Nutrient composition of selected fresh and processed fish species from lake Malawi: a nutritional possibility for people living with HIV/AIDS

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Abstract

Nutrition is important for both healthy and sick people. Unfortunately for sick people, especially those living with HIV/AIDS, the emphasis has mostly been on drugs at the expense of nutritional aspects. People living with HIV/AIDS and related diseases need a lot of protein and energy-rich foods together with vitamins and minerals. Fish are particularly rich in these nutrients. In Malawi, fish are harvested in large numbers and to avoid deterioration, some are smoked, sun dried or partially boiled and then sun dried. Since the nutrient contents of the fresh and processed fish may differ, a study was carried out on four different fresh and processed fish species (Copadichromis inornatus, Rhamphochromis ferox, Engraulicypris sardella and Oreochromis lidole) in order to determine which species was the more nutritive. The results showed that E. sardella and C. inornatus species, fresh or processed, had relatively higher (P < 0.001) protein content (58.22 ± 0.6% and 57.78 ± 0.7% respectively), fat (25.2 ± 1.2 and 22.08 ± 0.4% respectively), energy (24086.7 ± 151.7 J/g and 22204.9 ± 84.7 J/g respectively) than either R. ferox or O. lidole. Although the R. ferox species had lower protein, fat and energy than E. sardella or C. inornatus, this species had higher available lysine content. Calcium and magnesium contents of E. sardella and C. inornatus were however, slightly lower (P < 0.001) than those of the other two species. There were variations between and within the species for all parameters analysed. The results obtained in this work suggest that people living with HIV/AIDS in Malawi can best build their muscle and get more energy and minerals from the E. sardella and C. inornatus fish species. It would therefore be recommended that appropriate technologies for improving the availability and productivity of such fish should be developed and tested for people living with HIV/AIDS or affected households. However, it is suggested that a larger group of the commonly available fish species should be analysed so as to offer a wider choice to consumers.

Keywords  Fish species, nutrient components, HIV/AIDS.

Introduction

Malawi has a population of 9.9 million people1 and most of these (80%) live in rural areas. The diet of the majority of the people is thick porridge made from maize meal and this is consumed with relish in the form of vegetables mixed with groundnut powder. The annual per capita protein supply from meat from livestock is estimated to be in the range of 5.4–6.6 kg and that from fish, in the range of 7–10 kg. This supply is much lower than in the surrounding countries (13 kg) in the South Africa Development Community (SADC).2 The consequence has been a prevalence of malnutrition throughout the country. The problem is compounded by the incidence of HIV/AIDS. The nutritional aspect of people living with and affected by HIV/AIDS and related illnesses worldwide has been ignored for a long time. The attention has most often focused on drugs. Unfortunately, the majority of the sufferers live in developing countries where healthcare resources and drugs are scarce. In Malawi, the HIV prevalence rate has been estimated at 15%, 25% in urban areas and 13% in rural areas.3 For such people, a balanced diet is a positive way of responding to illness. By bolstering the immune system and boosting energy levels, balanced nutrition can help the body fight back against the ravages of the disease. In addition, it is said that people living with HIV/AIDS need more protein to rebuild muscle tissue, more
energy-rich foods for weight gain, immune system boosting and minerals. Reports have indicated that people living with HIV/AIDS require up to 50% more protein and 15% more energy. Fortunately for Malawi, there is a lake, which has the highest number of fish species in the world. Fish are known to be a nutritious and a functional food. They are a good source of high-quality protein, rich in lysine together with a high concentration of vitamins, phosphorus, calcium and iron. Fish are consumed by the majority of Malawians most of whom are poor and cannot afford drugs for most of the ailments. Because fish is the main source of protein in Malawi, which contributes 60–70% of the animal protein consumed, fish foods can help mitigate the negative effects of the disease.

The fish is sold on the Malawi market either fresh, fire-smoked or sun dried. The traditional application of heat to preserve fish is important in Malawi as it is in other parts of the world. Fresh fish is more expensive than sun dried or smoked fish. This is advantageous to the rural poor who cannot afford expensive goods such as refrigerators or freezers. In addition, fish is harvested in large amounts and by sun drying or smoking some, the fish can be kept for a longer period in places where cooling equipment is not available.

Obviously, the nutritional value of these three different types of fish cannot be the same. No studies on the nutritive values of the different fresh or locally processed Malawi fish species have been carried out.

This study was therefore carried out to investigate the nutritive values of selected and moderately less expensive fish species in an attempt to assist consumers buy the best nutrition wise and, at the same time, give them the highest calories.

Materials and methods

Samples and sample preparation

Four different readily available (on the Malawi market) fresh water species of fish in three families, were purchased from the near by Lilongwe city market, either fresh or already processed. The objective of getting the already processed samples rather than processing in the laboratory was to get the actual fish that is used by the consumers. Generally, there are three ways of processing fish in Malawi; smoking is carried out on a platform erected over a pit. Fire is made in the pit and the oils from the fish laid on the platform drip producing smoke, which dries the fish. In the sun-drying method, the fish are laid on a platform without the fire underneath and drying is effected by the heat from the sun. The third method is a combination of part boiling and sun drying. The fish are slightly boiled (or steamed) and then sun dried. The species purchased were:

- *Oreochromis lidole* (family, Cinclidae and locally known as ‘chambo’) has a scaly body and has rounded bones. It is found in the open water away from the coast.
- *Engrauficypris sardella* (family, Cyprinidae and locally known as ‘usipa’) has a steely blue colouration on the upper part and silvery blue on the lower part of the body.
- *Copadichromis inornatus* (family, Cinclidae and locally known as ‘utaka’) is widely distributed in lake Malawi including offshore islands. It usually feeds alone or in small groups with other species on the aufwuchs cover on rocks in shallow water.
- *Rhamphochromis ferox* (family, Alestiidae and locally known as ‘mcheni’) is a slender fish, which prefers warm and well-oxygenated waters.

All the species except the *O. lidole* are sold on the Malawi market fresh, smoked, para-boiled and then sun dried (in the case *E. sardella* only) or just sun dried. The chambo (*O. lidole*) is sold either fresh or smoked and not sun dried. These were purchased as such. Almost always, one person consumes the whole fish including the head in a single meal. This is taken in combination with thick porridge made from maize meal and some vegetables, if available.

After purchasing, three whole fish of each species were weighed and then ground in a mortar and duplicate portions of each sample were then used for chemical analysis.

Chemical analysis

Crude protein

Crude protein was determined by the kjeldahl method. A 2.5 g ground sample from each fish species
was digested in kjeldahl flask using 98% sulphuric acid after which it was steam-distilled. The resulting distillate was titrated to a pink or wine-red colour using 0.01 M HCl. The whole procedure was repeated three times for each sample. The percentage crude protein was calculated as \((N \times 6.25)\).

**Fat**
This was determined using Soxhlet extraction apparatus. Petroleum ether (Bp = 40–60°C) was added to a 2.0 g sample of fish placed in an extraction apparatus. Extraction was carried out for 16 h, after which the ether was evaporated to dryness. The amount of fat was obtained from the difference in the weight of the flask before and after drying off the ether. The procedure was repeated three times.

**Available lysine**
This parameter was determined by the conventional calorimetric method. A 2.0 g portion of the each of the ground fish samples was allowed to react under alkaline conditions with 12 mL of 1-fluoro-2,4-dinitrobenzene (2.5%) to give a DNP-lysine derivative. The absorbance of the solution was measured at 453 nm and the amount of available lysine obtained from a standard curve.

**Moisture**
Separate whole fish samples (5.0 g) were dried at 105°C to a constant weight after the initial weighing, and the difference in the final and the initial weights gave the moisture content of the fish.

**Calcium and magnesium**
These parameters were determined by titration according to the method described by Skoog et al. (1976). A 2.0 g fish sample was first dry-ashed, the contents transferred into a 250 mL volumetric flask and diluted to the mark with water. A buffer solution (pH 10, 2 mL) and Eriochrome Black T indicator (2 drops) were added to 50 mL of the test solution. The solution was then titrated with 0.1 M disodium ethylenediamine tetraacetate (EDTA) to blue colour. The results of this test were expressed as milligrams magnesium per litre of sample. For calcium, a similar test was carried out except, a magnesium EDTA salt (1 mL) was added to a fresh 50 mL sample solution before titration with EDTA.

**Phosphorus**
Phosphorus was determined by calorimetric methods. A 2.0 g of the ground fish sample placed in a crucible was first dry-ashed after which 3 mL of distilled water was added followed by dropwise addition of 2 mL of HCl (7 N). Then 5 mL of 36% HCl was added after which the sample was evaporated to dryness on a sand bath. After cooling down, 5 mL of 6 M HCl was added to break the ash. The contents were then filtered into a 50 mL volumetric flask then made up to the mark with distilled water. Into 50 mL volumetric flask were pipetted, 5 mL of 5 M HCl, 5 mL of Ammonium molybdate-ammonium-metavanadate. Finally, 50 mL of distilled water was added to make up to the mark and the solution was left to stand for 30 min. The absorbance was measured at 600 nm. The phosphorus content was determined from a standard curve.

**Iron**
A 2.0 g ground sample was dry-ashed by using a mixture of concentrated HCl (10 mL) and HNO3 (1 mL) after which, the contents were transferred into a 250 mL volumetric flask and diluted to the mark with distilled water. To 5 mL of the test solution was added hydrochloric acid (1 mL) followed by two drops of 1 M potassium permanganate, 5 mL ammonium thiocyanate (7.5 m) and then 10 mL of a mixture of amyl acetate and amyl alcohol (1:1). The contents were shaken vigorously and left to stand for 5 min. The upper layer was transferred to a test tube. The procedure was repeated with iron standards and distilled water as a blank. The absorbance of the solution was read at 510 nm and the concentration of iron obtained from a standard curve.

**Ash**
A 2.0 g of the ground fish sample was placed in a crucible and ashed at 555 °C for 5 h in a carbolite muffle furnace after which it was allowed to cool to room temperature. The difference in the weight of the crucible before and after cooling gave the amount of ash.

**Energy**
This was obtained by using a bomb calorimeter (Model 1013 U). A 0.85 g of the ground sample was used for this
purpose. The energy was obtained by dividing the heat gain by the weight of the sample.

Statistical analysis

All data were analysed using the General Linear Model (GLM) of SAS.\textsuperscript{15} The means were separated by using Duncan’s Multiple Range Test.

Results and discussion

The bio-molecule, water and energy contents in the various fresh and processed fish species are presented in Table 1. The protein content varied among the species studied ($P < 0.001$) but was highest in smoked \textit{E. sardella} (62.04 ± 0.45\%) and smoked \textit{C. inornatus} (62.21 ± 1.70\%). Other researchers\textsuperscript{11} who have done similar work have also reported similar variations. The cinclids species in this work had higher values than those reported for similar species elsewhere but the values for the alestiidae species were comparable to those reported by the same workers.\textsuperscript{16} The average protein content of the \textit{Oreochromis} species was lower than reported\textsuperscript{6} for this species, which is said to be more than 60\%. This was probably because of the medium-sized fish that were used.

There were also differences in protein content within each species. In general, processed fish had higher protein content ($P < 0.001$) than the fresh. Although, it is reported that heat generally reduces the protein content of fish, what was observed in this study was in fact the reverse. It is difficult to state why there was such a general increase in the protein content on especially, smoking. The fat content also varied greatly among the species, the highest being in fresh \textit{E. sardella} (29.9 ± 0.8\%). Within the species, the sun-dried fish seemed to have higher fat contents compared to the smoked ones. Work carried out else where has also shown that heat treatment of fish increases the oil content and that this originates from the liver and adipose tissues of the body cavity.\textsuperscript{11} It may be possible that sun drying has a greater effect than smoking, which depends on the temperature and length of smoking. More significant however, were the low values of protein and fat in \textit{R. ferox} species. Because the whole fish are eaten as a meal portion in Malawi, the relatively bigger size of this fish compared to \textit{E. sardella} would make one believe that it would contain more nutrients. Unfortunately, it is difficult to speculate the reasons for the observed values.

The available lysine contents were generally low in all the species, with the highest values at 0.69 ± 0.04\% in fresh \textit{R. ferox}. There were also significant differences between species ($P < 0.001$). Within each species the values were higher in the fresh than in the processed fish. The loss in available lysine contents because of

\begin{table}[h]
\centering
\caption{Bio-molecule, energy and water contents in various fresh and processed fish species}
\begin{tabular}{|l|c|c|c|c|c|}
\hline
Fish species & Protein (%) & Fat (%) & Available lysine (%) & Water (%) & Energy (J/g) \\
\hline
\textit{O. lidole} – fresh & 42.25 ± 0.5\textsuperscript{e} & 22.9 ± 0.1\textsuperscript{c} & 0.19 ± 0.01\textsuperscript{d} & 74.75 ± 0.25\textsuperscript{a} & 21 933.6 ± 622.3\textsuperscript{cd} \\
\textit{O. lidole} – smoked & 49.64 ± 1.01\textsuperscript{d} & 15.6 ± 1.0\textsuperscript{c} & 0.09 ± 0.001\textsuperscript{e} & 12.75 ± 1.60\textsuperscript{a} & 18 442.1 ± 990.5\textsuperscript{d} \\
\textit{E. sardella} – fresh & 55.32 ± 1.34\textsuperscript{e} & 29.9 ± 1.85\textsuperscript{a} & 0.12 ± 0.01\textsuperscript{f} & 72.65 ± 0.38\textsuperscript{a} & 24 643.4 ± 996.7\textsuperscript{d} \\
\textit{E. sardella} – para-boiled + sun dried & 62.04 ± 0.45\textsuperscript{a} & 21.75 ± 1.85\textsuperscript{a} & 0.14 ± 0.02\textsuperscript{g} & 56.3 ± 0.40\textsuperscript{a} & 23 265.8 ± 225.7\textsuperscript{d} \\
\textit{E. sardella} – sun dried & 57.3 ± 0.09\textsuperscript{b} & 23.95 ± 1.0\textsuperscript{a} & 0.29 ± 0.01\textsuperscript{h} & 20.25 ± 1.1\textsuperscript{i} & 24 350.8 ± 129.8\textsuperscript{b} \\
\textit{C. inornatus} – fresh & 54.2 ± 0.80\textsuperscript{c} & 22.7 ± 1.1\textsuperscript{c} & 0.016 ± 0.001\textsuperscript{i} & 72.9 ± 1.0\textsuperscript{a} & 22 534.9 ± 56.1\textsuperscript{c} \\
\textit{C. inornatus} – smoked & 62.21 ± 1.70\textsuperscript{c} & 17.65 ± 0.15\textsuperscript{c} & 0.06 ± 0.01\textsuperscript{j} & 52.7 ± 0.30\textsuperscript{c} & 21 124.9 ± 157.1\textsuperscript{c} \\
\textit{C. inornatus} – sun dried & 56.91 ± 0.70\textsuperscript{c} & 25.9 ± 0.001\textsuperscript{i} & 0.02 ± 0.001\textsuperscript{k} & 30.05 ± 0.30\textsuperscript{j} & 22 955.0 ± 40.8\textsuperscript{c} \\
\textit{R. ferox} – fresh & 19.1 ± 0.50\textsuperscript{c} & 5.05 ± 0.05\textsuperscript{c} & 0.69 ± 0.04\textsuperscript{c} & 24.1 ± 0.50\textsuperscript{c} & 18 974.0 ± 181.1\textsuperscript{c} \\
\textit{R. ferox} – smoked & 34.8 ± 0.20\textsuperscript{c} & 6.4 ± 0.10\textsuperscript{c} & 0.4 ± 0.04\textsuperscript{c} & 48.8 ± 1.6\textsuperscript{c} & 9 388.8 ± 456.7\textsuperscript{c} \\
\textit{R. ferox} – sun dried & 49.1 ± 1.20\textsuperscript{c} & 17.01 ± 0.15\textsuperscript{c} & 0.31 ± 0.04\textsuperscript{c} & 24.1 ± 0.50\textsuperscript{c} & 18 974.0 ± 181.1\textsuperscript{c} \\
\hline
\end{tabular}

\*Means with different letters in a column are significantly different ($P < 0.001$).
\end{table}
Table 2 Mineral and ash contents of the various fresh and processed fish species

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Parameters (mean ± standard error)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ca (mg/g)</td>
</tr>
<tr>
<td>O. lidole – fresh</td>
<td>43.4 ± 0.40σ</td>
</tr>
<tr>
<td>O. lidole – smoked</td>
<td>58.7 ± 0.00σ</td>
</tr>
<tr>
<td>E. sardella – fresh</td>
<td>12.43 ± 0.70σ</td>
</tr>
<tr>
<td>E. sardella – para-boiled + sun dried</td>
<td>11.68 ± 0.2σ</td>
</tr>
<tr>
<td>C. inornatus – fresh</td>
<td>26.34 ± 0.38σ</td>
</tr>
<tr>
<td>C. inornatus – sun dried</td>
<td>36.88 ± 0.70σ</td>
</tr>
<tr>
<td>R. ferox – fresh</td>
<td>8.25 ± 1.70σ</td>
</tr>
<tr>
<td>R. ferox – smoked</td>
<td>23.0 ± 0.70σ</td>
</tr>
<tr>
<td>R. ferox – sun dried</td>
<td>24.85 ± 0.40σ</td>
</tr>
</tbody>
</table>

*αβMeans with different letters in a column are significantly different (P < 0.001).

processing has also been reported for other fish species.11

The energy values varied significantly between and within species. Highest values were obtained in E. sardella. This was probably a reflection of the higher fat content obtained in this species of fish.

The mineral contents in the various fish species are given in Table 2. The calcium contents varied between the species. The O. lidole species had highest values (mean = 45.95 ± 3.02%) and the E. sardella had the lowest (mean = 9.92 ± 0.6%). This variation could be a result of biological differences because of differences in sizes of these species.9

An adult male (age between 18 and 60 years) requires 49 g of protein; 83 g of fat and 2944 kcal of energy while a female of childbearing age requires 41 g of protein, 59 g of fat and 2140 kcal of energy17 per day. The values obtained in this work may be slightly lower than required but they can be used as supplements to provide adequate nutrients. Because the E. sardella and C. inornatus have higher protein, fat and energy contents, increased consumption of these fish species may help to provide the necessary nutrients to patients.

For magnesium, phosphorus, iron and ash, although differences were observed between species, there was not much variation within species. The highest magnesium content was also obtained in E. sardella followed by R. ferox and for iron, the highest values were obtained in R. ferox. The phosphorus levels observed in all fish species were far below those recorded in, for example hake fish.9 This could be explained as being because of biological differences of the fish. Similarly, the iron was much lower than that required by a child (12 mg), adult male (23 mg) or female (24 mg).17 The values observed for minerals in fresh O. lidole were however, higher than those that were obtained in O. Shiranus18 which is of the same species. In the latter case, only certain parts of the fish were used and this could account for the lower values in O. Shiranus. The R. ferox species had the highest iron content although lower than required. As such, an increase in consumption of this fish species would help to provide the much-needed iron in, for example, pregnant women who require more of this metal.

Conclusion

The results obtained in this study have shown that the E. sardella species, whether fresh, smoked or sun dried, has a relatively lower mineral content but high values of protein, fat, energy and a moderately high available lysine. However, the C. inornatus has relatively high values of all the nutrients. Therefore, if a good and balanced diet for a patient living with HIV/AIDS is required, then these two fish species would be the best. The O. lidole fish varies widely in size, and the ones used
in this study were of medium size and this gave relatively high values of protein, fat and energy. Because the mineral content is also reasonably high in the *O. lidole*, this fish species would provide required nutrients for a patient. However, with the high cost of the *O. lidole*, smaller fish species like *E. sardella* and *C. inornatus* would be preferred. It would be recommended therefore, that people living with HIV/AIDS in Malawi can best build their muscle and get more energy and minerals from the *E. sardella* and *C. inornatus* fish species. Appropriate technologies for improving the availability and productivity of such fishes should be developed and tested for people living with HIV/AIDS or affected households. However, it would be recommended that a larger group of the commonly available fish species should be analysed to offer a wider choice to consumers.

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**References**