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Nutritional Value of *Kejeik*: A Dry Fish Product of the Sudan

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Abstract: *Kejeik* product samples were collected from two different locations in Sudan including Singah city (Blue Nile) and Kusti city (White Nile). The contents of protein, moisture, ash, fat, crude fiber and carbohydrates varied considerably and ranged between 63.52-78.06, 5.37-6.69, 5.78-11.8, 9.04-16.13, 0.55-1.34 and 0.59-1.61% respectively, in the various *Kejeik* samples. However, the production area has a non-significant effect in most of the chemical components. All *Kejeik* samples contained appreciable amounts of macro-minerals and the calcium was the highest in all samples. In addition, *Kejeik* samples contained most of the micro-minerals, however, Nawk and Ijl *Kejeik* collected from Singah contained the lowest concentrations of iron. The study concluded that *Kejeik* is a safe food with a highly nutritive value which is recommended to be utilized in Sudanese meals especially during shortage of protein and other nutrients sources.

Key words: Protein, ash, moisture, crude fiber, macro minerals

INTRODUCTION

The fishing industry in the Sudan practiced in a primitive ways and thus the quantities manufactured relatively few and consumed locally, that 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 and fish processing (MARF, 2001).

Sudan has immense fisheries resources within its inland waters especially along the River Nile and in the marine sub-sector along the Red Sea coast. Currently the largest single source of fish is the Sudd and adjacent areas in the south of the country. Sudan is, however, a significant importer of fish from other areas of the Great Lakes region of Africa (http://acpfish2-eu.org/index.php?page = sudan, 2014).

Currently, seven fish products mostly produced in Sudan include: Alvesikh, dried fish *Kejeik*, indigenous Turkein "salinity" chilled fish, frozen fish, canned fish, smoked fish, 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, a dried blackor brown *Kejeik* made from garmut (mud-fish, Clarias angullaris, Clazera); nawk (thick-skinned fish, *Heterotis nilo*ticus,) humar-el-hout (black spotted cat fish, *Heterotis niloticus* bidarsalis). According to the classification of the Nile fish on the basis of market meat grade given by Amirthalingam and Khalifa (1965), *Kejei*k, also called korki and hout is a product obtained by sun drying large fish. The fish are first asymmetrically split along their dorsal axes before drying.

Very little work was carried out on the determination of consumers' preference and demand of fish as food in the Sudan. El Obied and Sid Ahmed (1988) studied the demand of fish as food in Khartoum and Port Sudan areas. Karar (1997) studied the taste, habits and attitude of the Sudanese consumers towards fish consumption and observed marked regional and tribal effects on the consumers' preferences and food habits. These findings were confirmed by El-Fazary (2005).

The drying of fresh fish (and meat) is the most commonly used preservation methods of food not only in the Sudan but throughout Africa. *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 sudd of the Nile. Here, the river spreads out in undating thousands of hectares, thus supporting a large growth of aquatic weeds, so members of these tribes catch fish by spears. *Kejeik* is also prepared in some part of northern Sudan along the White Nile, the Blue Nile and Atbara River (Dirar, 1993). The data about the fish industry is scanty in Sudan and most of the products are produced by traditional methods, as for *Kejeik* product, the nutritive value has not been

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researched satisfactorily, this initiate the researchers to study nutritive value of *Kejeik* product collected from two production areas in Sudan.

MATERIALS AND METHODS

Preparation of samples: Eighteen processed *Kejeik* (dry fish products) fish type Garmut (Eelcat fish), Ijl (Nile perch) and Nawk (Armoured fish) samples were collected from local markets in Singah and Kusti (Central Sudan) during the period January-April 2010. The fish samples had been produced by natural fermentation. In this process the fisher men are used to prepare *Kejeik* from fresh water Nile fish, the fish were split longitudinally, gutted and beheaded, the split fish were then hung on ropes or spread on rock or tree branches, out in the open air, under the direct sun. When the drying process was over, the large pieces of fish are stacked together on mats, covered with another set of mats and trodden check on by fishermen, to flatten and pack the dry fish more compactly, further shade drying them follows after which the fish production were ready to be transported by the local markets.

The *Kejeik* samples were collected in clean, dry containers and were ground, homogenized and packed in sterilized plastic vacuum bags, stored in carton and transported to the Central Food Laboratory in Qatar pending chemical analyses.

Determination of the chemical composition

Determination of moisture content: The moisture content of the *kejeik* samples was determined according to AOAC (1998). Twenty seven glass dishes were taken, washed and dried for one hours at 10°C by oven, then cooled down to room temperature in a desiccators for 30 min and weighed; (1-2 g) of homogenized *Kiejeik* samples were taken and transferred to the glass dishes, the dishes sample was dried at 103°C±3. Then covered the dishes into the oven and cooled down in a desiccator and weighed, the moisture content was calculated according to following equation:

$$\text{Moisture (\%)} = \frac{\text{W2-W3}}{\text{W2-W1}} \times 100$$

Where:
W1: Weight of the dish
W2: Weight of dish+sample
W3: Weight of dish+sample after drying

Determination of ash content: The ash content of the *Kiejeik* (Dry fish) samples was determined according to AOAC (1998). Twenty seven silica dishes were taken, washed and dried for one hours at 100°C by oven, then cooled down to room temperature in a desiccator for 30 min and weighed; in a Mettler Toledo balance (AG) in silica dish about (1-2 g), of homogenized samples were taken and transferred to the crucible and weighed, incinerate the sample by electric burner until charred the crucible was ignited in a muffle furnace at 600°C overnight and cooled down in desiccators and weighed after attained to room temperature (20°C). The ash content was calculated according to following equation:

$$\text{Ash content (\%)} = \frac{\text{W3-W1}}{\text{W2-W1}} \times 100$$

Where:
W_1: Weight of silica dish
W_2: Weight of silica dish+sample
W_3: Weight of silica dish+sample after ignition

Protein content: The crude protein content was determined according to AOAC (1998). By measuring the nitrogen content using the Semi-Micro Kjeldahl method and multiplying the result by the factor of 6.25 for fish. (150 mg) from homogenized *Kejeik* sample were weighted accurately into a digestion tube.

After the addition of 800 mg of catalyst mixture (one kietab) and 8.0 mL of concentrated H_2SO_4, both the blank and the sample tube were digested at 420°C for 45 min using a Technicon Block Digestor. After cooling, connected the digestion tube to the Kjeltec 2300 Analyzer Unit for instillation, the solution were neutralized using 25 mL of 40%NaOH. The alkaline mix was then distilled using the Semi-Micro-Kjeldahl distillation apparatus. The liberated ammonia was absorbed in 2%boric acid solution and the ammonia trapped in boric acid solution was titrated against standard 0.05N sulphuric acid using 10 drops of screened methyl red indicator solution (0.125 g methyl red and 0.082 g ethylene blue per 100 mL ethanol) till a grey end-point was reached. The titration and calculation of the result as percent nitrogen:

$$\text{Nitrogen (\%)} = 0.001401 \times (\text{X-Y}) \times \text{N} \times \text{F} \times \frac{(100\text{-M})}{\text{W}}$$

Where:
Crude protein (%): N×6.25
X: Titer value

Y: Blank value
N: Normality of H_2SO_4
F: Dilution factor used
M: Moisture content
W: Weight of sample

Fat content: The fat content determined according to AOAC (2005).

By Soxhlet. The homogenized *Kejeik*, (1-2 g) using analytical balances to the nearest g (W1) were weighed into a folded filter paper and transferred into an extraction thimble. Then, a few boiling chips were added into the extraction jars and dried at 103°C for 2 h then the jars was cooled down to room temperature (20°C) in desiccator and weighed to the nearest g (W_2). Then the extraction thimble was inserted into the extraction jars and approximately 140 mL of the solvent (diethyl ether) were added, then the jars containing the thimble were loaded into the unit. After the termination the jars were removed from the unit and dried at 100°C for 2 h, then transferred to the desiccator and cooled down to room temperature (20°C), then weighed to the neared mg (W3):

$$\text{Fat content (\%) (DM basis)} = \frac{\text{W3-W2}}{\text{W1 (100-M)}} \times 100$$

Where:
W_1: Weight of the dry sample taken
W_2: Weight of the extraction jar+boiling chips
W_3: Weight of the extraction jar+boiling chips+fat
M: Percent of moisture in the sample

Crude fiber content: The crude fiber content determined according to the AOAC (2005), one gram of *Kejeik*, fat-free were weighed accurately and digested using 100 mL of 1.25% H_2SO_4 and boiling for 30 min. After 30 min, the digested material was filtered under vacuum through a sintered glass filter crucible. The residue was washed three times with 100 mL portions of boiling water. Then the residue was digested with 100 mL of 1.25% NaOH for 30 min. The contents of the flask were filtered the same crucible and residue was washed with 10 mL of 1.25% boiling H_2SO_4. The residue was then washed three times with 100 mL portions of boiling water. Then the crucible was dried containing the residue for 2 h at 130°C±2 in an oven and cooled in a desicator.

After reweighing the crucible (W_1), the residue was heated at 600°C, in a muffle furnace for 30 min. Cooled and reweighed (W_2):

$$\text{Crude fiber (\%)} = (\text{W1-W2}) \times (100\text{-F}) \frac{100 \times 100}{\text{W}}$$

Where:
W: Weight of the sample taken
W1: Weight of the crucible+residue before ashing
W2: Weight of the crucible+residue after ashing
F: Percent of fat in the sample

Carbohydrates content: The carbohydrate content was calculated based on the result of individual composition difference.

$$\text{Carbohydrates (\%)} = 100\text{-(\% moisture+ash+fat+protein+crude fiber)}$$

Determination of macro and micro minerals: Macro and micro minerals determined according to the AOAC (1995) by ICP-OES. Standards solution 1000 μg mL^{-1} of (Hg, Ni, Zn, Cu, Cd, As, Pb, Cr, Mg, Fe, Ba, Se.Si, Al, Na, K, Ca) were prepared.

Preparation of calibration standard solution: A mixed standard solution were used (Perkin-Elmer pure Atomic Spectroscopy Multi element STD, 1000 ppm).

A-stock solution = 1000 mg L^{-1} (1 mg/1 mL) = 1000 ppm:

- For (Hg, Ni, Zn, Cu, Cd, As, Pb, Cr, Fe, Ba, Se, Si, Al, ca) we were used a series of (0.01, 0.1, 0.5, 1.0) standard
- For (Na, K, Ca, Mg) we were used a series of (0.50, 1.0, 2.0) standard

Sample preparation: About (0.5±0.01) g dried homogenized *Kejeik* samples were weighed accurately into TFM vessel, then 1ml of 30% H_2O_2 and 7 mL of con. Nitric acid was added and then the vessels were closed and introduce into the rotor segment and tighten by using the torque wrench. Next the microwave programmed was run to completion, after the rotar was cooled by air till the solution reached room temperature, then the vessel was opened and transferred the solution to a 25 mL volumetric flask and made to the volume with deionized water, then we were prepared reagent blank similarly by omitting the sample.

ICP-OES conditions: Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) with radial torch equipped with argon saturation assembly was used for the determination of lead and cadmium. High purity (99.9%) argon was used as plasma, auxiliary and nebulizer gas. the gas flows were kept at 15.0 L min^{-1} for plasma, 1.5 L min^{-1} for auxiliary and 0.56 L min^{-1} for nebulizer. Radio Frequency (R.F) power of the plasma generator was 1300 Watts. Vertical height of the plasma was fixed at 7 mm.

Sample uptake time of 30.0 sec, delay time of 5 sec, rinse time of 5 sec, initial stabilization time of 10 sec and time between replicate analyses of 5 sec was maintained throughout the studies for ICP-OES. All the observation of emission were recorded at 396.153, 188.979, 233.527, 317.933, 228.802, 267.716, 327.393, 238.204, 253.652, 766.490, 285.213, 589.592, 231.604, 220.353, 196.026, 251.611 and 206.200 nm. Which corresponds to the most sensitive emission wave length of Al, As, Ba, Ca, Cd, Cr, Cu, Fe, Hg, K, Mg, Na, Ni, Pb, Se, Si and Zn, respectively. The instrument was calibrated for various parameters before the studies.

Determination of phosphorus content: Phosphorous was determined according to Official Methods of Analysis, AOAC (1995).

RESULS AND DISCUSSION

Proximate chemical composition of *Kejeik*: The present study aimed at the determination of nutritive value of *Kejeik* samples (dried fish product) collected from various sources in the Sudan.

The processor, the nutritionist, the cook and the consumer all have a direct interest in the composition of fish. The processor needs to know the nature of the raw material before he can apply correctly the techniques of chilling, freezing, smoking or canning. The nutritionist wants to know what contribution fish can make to the diet and to health and the cook must know for example whether a fish is normally lean or fatty in order to; prepare it for the table. The consumer is interested not only in whether a particular fish tastes good which is a matter of opinion, but also in whether it is nutritious.

The chemical composition of *Kejeik* samples collected from Singah city (Blue Nile) is presented in Table 1. The content of protein, moisture, ash, fat, crude fiber and carbohydrates varied considerably and ranged between 67.01-78.06, 5.37-6.36, 5.78-10.93, 9.09-16.13, 0.55-1.34 and 0.59-1.61%, respectively. On the other hand, the chemical composition of *Kejeik* samples collected from Kusti city (White Nile) is presented in Table 2 and Fig. 1. The content of protein, moisture, ash, fat, crude fiber and carbohydrates ranged between 63.52-75.71%, 5.48-6.69, 9.06-11.8, 4.58-14.83, 0.78-1.55 and 1.43-2.5%, respectively. The highest protein content of *Kejeik* samples was found in Ijl *Kejeik* which collected from Singah city (Blue Nile) (78.06%) and the lowest value (63.52%) was found in Garmut *Kejeik* collected from Kusti city (White Nile). In this study, value for protein content in Garmout was higher than that found by Dirar (1993) who reported that protein content of garmout *Kejeik* was 55.9%. The protein contents in the present study were also higher and lower than those of sun-dried Anchovy and sun-dried Tilapia fish which were 58.4 and 71.1%, respectively, as reported by Essuman (1992). The variation in protein content of the samples may be due to the methods of processing. Fish is one of the most valuable sources of high grade protein available to man in this hungry world and knowledge of its composition is essential if the fullest use is to be made of it (FAO, 1992). It is known that fish protein provides a good combination of amino acids which is highly recommended for human nutrition and compares favorably with that provided by meat, milk and eggs.

The protein content of fish products depend on the water content. The fish product is a good source of animal protein (Essuman, 1992). Thus, if *Kejeik* products are consumed on a large scale as food fish in the diet, they make a substantial contribution to the total protein intake. However, where only small quantities are used as a condiment to prepare sauces etc., their contribution is of minor importance.

The moisture content of the food does not contribute to the nutritive value in the common sense but it is important in describing food composition and microbial growth therefore to some extent nutritive value. The level of moisture content of *Kejeik* samples ranged between (6.69-5.37%). The highest moisture content (6.69%) was found in Nawk *Kejeik* (from Kusti), while the lowest (5.37%) was found in Garmut *Kejeik* (from Singah). The moisture content was higher than that reported by

Table 1: Chemical composition of *Kejeik* samples (dried fish product) collected from Singah city (Blue Nile) (Mean±STDEV)

Kejeik type	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrates (%)
Ijl	5.94±0.13	5.78±0.31	9.09±0.47	0.59±0.01	78.06±1.68	1.61±1.17
Garmut	5.37±0.23	10.39±0.55	16.13±0.59	1.34±0.81	67.01±0.82	0.66±0.61
Nawk	6.36±0.04	6.30±0.54	11.56±0.20	0.55±0.25	74.96±0.37	0.59±0.18

Table 2: Chemical composition of *Kejeik* samples (dried fish product) collected from Kusti city (White Nile) (Mean±STDEV)

Kejeik type	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrates (%)
Ijl	6.48±0.15	11.8±0.17	4.58±0.64	0.78±0.34	75.71±2.21	1.43±1.42
Garmut	5.48±0.56	11.76±0.68	14.83±0.76	1.55±1.23	63.52±0.98	2.5±0.19
Nawk	6.69±0.41	9.06±0.97	14.05±1.25	1.27±0.47	68.28±1.30	1.58±0.58

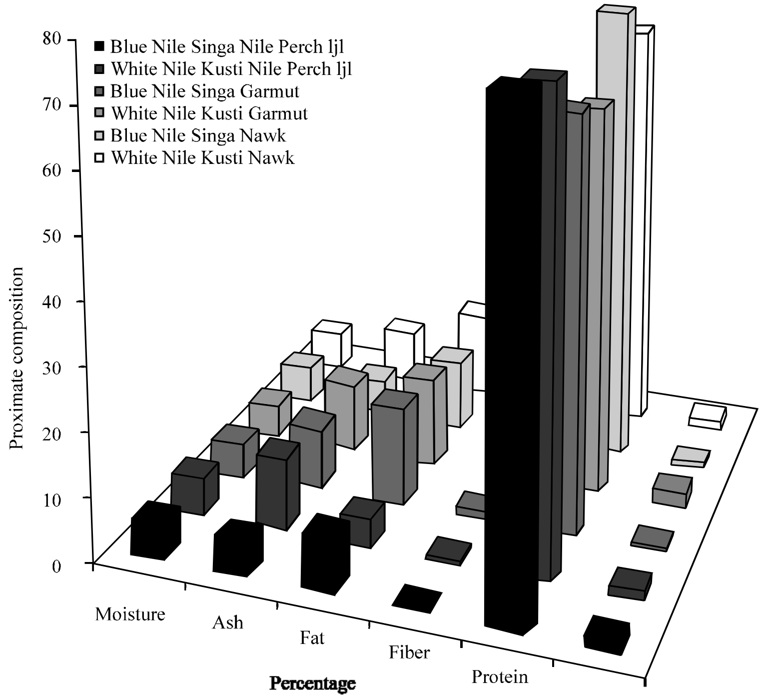

Fig. 1: Chemical compositions of *Kejeik* samples collected from various sites

Sulieman and Mustafa (2012) who found a range of 4.80 and 4.70% in sun-dried Garmut and lower than those of sun-dried Anchovy and sun-dried Tilapia fish which were 16.2 and 12.6%, respectively as reported by Essuman (1992). However, the variation in moisture content of the different samples maybe due to drying process. The variation in moisture content is an indication of the lack of quality standards for artisanal fishery products. Products with high moisture content tend to deteriorate faster than drier products especially if the salt level is low.

The level of ash content of *Kejeik* samples ranged between 5.78 and 11.80%. The highest ash content (11.80%) was found in Ijl *Kejeik* from Kusti and the lowest value (5.78%) was found in Ijl *Kejeik* collected from Singah. The determined value for ash was lower than those of both sun-dried Tilapia fish and salted dried Kako fish (Pseudotolithus senegalensis) which were 18.4 and 20.8%, respectively as reported by Essuman (1992). The variation in ash content of the various *Kejeik* samples could be attributed to the variation in the environmental conditions or food type. High levels of ash in all of the *Kejeik* fish products were obtained. This is a reflection of the level of salt uptake during the fermentation process. When salted products are to be used in relatively large quantities in food preparation, the common practice is to steep the fish in water for a short period (one to three hours) to leach out some salt.

The fat content of *Kejeik* samples ranged between (4.58-16.13%). The highest fat content (16.13%) was found in Garmut *Kejeik* from Kusti while the lowest value (4.58%) was found in Ijl *Kejeik* from Singah. The determined value for fat content was higher than that reported by Sulieman and Mustafa (2012) who found that fat content ranged between 7.3 and 8.4%. The variation in fat content of the various *Kejeik* samples could be due to the seasonal variations or feeding. It is known that, the fat content of fish can vary very much more widely than the water, protein or mineral content. Whilst the ratio of the highest to the lowest value of protein or water content encountered is not more than three to one, the ratio between highest and lowest fat values is more than 300-1. The fat is not always uniformly distribute throughout the flesh of a fatty fish (FAO, 1992).

The crude fiber content of *Kejeik* samples ranged between (0.55-1.55%). The highest value (1.55%) was found in Garmut *Kejeik* from Kusti city (White Nile) and the lowest value (0.55%) was found in Nawk *Kejeik* collected from Singah. The determined value for crude fiber content was close to that reported found by Sulieman and Mustafa (2012) who found that crude fiber content ranged between (1.3-1.2%) in Garmut dried fish. The variation in crude fiber content of the various *Kejeik* samples maybe due to the quality of food that the fish eats and the amount of movement it makes.

Table 3: Macro and micro mineral contents (mg kg^{-1}) of *Kejeik* sample collected from Singah city (Blue Nile) (Mean+STDEV)

	Kejeik samples		
Macro and micro minerals	Ijl	Nawk	Garmut
Ni	1.96±0.34	1.06±0.28	0.21±0.09
Zn	25.14±0.74	32.69±1.61	23.44±0.44
Cu	3.49±0.72	2.89±0.14	1.99±0.18
Pb	0.29±0.05	0.06±0.01	0.13±0.02
Fe	92.51±0.05	77.99±2.57	187.95±8.7
Ba	5.98±0.38	7.09±0.83	5.86±0.17
Se	1.37±0.20	1.12±0.14	0.83±0.06
Si	120.95±0.92	112±0.42	187.50±25.46
Al	83.98±2.65	51.13±1.78	257.55±19.02
Na	286.25±2.19	2321.50±21.92	2161±161.22
K	12865±162.63	11140±14.14	11915±445.8
Ca	6585.5±94.05	5443.50±368.40	19270±148.92
Mg	824±46.67	832.65±3.46	836.35±54.80
P	8.3±0.95	10.22±0.32	78.05±1.20

The carbohydrates content of *Kejeik* samples ranged between (0.59-2.5%). The highest value (2.5%) was found in Garmut *Kejeik* from Kusti city and the lowest value (0.59%) was found in Nawk *Kejeik* collected from Singah. The determined value for carbohydrates content was lowest than that reported found by Sulieman and Mustafa (2012) who found that carbohydrates content ranged between (6.4-3.9%) of Garmut dried fish. The variation in carbohydrates content of the samples maybe due to the quality of food that the fish eats and the amount of movement it makes. The amount of carbohydrate in white fish muscle is generally too small to be of any significance in the diet; hence no values are given in the tables. In white fish the amount is usually less than 1%, but in the dark muscle of some fatty species it may occasionally be up to 2%. Some molluscs, however, contain up to 5% of the carbohydrate glycogen (FAO, 1992). Generally, the composition of a particular species of fish often appears to vary from one fishing ground to another and from season to season, but the basic causes of change in composition are usually variation in the amount and quality of food that the fish eats and the amount of movement it makes. For example, fish usually stop feeding before they spawn and draw on their reserves of fat and protein. Again, when fish are overcrowded, there may not be enough food to go round; intake will be low and composition will change accordingly. Reduction in a basic food resource (FAO, 1992).

Kejeik contents of micro and macro minerals: Minerals present in food can be essential, non-essential or toxic to human consumption (Sivaperumal *et al*., 2007). Marine foods are very rich sources of various mineral components. The total content of minerals in raw flesh of marine fish and invertebrates is in the range of 0.6-1.5% of wet weight (Sikorski, 1990). However, variation in mineral composition of marine foods can occur due to seasonal and biological differences (species, size, dark/white muscle, age, sex and sexual maturity), area of catch, processing method, food source and environmental conditions (water chemistry, salinity, temperature and contaminant), (Ganbi, 2010; Rodrigo *et al*., 1998; Alasalvar *et al*., 2002; Turhan *et al*., 2004). Profile will aid in determining oils suitable for the production of solid fats for industrial uses.

The micro and macro minerals content in *Kejeik* samples collected from Singah and Kusti cities are shown in Fig. 2 and Table 3 and 4. The contents of micro-mineral (mg kg^{-1}) Ni, Zn , Cu, Pb, Fe, Se, Si and Al ranged between 0.21-1.96, 23.44-32.69, 1.99-3.49, 0.06-0.29, 77.99-187.95, 0.83-1.37, 112-187 and 51.13-257.55, respectively. On the other hand, the macro minerals (mg kg^{-1}) Ba, Na, K, Ca, Mg and P ranged between 5.86-7.09, 286.25-2321.5, 11140-12865, 5443.5-19270, 824-836.35 and 8.3-78.05, respectively. On the other hand the micro minerals of *Kejeik* samples collected from Kusti city (White nile) (mg kg^{-1}) Ni, Zn, Cu, Pb, Fe, Se, Si and Al ranged between, 13.81-26.09, 25.0-60.76, 7.33-28.1, 0.31-0.55, 146.1-216.3, 0.83-1.26, 158.75-165.35 and 128.55-175.65, respectively, while, the macro minerals (mg kg^{-1}) Ba, Na, K, Ca, Mg and P ranged between, 2.48-10.03, 2276.5-11300, 11555-23355, 10970-31360, 721.7-1791.5 and 10.25-55.26, respectively.

The copper content in *Kejei*k samples determined in the present study were within range of 1.99-28.1 mg kg^{-1}, the lowest was found in Garmut *Kejeik* (1.99 mg kg^{-1}) while the highest was in Ijl *Kejeik* (28.1 mg kg^{-1}). The permissible limit of copper set by FAO/WHO (1984) is 10 ppm or 1000 μg/100 g.

There was a wide variation of iron contents in *Kejeik* samples; with the lowest value) 77.99 mg kg^{-1} (in (Nawk *Kejeik*) from Blue Nile and the highest value (216.3 mg kg^{-1}) in Ijl *Kejeik* collected from White Nile. These values were lower than those of cockles and fish which were 7830 μg/100 g and 442 μg/100 g, respectively (Guerin *et al*., 2011).

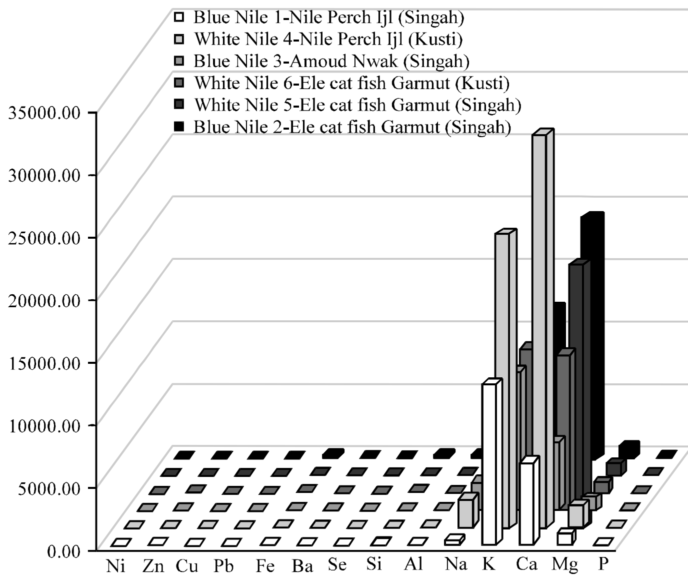

Fig. 2: Macro and micro mineral contents of *Kejeik* samples

Table 4: Macro and micro mineral contents (mg kg^{-1}) of *Kejeik* sample) collected from Kusti city (White Nile) (Mean±STDEV)

	Kejeik samples		
Macro and micro minerals	Ijl	Nawk	Garmut
Ni	26.09±5.38	17.33±1.71	13.81±4.43
Zn	25.0±1.51	60.76±2.28	27.19±1.11
Cu	28.1±1.66	11.64±0.95	7.33±1.52
Pb	0.55±0.09	0.31±0.05	0.5±0.01
Fe	216.3±1.98	146.1±2.97	148.5±3.25
Ba	2.48±0.24	10.03±0.85	5.36±0.49
Se	0.83±0.17	1.21±0.05	1.26±0.12
Si	158.75±1.2	165.05±2.7	165.35±1.2
Al	128.55±1.2	152.45±7.57	175.65±13.93
Na	2276.5±184.55	7653±33.94	11300±678.82
K	23355±403.05	11555±134.35	12630±339.41
Ca	31360±2220.32	10970±791.96	16890±989.95
Mg	1791.5±28.99	721.7±6.36	945.85±36.98
P	12.73±1.65	10.25±1.2	55.26±8.98

However, most of the *Kejeik* samples (except Nawk and Ijl *Kejeik* collected from Singah, had low concentrations of iron, this discrepancy could be due to factors affecting the iron content; such as species, individuals and sampling period (Yilmaz *et al*., 2010).

The zinc content in *Kejeik* samples ranged between 23.44-60.76 mg kg^{-1}, in the current study. All *Kejeik* samples contained lower zinc content than the value set by FAO/WHO (1984) which was (150 ppm or μg/100 g).

The seleniumn content in *Kejeik* samples ranged between 0.83-1.37 mg kg^{-1}, the highest was shown in Ijl *Kejeik* 1.37 mg kg^{-1}.

The lead contents in *Kejeik* samples in the present study were within a range of 0.06-0.55 mg kg^{-1}, the highest was shown in Ijl *Kejeik* (0.55 mg kg^{-1}) and Garmut *Kejeik* (0.5 mg kg^{-1}). These results where higher compared with the permissible limit set by Codex STAN 193 (1995) which reported that the permissible limit of lead (Pb) content was 0.3 mg kg^{-1} in fish. The high concentrations of lead in this study could be attributed to storage or the processing.

The aluminum, nickel and silicon, content in *Kejeik* samples determined in the present study ranged between 51.13-257.55 mg kg^{-1}, 0.21, 26.09 and 112-187.5 mg kg^{-1}, respectively. Finally the others elements (chromium (Cr), arsenic (As), cadmium (Cd) and Mercury (Hg) were not detected.

The concentration of potassium (K) was realtively high in all samples and the lower value was found in Nawk *Kejeik* which contained a value of 11140 mg kg^{-1}. The values of K in the present were higher than those of *B. bayad*, *O. niloticus*, *C. lazera* and *T. Fahaka* which were 1.2580, 1.3205, 1.8871 and 1.8926%, respectively (Karar, 1997).

Generally, calcium was found to be the mineral with highest concentrations in all samples compared to all minerals analyzed. However, the highest value was found in Ijl *Kejeik* (31360 mg kg^{-1}) and the lower value was found in Nawk *Kejeik* (5443.5 mg kg^{-1}).

The highest magnesium content was found in Ijl *Kejeik* (1719.5 mg kg^{-1}) and the lowest value was found in Nawk *Kejeik* (721.7 mg kg^{-1}). The concentrations of magnesium (Mg) content in all *Kejeik* samples were higher than those found by Erkan and Ozden (2007), who reported that magnesium contents were 32.6 mg/100 g (sea bass) and 22.2 mg/100 g (sea bream) which were lower compared to all *Kejeik* samples in the current study. This could be due to the difference of species, seasons, area of catch, processing and many other physical and environmental conditions in these studies.

The range of sodium content in all *Kejeik* samples was between 286.25-11300 mg kg^{-1}, the concentration of sodium (Na) content in all Kejeik samples was higher than that found by Karar (1997).

The range of phosphorus content in all *Kejeik* samples was between 8.3-78.05 mg kg^{-1}. The highest phosphorus content was found in Garmout Kejeik (78.05 mg kg^{-1}) and the lowest value was found in Ijl *Kejeik* (8.3 mg kg^{-1}).

In addition to Table 3 and 4, the results of macro and micro minerals content of *Kejeik* prepared from various fish types and collected from Singah and Kusti cities are presented in Fig. 2 which shows that there were significant differences in macro and micro minerals content of *Kejeik* products obtained from Blue Nile and White rivers (Singah and Kusti). It is observed that, the macro and micro mineral content of three types of fish was affected by the different areas.

CONCLUSION

The present study aimed to determine the chemical composition of *Kejeik* (a traditionally dried fish product) prepared in rural areas in many parts of Blue Nile and White Nile basins and consumed by many people in these areas and other parts of Sudan. The analyses indicated that there was non-significant difference between the Blue Nile and White Nile *Kejeik* samples in most of the chemical components of *Kejeik* samples prepared from three fish types. However, Ijl *Kejeik* contined significantly higher contents of protein, fat, fiber ash, moisture and carbohydrate as compared to Garmout *Kejeik* and Nawk *Kejeik*. *Kejeik* samples contained appreciable amounts of macro-minerals and the calcium was the highest in all samples. Moreover, *Kejeik* samples contained most of the micro-minerals; however, Nawk and Ijl *Kejeik* collected from Singah contained the lowest concentrations of iron. All *Kejeik* samples free from toxic metals such as mercury, arsenic and cadmium. It is highly recommended to utilize *Kejeik* in Sudanese meals especially during shortage of protein and other nutrients sources.

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