea for marine fish production. The fishing industry in Sudan practiced in primitive waysand thus relatively few quantities are manufactured and consumed locally, which does not allow for the export level which promotes the expansion of large-scale manufacturing. It is imperative to increase investment in the exploitation of fish stocks and commercial quantities by the appropriate preservation of fish (FAO, 1989)

4.1 Fresh Fish:

Fish in general usually spoil more rapidly than other muscle foods, particularly when mishandled and such spoilage is primarily bacterial in nature, about 30% of landed fish are lost through microbial activity alone (Ghaly *et al.*., 2010). With the over growing world population and need to store and transport food, fish preservation becomes necessary to supply the distant market, to produce a range of products with different flavors and textures and creation of conditions unfavorable to the growth or survival of spoilage organisms (Gracey, 1986, Yohanna *et al.*., 2011).

Table 4.1.1: Bacterial Load Colony Forming Unit/Gram (C.F.U/G) in Different Organs and Different Seasons of the Year

Fish	Season	liver	Kidney	Gill	Water	Intestine	Region	Author
C. lazera	Summer	4.5×10^3	5.5×10^3	3.7×10^5	0.5×10^4	1.2×10^4	Jebal aulia dam, shajara research center, elmourada fish market	Hamid S. H. A (2007)
O. niloticus		1.5×10^4	2.2×10^3	0.4×10^4		0.7×10^5		
C. lazera	Autumn	2.2×10^4	0.2×10^4	3.5×10^3	0.8×10^4	0.3×10^5		
O. niloticus		2.5×10^4	0.5×10^4	0.5×10^5		0.37×10^4		
C. lazera	Winter	0.5×10^3	0.15×10^4	0.3×10^4	0.5×10^4	0.65×10^4		
O. niloticus		0.11×10^3	0.2×10^3	0.6×10^3		1.3×10^3		

Water has a high load (0.8×10^4) in rainy season (autumn) than in other seasons. The intestine has high bacterial load (1.3×10^3 to 0.7×10^5) in the three seasons, followed by the gills, liver and kidney respectively.

Generally, *O. niloticus* had high bacterial load, than *C. lazera*, in summer and winter, in different organs, while *C. lazera* had high bacterial load in autumn especially in the gills.

Table 4.1.2: Distribution of Isolated Gram-Negative and Gram-Positive Bacteria Spp. among the Different Fish Samples and Organs.

Fish	Bacteria	Fresh fish	Putrefied Fish	Skin	gill	Intestine	Region	author
Different fish samples	*Staphylococcus*	2	4	4	4	1	El mawreda fish market	Osman S. M.M. M (2006)
	Micrococcus	3	7	7	1	2		
	Bacillus	1	2	2	2	1		
	Cryonebacterium	-	-	-	2	5		
	Kurthia	3	1	1	6	-		
	Aeromonas	-	-	-	1	-		
	Proteus	1	17	12	2	8		
	Citrobacter	3	10	1	9	15		
	Serratia	-	-	5	3	-		
	Klebsiella	4	7	1	2	4		
	Pseudomonas	-	-	7	2	3		
	E.coli	2	5	1	-	9		
	Vibrio	-	1	1	-	-		
	Aeromonas	-	-	1	-	-		
Oreochromis niloticus	*Aeromonas hydrophila*				13	17	Alshagara fish farm	Haj Ali H. M. (2004)
	Aeromonas sobbria				6	5		
	Pseudomonas aerugenosa				3	6		
	Citrobacter freundii				9	12		
	Enterobacter cloacae				15	19		
	Enterobacter aerogenes				7	9		
	Escherichia coli				5	11		
	Bacillus macerans				11	7		
	Micrococcus varians				2	-		
	Staphylococcus gallinarum				5	4		
	Enterococus casseliflavus				1	-		

In different fish samples (Osman S. M.M. M, 2006) found the gram-negative more than gram-positive bacteria. *Proteus* was most frequently isolated followed by *Citrobacter*, *Micrococcus*, *Klebsiella*, *E.coli*, *Pseudomonas*, *Staphylococcus*, *Kurthia*, *Bacillus*, *Serratia*, *Cryonebacterium*, *Vibrio*, *Aeromonas*. The putrefied fish has more bacteria than fresh. The intestine has higher number of bacteria followed by skin and gills. This result agree with (Haj Ali H. M), the number of bacteria in intestine was more than gills. The number of isolated bacteria ranged as follows: *Aeromonas hydrophila*, *Pseudomonas Aerugenosa*, *Citrobacter freundii*, *Enterobacter* species, *Escherichia coli*, *Micrococcus varians*, *Enterococus casseliflavus*, *Staphylococcus gallinarum* and *Bacillus macerans.*

4.2 Fresh, Chilled and frozen Fish:

Chilling by ice is considered as one of important treatments which prolongs preservation of fishes and keeps them in characteristics close to fresh fishes (FAO, 1975)

The rate of deterioration in fish is highly temperature dependent and can be inhibited by use of low storage temperature (Sivertsvik *et al*. 2002). Chilling generally slowdown, the deterioration of seafood. The prevalent method of retarding spoilage in India as well as in other tropical countries is storage in ice (Surendran *et al*.., 1989). The most common chilling medium for preserving fresh fish is ice. However, the quantity of crushed ice required for chilling fresh fish is quite substantial which is at least 1:1 ratio (wt/wt) and sometimes is even higher with tropical conditions (Lima dos Santos *et al*.., 1981).

Table 4.2: The total count ± Standard deviation of bacterial load (CFU/g) and Bacteria Species found on fresh, Chilled and frozen Fish.

Species	Treatment	M.load/cfu	Staphylococcus	Salmonella	E. coli	Vibrio spp.	Region	Author
Tilapia	Fresh	$3.50x10^4$	-	-	-	ˈ	Elmourada fish market	Taha,S.H and Ahmed, S.H (2014)
Nile perch	Fresh	$6.10x10^4$	-	-	-	ˈ		
Tilapia	frozen 7 days	$5.17x10^5$	-	-	-	ˈ		
Nile perch	frozen 7 days	$5.40x10^5$	-	-	-	ˈ		
Oreochromis niloticus	Fresh	$4.69\times10^5 \pm 1.35\times10^5$	+ ve	- ve	+ve	ˈ	Elmourada fish market	Ahmed, S.H, *et al.* (2014)
Lates niloticus	Fresh	$3.69\times10^5 \pm 0.86\times10^5$	+ ve	- ve	+ve	ˈ		
Oreochromis niloticus	Chilled	$5.65\times10^5 \pm 1.88\times10^5$	+ ve	- ve	+ve	-		
Lates niloticus	Chilled	$3.81\times10^5 \pm 1.22\times10^5$	+ ve	- ve	-ve	-		
Plectropomus areolatus	Fresh ice ratio 1:2	3×10^3	-ve	-ve	-ve	-ve	Port Sudan and Sawakin	Ahmadoon H.G. A & Ali, M.E (2013)
	Fresh ice ratio 1:1	3×10^3	-ve	-ve	-ve	-ve		
	Chilled 21 days ice ratio 1:1	1.3×10^4	-ve	-ve	+ve	-ve		
	Chilled 21 days ice ratio 1:2	1.2×10^4	-ve	-ve	-ve	-ve		
	Fresh small Piece	1×10^3	-ve	-ve	-ve	-ve		
	Fresh large piece	3×10^3	-ve	-ve	-ve	-ve		
	Chilled small piece	2.5×10^4	-ve	-ve	-ve	-ve		

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	Chilled large piece	1.2×10^4	-ve	-ve	-ve	-ve		
	Fresh winter	5×10^3	-ve	-ve	-ve	-ve		
	Fresh summer	3×10^3	-ve	-ve	-ve	-ve		
	Chilled winter	1.9×10^4	-ve	-ve	-ve	-ve		
	Chilled summer	1.2×10^4	-ve	-ve	-ve	-ve		
Plectropomus areolatus	Chilled 0 days ice ratio 1:1	5×10^3	-ve	-ve	-ve	-ve	Port sudan fish market	Ahmadoon H.G. A (2013)
	Chilled 0 days ice ratio 2:1	5×10^3	-ve	-ve	-ve	-ve		
	Chilled 7 days ice ratio 1:1	6.6×10^3	-ve	-ve	-ve	-ve		
	Chilled 7 days ice ratio 2:1	3.6×10^3	-ve	-ve	-ve	-ve		
	Chilled 14 days ice ratio 1:1	2.8×10^3	-ve	-ve	-ve	-ve		
	Chilled 14 days ice ratio 2:1	2.5×10^3	-ve	-ve	-ve	-ve		
	Chilled 21 days ice ratio 1:1	1.3×10^4	-ve	-ve	+ve	-ve		
	Chilled 21 days ice ratio 2:1	1.2×10^4	-ve	-ve	-ve	-ve		
	Chilled 28 days ice ratio 1:1	5.1×10^4	-ve	-ve	-ve	-ve		
	Chilled 28 days ice ratio 2:1	2.7×10^4	-ve	-ve	-ve	-ve		
Oreochromis nilotics	Iced 0 day	$8.7\times10^5 \pm 7.4 \times10^5$	-	-	-	-	El-morada fish market	Mohammed, A, I.M and Ahmed, S.H (2011)
	Iced 4 days	$3.2\times10^5 \pm 8.5\times10^4$	-	-	-	-		
	Iced 7 days	$1.7\times10^6 \pm 6.5\times10^5$	-	-	-	-		
	Refrigerated 0 day	$8\times10^5 \pm 8.5\times10^5$	-	-	-	-		
	Refrigerated 4 days	$2.1\times10^6 \pm 1.2\times10^6$	-	-	-	-		
	Refrigerated 7 days	$1.1\times10^7 \pm 2.6\times10^6$	-	-	-	-		
Clarias lazera	Iced 0 ay	2.6×10^5	-	-	-	-		
	Iced 4 days	9.3×10^5	-	-	-	-		
	Iced 7 days	1.6×10^6	-	-	-	-		
	Refrigerated 0 day	8×10^4	-	-	-	-		
	Refrigerated 4days	8.8×10^6	-	-	-	-		
	Refrigerated 7 ays	1.6×10^7	-	-	-	-		
Oreochromis niloticus	Freezing 0 day	$3.6\times10^5 \pm 0.427$	-	-	-	-	Jebel Aulia dam	Hassan A.A (2011)
	Freezing 10 days	$7.8\times10^4 \pm 6.19$	-	-	-	-		
	Freezing 20 days	$2\times10^3 \pm 2.230$	-	-	-	-		
	Freezing 30 days	$2.6\times10^3 \pm 1.85$	-	-	-	-		

Taha, S.H & Ahmed, S.H (2014) found total bacterial count on *Tilapia &* Nile perch is increased after frozen, Ahmed, *et al.* (2014) stated highly significant difference in total bacterial count between chilled *Oreochromis niloticus* and *Lates niloticus* while there was no significant difference between fresh *Oreochromis niloticus* and *lates niloticus*. *Staphylococcus* and *E.coli* were isolated as contaminant bacteria, while *Salmonella* was not isolated from both fresh and chilled *Oreochromis niloticus* and *lates niloticus*.

The total bacterial count in all (*Plectropomus areolatus***)** samples increased after ice preservation but count is less than hazard of the fresh and frozen sea food. The highest bacterial count was in fish to ratio of 1:1, small size, winter and in Sawakin with more *E.coli* in fish ice ratio of 1:1, no contamination with *Staphylococcus, Salmonella, Vibrio* in both ratios of ice for all fresh and preserved sample. *E,coli* appeared in some cases after 21 days of preservation in ratio 1:1.(Ahmadoon H.G.A & Ali, M.E (2013) & Ahmadoon H.G.A (2010).

The gutted and whole (*Plectropomus areolatus***)** fish samples, before and after chilling with ice, were free from *Salmonella* spp. *Staphylococcus* spp. and *Vibrio* spp. However, *E. coli* appeared in gutted fish before whole fish. The study showed that, there were significant difference in all sensory parameters except for smell and firmness of flesh. The gutted fish show best assessment in slime, skin and firmness of flesh. At the end of preservation there was no significant difference in all sensory parameters between gutted and whole fish and the assessment became unpleasant; Ahmadoon (2015).

Mohammed, I.M A, & Ahmed, S.H (2011) results of total bacterial count, indicated high contamination in *Oreochromis nilotics* and *Clarias lazera* after chilling and frozen storage, but Hassan A.A (2011) found the total bacterial in *Oreochromis niloticus* decreased, when duration of freezing increased**.**

4.3 Fresh and Dried Fish:

Drying means extraction of water from a substance, usually by heating. During drying, there are two things of primary importance, the heat transfer that causes the evaporation of water and the mass transfer of the evaporated water through the substance and subsequently the removal of moisture away from the surface of the substance itself. The main purpose of drying is to prolong the presentation time of the product

Drying is of the most commonly used method for preserving fish in the Sudan; kejeik is produced in large quantities in the southern Sudan by the Nilotic tribes and also is prepared in the Northern parts of the country along the White, Blue Nile and the Atbara River (Dirar, 1993). Drying and Salting is an ancient and simplest method to preserve fish. Salting and sun drying of fish is a traditional method of seafood preservation employed in many countries (FAO, 1989).

Table 4.3: The total count ± Standard deviation of bacterial load (CFU/g) and Identification of Bacteria sp. on fresh and dried fish

Species	Treatment	Microbial load/cfu	Staphylococcus	Salmonella	E. coli	Region	Author
Clarias sp	Fresh	$7.6 \pm 4.7 \times 10^5$	-Ve	+ve	-ve	Elmourda fish market	Ahmed S.Hand Eltegani I.E (2012)
	Dried	$5.6 \pm 3 \times 10^5$	-Ve	-ve	-ve		
Clarias sp	Dried	$5.6 \times 10^5 \pm 3.9 \times 10^5$	-	-	-	Gedarif market	Mohammed A.A, (2012)
Tilapia sp	Dried	$2.9 \times 10^5 \pm 2.4 \times 10^5$	-	-	-		
Bagrus bayad	A fresh	1.3×10^8	-	-	-	Food Research Center	Babiker A. O. A (2008)
	A (open sun) Dried	4×10^6	-	-	-		
	B fresh	9.6×10^7	-	-	-		
	B (natural convective) Dried	3.2×10^5	-	-	-		
Labeo Sp.	Dried solar	5.25×10^3	4.51×10^3	-Ve	-Ve	White Nile	Elobied A. O. (2003)
	Dried sun	2.16×10^5	3.25×10^5	-Ve	-Ve		
	Dried 5 days	1.9×10^5	3.18×10^5	-Ve	-Ve		
	Dried 7 days	2.23×10^4	1.11×10^4	-Ve	-Ve		
	Dried salted	3.46×10^4	1.500×10^4	-Ve	-Ve		
	Dried non salted	1.87×10^5	3.14×10^5	-Ve	-Ve		

In table (4-3) Ahmed S.H, Eltegani I.E (2012) and Mohammed A.A, (2012) found total bacterial count in fresh fishes decreased when dehydrated. Solar drying lower bacterial count than sun-drying, microbial load is reduced by use of salt and when duration of drying is increased (Babiker, 2008. Elobid, 2003); *Staphylococcus* present only in *Labeo, E.coli* and *Salmonella* not present in dried fish *Labeo* and *Clarias sp*. Yeast and mold not existing in *Labeo* (Elobid, 2003).

4.4 Fresh and Salted Fish:

Fermentation is considered an easy and low-energy preservation method for meat that results in distinctive products that have an important part in the diet of people making them (Margy W, 1992). Salting and drying fish in Africa are accompanied by fermentation, but the period is short (a few days). Preservation by salting, smoking, drying is called curing of fish. This term is defined as fish preserved without the need for refrigeration or freezing, but excluding sterilized products in air-tight containers. Drying, smoking, salting and combination of these treatments are the basic means whereby, such product is prepared. Cured fish are consumed mainly in tropical countries (FAO, 1981).

Salted fish is always made from *Hydrocynus* spp “Kass” which belong to the family Characidae (Idris. Z. O, 1981). The major reason given by the processors for choosing this species for salting is that this type of fish is relatively lean, Sudanese consumer prefers little fat in the salted products (Dirar, 1993). The count of microorganisms increased rapidly during first fermentation days and began to decrease later and that traditional product had a large number of micro-organisms than the laboratory products, (El-Tom, 1989).

Table 4.4: The Total Count ± Standard Deviation of Bacterial Load (CFU/G) and Bacteria Species Found in Fresh and Salted Fish

Species	Treatment	Microbial load/cfu	Staphylococcus Sp	Salmonella	E. coli	Listeria Sp.	Region	Author
Hydrocynus. Sp	Salt (0)	$58.1\times10^3 \pm 21.1\times10^3$	-	-	-		Elmawrada fish market	Abbas.H.H, Khogalie.F.A.E (2011)
	Salt (15%)	$10\times10^3 \pm 1\times10^3$	-	-	-			
	Salt (20%)	$7.8\times10^3 \pm 0.76\times10^3$	-	-	-			
	Salt (25%)	$4\times10^3 \pm 1\times10^3$	-	-	-			
Altests	Fresh	3.6×106 ± 2.3×106	+ve	-ve	-ve		Elmawrada fish market	Eltahir T.O, Ahmed S.H (2011)
Dentex	salt	2.1×106 ± 1.1×105	+ve	-ve	-ve			
Hydrocynus spp	Raw Fassiekh	-	7.6×10^3	-ve	-ve	-ve	local market of Khartoum-Sudan	Sulieman H.M.A, Allaahmed A.A.A.(2012)
	Fassiekh+5% Sweet pepper, 24 hrs.	$113.4\times10^3 \pm 4.5\times10^3$	+Ve	-ve	-ve	+Ve		
	Fassiekh+5% Sweet pepper, 48 hrs.	$84\times10^3 \pm 10.6\times10^3$	+Ve	-ve	-ve	+Ve		
	Fassiekh+5% Sweet pepper, 72 hrs.	$65\times10^3 \pm 4.9\times10^3$	+Ve	-ve	-ve	+Ve		
	Fassiekh+5% Sweet pepper 96 hrs.	64.5×103 ± 4×10^3	+Ve 21.9×10^3	-ve	-ve	+Ve		
	Fassiekh+5% Hot pepper, 0 hur	$43.4\times10^3 \pm 1.3\times10^3$	-ve	-ve	-ve	+Ve		
	Fassiekh+5% Hot pepper, 224 hur	$47\times10^3 \pm 3.5\times10^3$	-ve	-ve	-ve	+Ve		
	Fassiekh+5% Hot pepper, 48 hrs.	$32.4\times10^3 \pm 6.4\times10^3$	-ve	-ve	-ve	+Ve		
	Fassiekh+5% Hot pepper, 72 hrs.	$6\times10^3 \pm 1.6\times10^3$	-ve	-ve	-ve	+Ve		
	Fassiekh+5% Hot pepper 96 hrs.	$4.5\times10^3 \pm 1\times10^3$	nil	-ve	-ve	+Ve		
Hydrocynusspp & Alestes spp	Terkin	$3.5\times10^5 \pm 7.7\times10^3$	-	-	-		Jebel Alaulia	Abu-Hassan, O. and Adam Sulieman, H.M. 2012)
	Terkin	$6.2\times10^5 \pm 2\times10^4$	-	-	-		WadiHalfa	
Hydrocynus forskahlii	salted 0 week	6.5×10^3	Micrococcus: 3.4×10^3 aureus: 2.5×10^2	-	-		local fishermen market	Ahmed E.O, Ali M.E, Hamed A.A

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	salted 1month	4.5×10^3		2.5×10^3	1.5×10^2	-	-			(2010)
	salted 2 month	2×10^3		1.5×10^3	<100	-	-			
	salted 3 month	1.5×10^3		<100	0	-	-			
	salted 4 month	<100		0	0	-	-			
Alestes sp	salt (25%) 4 days	35.16		+ve		-	-		Elmawrada fish market	El Hag G .A, *et al.* (2012)
	salt (25%) 8 days	390.06		+ve		-	-			
	salt (25%) 12 days	128.40		+ve		-	-			
	salt (25%) 1 month	2.23		+ve		-	-			
	salt (25%) 2 month	8.37		+ve		-	-			
	salt (25%) 3 month	1.45		+ve		-	-			
	salt (25%) 4 month	1.73		+ve		-	-			
	salt (25%) 5 month	0.26		+ve		-	-			
	salt (25%) 6 month	10.25		+ve		-	-			
Labeo sp	salt (25%) 4 days	9233.3		+ve					Elmawrada fish market	El Hag. G .A,. *et al.* (2012)
	salt (25%) 8 days	16754.44		+ve		-				
	salt (25%) 12 days	2299.22		+ve		-				
	salt (25%) 1 month	0.00		+ve		-				
	salt (25%) 2 month	2.66		+ve		-				
	salt (25%) 3 month	23.83		+ve		-				
	salt (25%) 4 month	43.83		+ve		-				
	salt (25%) 5 month	10.33		+ve		-	-			
	salt (25%) 6 month	0.00		+ve		-	-	-		
Hydrocyonus spp	Fresh (unsalted fish)	Aerobic	Anaerobic	4.8×10^2		-ve	+ve			Mustafa.W. A & Osman.O. A (2013)
		8×10^4	3.5×10^4							
	dry salted (fassiekh)	2.6×10^5	8.2×10^4	2.4×10^2		-ve	-		El-Dueim markets	
		7.9×10^5	3.2×10^3	5.2×10^2		-ve	-		Um Dihaeka	
		2.7×10^6	8.4×10^4	6.8×10^3		+ve	-		Alsharig	
		4.9×10^5	2.8×10^3	4.2×10^3		+ve	-		Roto	

Abbas.H.H & Khogalie. F.A. E (2011) data showed significant difference, the highest value (58.17×10^3) was reported in fresh fish, while the lowest value (4×10^3) was reported in fassiekh with 25% salt concentration after 10 days. Eltahir T.O & Ahmed S.H (2011) determined, total viable counts in fresh sample, higher than salted at 15 days. The *Salmonella* and *E. coli*-were not detected but Staphylococcus sp. was present in fresh and salted *Altests dentex*.

Sulieman, H.M.A and Alla Ahmed, A.A.A. (2012) found total viable counts in the first four days after pepper fruit addition, were decreased and showed high significant differences between the two types of pepper fruits and the addition of hot pepper was more effective on the total viable counts which decreased the limits of studied product from $43.4\times10^3 \pm 1.3\times10^3$ at first day to $4.5\times10^3 \pm 1.0\times10^3$ after 96 hours. The *Staphylococcus aureus* test showed positive results with count ($7.6x10^3$) for Raw Fassiekh and ($21.9x10^3$) for sweet pepper-treated Fassiekh and negative for hot pepper-treated Fassiekh. The *Listeria spp.* test was found to be positive for Fassiekh treated with sweet and hot pepper and negative for crude Fassiekh samples and *Staphylococcus aureus* and *Listeria monocytogens* test. Abu-Hassan, O. and Sulieman, H.M. A (2012) in the Jebel Al-auliaTerkin, showed a lower level of total bacterial count (3.5×10^5 CFU/g), than Wadi Halfa Terkin product (6.2×10^5) CFU/g. Ahmed E.O, Ali M.E, Hamed A.A (2010) found total viable count of salted samples were variable during storage time. The total of viable counts of bacteria were found least <100 cfu/g (after 6 months), highest $6.5x10^3$cfu/g count of *Staphylococcus*. *Micrococcus* were least <100 cfu/gand highest 3.4×10^3cfu/g (for fresh).

El Hag. G.A *et al.* (2012) found in fresh samples, some species of bacteria and during the storage. In the treated material the occurrence of bacteria is closely correlated with the salt penetration and preliminary treatment during the first 12 days as well as the prolonged phase lasting six months. *Staphylococcus xylosus* was the dominant bacteria found in *Alestes sp*. during the first days of treatment at 25% salt concentration. This result agreed with that in *Labeo* sp. The number of bacteria increased during 4 to 12 days of storage time and then decreased until the end of experiment. The decreases in the total viable count of bacteria could be related to salt concentration (25%) by weight of fish.

Mustafa.W. A & Osman. O. A (2013) count of aerobic bacteria was higher than that of fresh fish sample. Fassiekh sample collected from Um Dihaeka and fassiekh sample collected from Roto, were low in counts of anaerobic bacteria than that of the fresh fish sample. The *Coliform* bacteria were not detected in all fassiekh samples, but detected in fresh sample. Count of *Staphylococcus* was higher in fassiekh sample collected from Alsharig and fassiekh sample collected from Roto which were 6.8×10^3 and 4.2×10^3, respectively. The result showed absence of *Salmonella* in sample, fassiekh sample collected from El-Dueim markets, fassiekh sample collected from Um Dihaeka and control fresh fish sample.

4.5 Fresh and Smoked Fish:

Smoking is the process of applying wood smoke to impart a smoky or smoked flavor and to partially dry a fish or part of fish such as fillets, to produce a smoked fish product and also to extend the shelf life of the product under some conditions. In many parts of the world, preservation is still the main purpose of smoking. Any preservative effect of the smoke itself is probably largely due to the presence of a range of phenolic compounds, nitrites and formaldehyde (Ahmed E.O *et al.*, 2010).

Table 4.5: The total count ± Standard deviation of bacterial load (CFU/g) and bacteria species found on fresh and smoked fish

Species	Treatment	Microbial load/cfu	Staphylo Sp	Sterpto Sp	Salmonella	E. coli	bacillus	Region	Author
Oreochromis niloticus	Fresh	281.5×10^3	+ve	-	-ve	-ve	-	Jebl-Aulia reservoir	Ahmed E.O, *et al.* (2010)
	Smoked - *Acacia seyal*	-	+ve	-	-ve	-ve	-		

	Smoked - Citrus lemon	2×10^3	+ve	-	-ve	-ve	-		
Clarias lazera	Fresh	183.7×10^3	+ve	-	-ve	-ve	-		
	Smoked - *Acacia seyal*	6×10^3	+ve	-	-ve	-ve	-		
	Smoked- Citrus lemon	-	+ve	-	-ve	-ve	-		
	Wet salt - smoked	5.39±0.20	+ve	+ve	-	-	+ve		
	Wet non salt smoked	5.16±1.48	+ve	-	-	-	+ve		
	Wet non smoked (fresh)	5.41±0.37	+ve	-	-	-	+ve		
	Open-air dried smoked salted	5.64±0.61	+ve	-	-	-	+ve		
	Open-air dried smoked non salted	5.49±1.09	+ve	-	-	-	-		
	Open-air dried non smoked	4.76±086	+ve	-	-	-	+ve		
	Shade-tent dried smoked salted	5.06±00.51	+ve	-	-	-	+ve		
	Shade-tent dried smoked non salted	5.63±0.23	-	-	-	-	-		
	Shade-tent dried non smoked	5.88±0.54	-	-	-	-	-		

Ahmed E.O, Ali M.E, Khalid R.A *et al.* (2010) results revealed that the flesh of the *O. niloticus* had a total microbial load reaching 2×10^3 and 6×10^3 per gram for *C. lazera*. No coliforms were detected in the two species before and after smoking, no pathogenic micro-organisms like *E. coli* and *Salmonella* were found. However, other microflora isolated was *Staphylococcus aureus*. Ibaid I.H. A, (2007) bacterial viable count, showed that there is no significant difference between treated and non-treated samples. The species of bacteria encountered according to their order of prevalence were *Bacillus, Staphylococcus* and *Streptococcus.*

4.6 Fish By-Product for Human Consumption

Fish received increased attention as potential source of animal protein and essential nutrients for human diets (Fawole O.O, 2007). Fish meat contains significantly low lipids and higher water than beef or chicken and is favored over other white or red meats (Nestel P.J.N. 2000). Fish flesh can be used as raw material for sausage production because muscle protein can form gel and act as an emulsifying agent (Yada R.Y.

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and Jackman R. 1994). Fish sausage is a product in which fish flesh is mixed with additives, stuffed into suitable casings and heat processed. The sausage butter has decisive influence on quality factors of the final products, such as texture, flavor, appearance and nutritive value. A sausage butter of constant composition also guarantees a predetermined uniformity of the final products throughout the production. This in turn, provides economic advantage to the processor and continued satisfaction to customer (Karms E. 1977).

Table 4.6.1: The Total Count ± Standard Deviation of Bacterial Load (CFU/G) and Bacteria Species Found in Fish Meat Product during Storage Time

Species	Treatment	TVC	Coliform	Staphylococcus aureus	Salmonella Spp	E. coli	Klebsiella Spp	Region	Author
Clarias lazera	Sausage Zero day	6.0×10^5	240	-ve	-ve	+ve	-ve	Jebel Aulia reservoir	Ahmed E.O, Elhaj G.A (2011)
	Sausage 10 day	4.4×10^5	220	-ve	-ve	+ve	-ve		
	Sausage 20 day	3.2×10^4	200	-ve	-ve	-ve	+ve		
	Sausage 30 day	2.8×10^3	<100	-ve	-ve	+ve	+ve		
Tetradon fahaka	Sausage Zero day	2.2×10^5	200	-ve	-ve	-ve	+ve		
	Sausage 10 day	1.1×10^5	<100	<100	-ve	-ve	-ve		
	Sausage 20 day	3.0×10^4	<100	<50	-ve	-ve	-ve		
	Sausage 30 day	2.7×10^3	<50	-ve	-ve	+ve	-ve		
Clarias lazera+ Tetradon fahaka	Sausage Zero day	4.2×10^5	220	-ve	-ve	+ve	-ve		
	Sausage 10 day	3.8×10^5	180	<100	-ve	-ve	-ve		
	Sausage 20 day	3.8×10^4	<100	<50	-ve	-ve	-ve		
	Sausage 30 day	4.0×10^3	<50	<50	-ve	+ve	-ve		

Microbiological analysis of the fresh fish sausage showed that TVC least $4.0x10^3$, highest $6.0x10^5$ and decreased with increase in freezing period of 30 days storage. *Staphylococcus aureus* was determined in two types of fish sausages. Count of coliform group microorganisms were determined least <50 CFU/g and highest 240 cfu/g in fish sausages during storage The presence of the species *Escherichia coli* and *Klebsiella* spp in the formulation of the sausage which can be bactericidal in nature, *Salmonella* Sp was detected in mince and sausage samples (Ahmed E.O & Elhaj G.A 2011).

Table 4.6.2: The Total viable Count (TVC) of Bacterial Load (CFU/G) Found in Fish Meat Product during season and Storage Time

Species	Treatment	TVC	Treatment	TVC	Treatment	TVC	Treatment	TVC	Region	Author
Labeo spp	Sausage 0 day s*	$8.9×10^8$	Burger 0 day s*	$1.2×10^8$	Koftta 0 day s*	$7.6×10^6$	Mince 0 day s*	$6.2×10^6$		Abdelmaged R. M. M (2008)
	Sausage 30 days s*	$4.5×10^7$	Burger 30 days s*	$5.5×10^6$	Koftta 30 days s*	$5.5×10^6$	Mince 30 days s*	$1.8×10^8$		
	Sausage 60 days s*	$2×10^6$	Burger 60 days s*	$1.05×10^7$	Koftta 60 days s*	$3.8×10^6$	Mince 60 days s*	$3.5×10^6$		
	Sausage 0 day A*	$5.5×10^5$	Burger 0 day A*	$3.3×10^4$	Koftta 0 day A*	$1.7×10^5$	Mince 0 day A*	$1×10^4$		
	Sausage 30 days A*	$2.7×10^6$	Burger 30 days A*	$1.5×10^6$	Koftta 30 days A*	$1.7×10^5$	Mince 30 days A*	$1.8×10^6$		
	Sausage 60 days A*	$8.9×10^5$	Burger 60 days A*	$4.3×10^4$	Koftta 60 days A*	$1.2×10^5$	Mince 60 days A*	$4.9×10^5$		
	Sausage 0 day A A*	0 at 10^{-2}	Burger 0 day A A*	0 at 10^{-2}	-	-	-	-		
	Sausage 30 days A A*	$9.5×10^4$	Burger 30 days A A*	$6×10^4$	-	-	-	-		
	Sausage 6 0 days A A*	$3.4×10^3$	Burger 6 0 days A A*	$3.7×10^4$	-	-	-	-		
	Burger 0 day W*	$9×10^4$	Koftta 0 day W*	$9×10^4$	Mince 0 day w*	$8×10^3$	-	-		
	Burger 30 days W*	$6.5×10^4$	Koftta 30 days W*	$9.7×10^4$	Mince 30 days W*	$1.2×10^5$	-	-		
	Burger 60 days W*	$8.3×10^5$	Koftta 60 days w*	$6.9×10^5$	Mince 60 days w*	$1.5×10^5$	-	-		
Tetraodon	Burger 0 day s*	$3.2×10^5$	Koftta 0 day s*	$1.4×10^9$	Mince 0 day s*	$2.5×10^8$	-	-		
	Burger 30 days s*	$1.7×10^8$	Koftta 30 days s*	$9.5×10^7$	Mince 30 days s*	$1.2×10^8$	-	-		
	Burger 60 days s*	Uncounted at 10^5	Koftta 60 days s*	$1.4×10^6$	Mince 60 days s*	$7.3×10^6$	-	-		
	Sausage 0 day A*	$1.6×10^6$	Burger 0 day A*	$1.5×10^6$	Koftta 0 day A*	$2.5×10^6$	Mince 0 day A*	$2.4×10^7$		
	Sausage 30 days A*	$2.8×10^5$	Burger 30 days A*	$2.1×10^6$	Koftta 30 days A*	$9×10^5$	Mince 30 days A*	$2.1×10^5$		
	Sausage 60 days A*	$1.5×10^5$	Burger 60 days A*	$5×10^4$	Koftta 60 days A*	$2×10^5$	Mince 60 days A*	$2.6×10^5$		
	Sausage 0 day A A*	$1.5×10^5$	Burger 0 day A A*	$1×10^7$						
	Sausage 30 days A A*	$4×10^5$	Burger 30 days A A*	$3.2×10^5$						
	Sausage 6 0 days A A*	$2×10^4$	Burger 6 0 days A A*	$3.2×10^5$						
	Burger 0 day W*	$2.1×10^5$	Koftta 0 day W*	$3×10^5$	Mince 0 day w*	$2.2×10^5$				
	Burger 30 days W*	$5.3×10^7$	Koftta 30 days W*	$4.5×10^7$	Mince 30 days W*	$1.3×10^7$				

	Burger 60 days W*	1.3×10^3	Koftta 60 days w*	3.1×10^5	Mince 60 days w*	7.1×10^5				
Key: S*= Summer A*= Atumun AA*= African Autumn W*= winter										

There was significant difference in the number of bacteria during storage of *Tetraodon* and *Labeo* spp, which is during autumn only (Abdelaged R. M. M, 2008).

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