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Proximate composition of *Rastrineobola argentea* (*Dagaa*) of Lake Victoria-Kenya

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Proximate composition analysis for crude lipid content, crude protein content, moisture content, total ash content and dry weight of *Dagaa* (*Rastrineobola argentea)*: a small pelagic fish which constitutes one of the main fish species in Lake Victoria was determined from selected beaches: Paga, Dunga, Rota, Usari and Nduru around Lake Victoria-Kenya. This was done with a view to provide nutritional data to guide food processing, industrial exploitation, preservation and consumption of the fish. On a wet weight basis (wwb), proximate composition values were established as crude protein content, kjedahl and biuret (19.1 - 21.7% and 1.93 - 5.80 mg/ml respectively), lipid content by Dyer and Bligh and Soxhlet (3.87 - 7.78 and 1.77 - 3.40% respectively), ash content (1.88 - 4.38%), ash content on a dry weight basis was (10 - 14.58%) and moisture content of (72.83 - 76.90%). Analysis of these results showed that there were significant differences ($p < 0.01$) in crude protein content, crude lipid content, total ash content and moisture content of *Dagaa* from the five landing sites. Hence, the inherent variations in *Dagaa* collected from the different landing sites were attributed to the difference in geographical locations of the sites. *Dagaa* was classified as a fatty fish (fat content >2%) based on Dyer and Bligh method. The high protein, ash and lipid content of *Dagaa* make it a nutritionally dense fish.

Key words: *Dagaa*, Lake Victoria, proximate composition.

INTRODUCTION

In most third world countries, food insecurity is increasingly becoming an issue of national concern (Owaga et al., 2010). Fish is an important food of high nutritive value. It is rich in essential nutrients; high quality protein with high digestibility and made of the ten essential amino acids in desirable quantities for human consumption, essential omega 3 fatty acids, vitamins A, B, D and a variety of minerals such as calcium, potassium, phosphorus, iron, copper and iodine required for supplementing both infant and adult diets (Ackman et al*.,* 1988, Gordon and Ratliff, 1992; Huss, 1988; Owaga et al., 2010; Saito et al., 1997). As a result, the fish industry has been identified as one of the sectors that if improved would effectively contribute towards alleviation of food insecurity (Owaga et al., 2010). This can be achieved by directly contributing as a food resource and also through income and generation of employment (Baidu, 1997).

To ensure maximized utilization of the fish industry to achieve this goal, several fish species have been investigated for their proximate content (Ghelichpour and Shabanpour, 2011). Lake Sardine, locally known as "*Dagaa*" (*Rastrineobola argentea)* is a small pelagic fish

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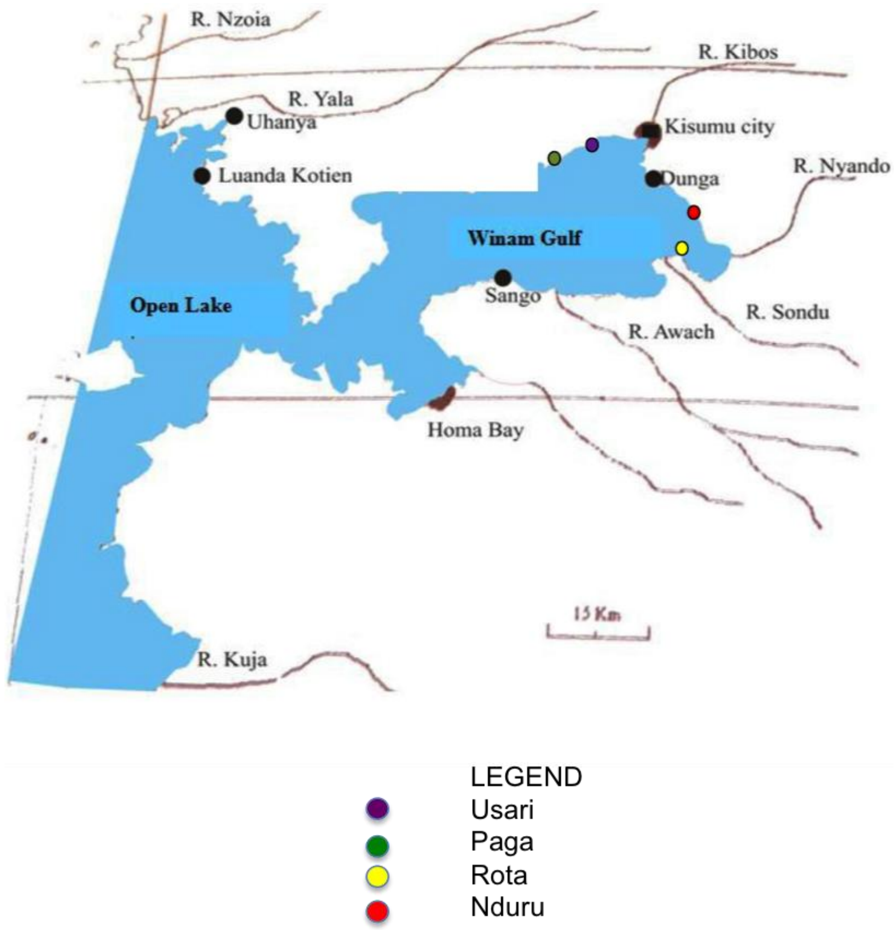

Figure 1. Dunga and other landing sites (Adopted from Onyango et al., 2009 with modifications).

that accounts for the second largest volume (62.9%) of the total fish catch along the Lake Victoria (Nyeko, 2008; Wanink, 1999; Witter et al., 1995).

It is also cheap in comparison with Nile perch (Owaga et al., 2010). Despite the large harvest of *Dagaa*, post harvest losses of 20 - 30% due to endogenous enzymes/-spoilage by microorganism and up to 50% during the rainy season are experienced (Bille and Shemkai, 2006). The rapid nutritive value depreciation due to endogenous enzymes signifies a high nutritive value that could be exploited.

Notwithstanding, its importance as a fish food for low income households, high numbers (30 - 50%) of malnutrition has been recorded among the population around Lake Victoria (GOK and UNICEF, 1999), an indication that not much attention has been given regarding its nutritional composition. Consequently, its potential, as a rich nutrient source remains largely unexploited Industrially and nutritionally.

The objective of this study therefore was to investigate the proximate composition of *Dagaa "Omena"* (*Rastrineobola argentea)* from various points along the Lake Victoria in order to provide evidence on nutritional composition of *Dagaa* that could guide its use in dietary consumption, food processing, industrial exploitation and preservation.

MATERIALS AND METHODS

Sampling

Fresh *Dagaa* (1 kg each) was sampled in labeled polythene bags from four fishermen from each of the landing sites: Dunga, Nduru, Paga, Rota and Usari around the shores of Lake Victoria (Figure 1) resulting in a sample weight of 4 kg from each landing site and a total sample weight of 20 kg (20 batches). The *Dagaa* was then transported for 2 h via flight to the laboratory (Chiromo campus - University of Nairobi, Kenya) in a cool box at 4°C, and each landing site sample divided into 200 g labeled batches and stored frozen at -20°C until analysis.

Preparation of fish mince

Two types of fish mince were prepared

A homogenate from well-mixed samples from the individual landing sites (Rota, Usari, Paga, Nduru and Dunga) was obtained and apportioned in 200 g batches. Each batch was then blended using a food blender. The individual landing sites' minced samples were stored in 200 g batches at (-20°C) until analysis.

A second homogenate of the *Dagaa* representative samples (mixture of samples from the five landing sites) was obtained by mixing 200 g of mince from each individual site to constitute a 1 kg representative mince. This was then mixed well and repacked in polythene bags in 200 g batches, labeled numerically and stored frozen at (-20°C) until analysis.

The average *Dagaa* size of the representative sample and *Dagaa* size of the individual landing sites was measured.

Proximate composition

Upon usage, batches of individual sites/*D*agaa representative samples were thawed in a cold room (4°C) for 16 h before analysis

Total moisture/total dry weight

Crucibles were cleaned and dried in an oven (Memmert, USA), cooled to room temperature and then weighed on a weighing balance (Metler, Switzerland). The minced samples for proximate analysis were allowed to attain room temperature to ensure accuracy in weights taken before they were put into the dried crucibles and weighed in triplicates.

Total moisture content/dry weight was determined using air oven method according to AOAC method 950.46 (AOAC, 1995). The dry matter/moisture content was obtained as follows:

$$\text{Dry matter content (\%)} = \frac{\text{Weight of dried sample}}{\text{Original wet weight}} \times 100$$

Total ash

Total ash content was determined from pre-dried *Dagaa* samples according to the AOAC method 920.153 (AOAC, 1995). Ash content was determined as follows:

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Original wet weight}} \times 100$$

Total protein

Crude protein content was determined by the Biuret and micro-Kjedahl methods according to AOAC method 928.08 (AOAC, 1995). A factor of 6.25 was used to convert percent nitrogen to percent protein. Protein content was determined as follows:

$$\text{Total protein} = \text{\% Nitrogen} \times 6.25$$

Total lipid (fat)

Crude fat was determined using the solvent extraction method after soxhlet extraction according to AOAC method 991.36 (AOAC, 1995) and modified method of lipid extraction by Dyer and Bligh (1959). Lipid content was determined using the formula below:

$$\text{Lipid/100 g sample} = \frac{\text{Lipid in the tube x (volume chloroform in total)}}{\text{Amount of sample weighed in (g) x (ml chloroform evaporated)}}$$

Comparison of fat analysis methods

The data obtained using modified Dyer and Bligh described above was then compared with those obtained from crude fat analysis using soxhlet extraction method according to AOAC method 991.36 (AOAC, 1995).

Statistical analysis

The proximate values for moisture, lipid, ash and protein were a mean of triplicate laboratory determinations. The mean values for each of the individual landing sites was tested by comparing the respective proximate values for each landing site. The proximate composition determinations were done in a completely randomized block design. The differences in means among the landing sites was measured using ANOVA while Tukey HSD test was used to determine significant differences between means at 5% ($p < 0.05$) level of significance. Statistical analyses were performed using the SPSS statistical package (SPSS, 2007).

RESULTS AND DISCUSSION

This study aimed at determining the proximate composition of *Dagaa* (*Rastrineobola argentea*). The lengths of *Dagaa* edible portion and proximate analysis of *Dagaa* from each of the landing sites are summarized in Tables 1 and 2, respectively. The average *Dagaa* length ranged from 4.0 - 5.0 cm. Moisture content among the landing sites ranged from 72.83 - 76.90%, ash content on a wet weight basis (wwb) and dry weight basis (dwb) was between 1.88 - 4.38% and 10.00 - 14.58%, respectively. Lipid content on a wet weight basis as determined by Dyer and Bligh and soxhlet methods was 3.87 - 7.78% and 1.77 - 3.40%, respectively. Protein content by Kjedahl and Biuret method was recorded at 19.11 - 21.78% and 1.93 - 5.80 mg/ml, respectively.

Protein content (Kjedahl and Biuret), ash content (dwb and wwb), lipid content (Dyer and Bligh/Soxhlet) and moisture content between the landing sites were significantly different ($p < 0.01$) (ANOVA) (SPSS). A further comparison between the landing sites' mean values by Tukey HSD test was conducted. All landing sites showed significant differences between their moisture content at 5% confidence level. On a wet weight basis, ash content of Rota, Nduru and Usari were significantly different ($p < 0.05$) (Tukey HSD), Paga and Dunga had approximately the same ash content. Usari, Paga, Dunga and Nduru had approximately similar lipid content (Dyer and Bligh) whereas Rota had significantly different lipid content (Dyer and Bligh) at 5% confidence level. Dunga, Paga and Rota had a significant difference ($p < 0.05$) in lipid content determined by Soxhlet method. All the landing sites showed significant difference in protein content determined by Biuret method at 5% significant level (Tukey, HSD). Nduru, Dunga and Rota had approximately similar protein content by Kjedahl method. However, Usari and Paga had significantly different protein content as determined by Kjedahl at 5% confidence level level (Tukey, HSD). Co-relational analysis matrix (Table 3) indicates relationship between the proximal parameters.

Table 1. Lengths of *Dagaa* edible portion.

Landing site	Dunga	Nduru	Paga	Rota	Usari	Homogenous	Average
Fish length (cm)	5.0±0.40	4.8±0.05	4.0±0.03	4.5±0.04	4.6±0.02	4.7±0.34	4.6±0.34

The mean lengths; (in cm) of the edible portions of representative *Dagaa* (second homogenate) from the different landing sites along Lake Victoria.

Table 2. Proximate composition of Dagaa on wet weight basis (wet weight basis).

Landing sites	Moisture (%)	Dry weight (%)	Ash content (%) (wwb)	Ash content (%) (dwb)	Lipid content (%) Dyer/Bligh	Lipid content (%) soxhlet	Protein content (%) kjedahl	Protein content Biuret (mg/ml)
Usari	76.35±0.05[as]	23.65±0.05[b]	1.88±0.94[ah]	11.49±0.61[a]	4.35±0.57[a]	1.77±0.00[a]	19.11±1.80[ar]	4.19±0.03[ad]
Nduru	74.05±0.95[as]	25.95±0.95[b]	2.08±0.69[ah]	10.70±0.00[ax]	7.32±0.59[a]	1.82±0.00[a]	21.07±0.19[a]	1.93± 0.15[ad]
Dunga	72.83±1.30[a]	27.17±1.30[b]	4.38±0.38[a]	10.00±0.00[ax]	3.87±0.19[a]	3.40±0.00[aw]	19.53±1.03[a]	5.80± 0.04[ad]
Paga	74.37±0.40[as]	25.63±0.40[b]	2.36±0.14[a]	10.55±0.78[ax]	7.78±0.44[a]	2.18±0.32[aw]	21.78±1.79[ar]	5.22± 0.12[ad]
Rota	76.90±0.30[as]	23.1±0.30[b]	3.08±0.81[ah]	14.58±2.94[a]	5.47±0.10[ay]	2.77±0.00[aw]	20.31±0.88[a]	4.39±0.06[ad]
Homogeneous	78.40±0.89[as]	21.6±0.89[b]	4.26±0.79[ah]	10.83±3.54[ax]	3.11±0.45[ay]	4.90±0.10[aw]	18.77±0.03[a]	4.76± 0.06[ad]

Moisture content, dry weight, ash content (wet weight and dry weight basis), Lipid content (dyer Bligh and soxhlet) and protein content (kjedahl and Biuret) of *Dagaa* from the five landing beaches along Lake Victoria. a- values with significant differences ($p < 0.01$) using ANOVA. Values with same double letters have significant difference ($p < 0.05$) {Tukey (HSD)}. Values are shown as mean ± standard deviation for triplicate analysis of a pooled sample.

There was a true positive correlation ($p < 0.01$) between protein content by kjedahl and lipid content by Dyer and Bligh method. However, there was a negative correlation between lipid content by soxhlet method and protein content by kjedahl.

The protein composition of fish affects the post harvest quality and characteristics with respect to oxidative changes in the muscle tissues (Owaga et al., 2010). Previous studies conducted, showed that deep-sea fishes are high in protein and low in fat as compared to pelagic fish (Suseno et al., 2010). However, in this study, Dagaa protein values 19.1 - 21.8% were higher than those reported for deep-sea species (11.9 - 20.6 %). The lipid values (4.4 - 7.8 %) on the other hand were also higher than those reported for deep-sea species whose fat content ranged from 0.01 - 4.84% (Suseno et al., 2010). The high lipid and protein values for *Dagaa* could be attributed to the fact that the edible portion is 100% (whole fish) despite its average length of only 4.6 cm; that is relatively small as compared to the deep sea fishes whose lengths range from 14 to 49 cm (Suseno et al., 2010).

Fish can be grouped into four categories according to their fat contents: lean fish (<2%), low fat (2 - 4%), medium fat (4 - 8%) and high fat (>8%) according to Dyer and Bligh (Huss, 1988; Ackman, 1989). Also, it could be classified based on the >5% (dwb) fat composition criteria for discriminating lean from fatty fish species according to soxhlet (Owaga et al., 2010). Dyer and Bligh and Soxhlet method classified *Dagaa* as fatty fish (Table 4); fat content >2 and >5% (dwb), respecttively.

Previous studies have reported that the percent moisture content of fresh fish is inversely related to the lipid content (Jahncke and Gooch, 1997). *Dagaa* non-polar lipid content is inversely related to its water content. However, its polar lipid content is directly proportional to water content as was confirmed in this study. *D*agaa from Dunga site, which recorded lowest moisture content (72.83%), reported the highest non-polar lipid content (3.40%) by Soxhlet method. Similarly, Dunga reported the lowest polar lipid content (3.87%) by Dyer and Bligh method.

The difference in the fat yields using the two methods; 3.9 - 7.9% by Dyer and Bligh and 1.8 - 3.40% by soxhlet could be attributed to difference in solvent polarities. Dyer and Bligh is more efficient in extraction of phospholipids (polar lipids) while soxhlet is more efficient for extraction of non-polar lipids e.g. triglycerides. However, the

Table 3. Correlation matrix of the proximate parameters.

Component	Moisture	Dry weight	Ash (wwb)	Ash (dwb)	Lipid (dyer/bligh)	Lipid (soxhlet)	Protein (Kjedahl)
Moisture	1	-.293	-.175	.494[a]	-.395	.402	-.379
Dry weight	-.293	1	-.166	-.182	.408	-.232	.537[a]
Ash (wwb)	-.175	-.166	1	.613[b]	.575[b]	.624[b]	.-.465
Ash (dwb)	.494[a]	-.182	.613[b]	1	-.500[a]	.681[b]	-.455
Lipid (dyer/Bligh)	-.395	.408	-.575[a]	-.500[a]	1	-.700[b]	.815[b]
Lipid (soxhlet)	.402	.232	.624[b]	.681[b]	-.700[b]	1	-.471[a]
Protein (kjedahl)	-.379	.537[a]	-.465	-.455	.815[b]	-.471[a]	1

A correlation study was done using SPSS v. 16.0. 1 shows perfect correlation. a shows significant correlation at the 0.05 level (2-tailed). Whereas, b shows significant correlation at the 0.01 level (2-tailed).

Table 4. Proximate composition of *Dagaa*: Comparison of fat analysis by Dyer and Bligh and soxhlet extraction methods (wet weight basis).

Sample ID	Soxhlet (g lipid /100 g fish)	Dyer and Bligh (g lipid /100 g fish)
Homogenous	4.909 ± 0.10	3.11 ± 0.45
Usari	1.77 ± 0.00	4.35 ± 0.57
Nduru	1.82 ± 0.00	7.32 ± 0.59
Dunga	3.40 ± 0.00	3.87 ± 0.19
Paga	2.18 ± 0.32	7.78 ± 0.44
Rota	2.77 ± 0.00	5.47 ± 0.10

Mean values of lipid content of representative samples from the six landing beaches determined by Soxhlet and Dyer Bligh methods. Values are shown as mean ± standard deviation.

difference in amount of lipids in *D*agaa from the different landing sites could be attributed to, water, temperatures, sex, age, season of the year, food availability and salinity of the different geographical locations of the landing sites (El Tay et al., 1998; Stansby, 1981).

Total ash content of *Dagaa* (1.88 - 4.38%) is relatively higher than those of deep-fish species (Suseno et al., 2010) with lower edible portions. This is because *Dagaa* is consumed whole (edible portion is 100%) unlike deep-sea fish species with edible portions of only 5 - 63% (Suseno et al., 2010). The high total ash content in comparison with other fresh water species is as a direct result of inclusion of skeletal muscles in the edible portion that contains calcium and iron in high amounts; 3600 mg/100 g and 10.2 mg/100 g, respectively (Ghelichpour and Shabanpour, 2011 and Owaga et al., 2010).

Conclusion

Fish industry, through *Dagaa* provides a solution to food insecurity. *D*agaa has been shown to be rich in proteins, minerals and lipids therefore a rich and relatively cheap inclusion for human dietary.

Its high nitrogen (protein) content makes it a rich Industrial bio resource for fish protein hydrolysate production for human/animal consumption. The high protein content also makes it viable for inclusion as an ingredient in bacteriological media. The high nitrogen content coupled with high ash content makes it viable for use as a foliar fertilizer and in aquaculture and poultry as feed. Its high lipid content makes it a viable raw material for bio ethanol production.

This information is important in informing industrial processing parameters for optimum yields, development of more efficient methods of preservation to ensure long shelf life and to preserve nutrient content and quality since the high nutrient content is also adequate for micro-organism activity and subsequent spoilage. As well as making informed human dietary consumption choices. The inherent proximate composition variations for all landing sites around the lake should be studied.

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