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Approaches to the effective utilization of *Haplochromis* spp. from Lake Victoria. I. Chemical composition in relation to utilization

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Summary

There are over 150 species of the cichlid genus *Haplochromis* in Lake Victoria constituting a major underexploited food resource. As an aid to the processing of the deepwater stock, chemical composition data were obtained for the whole fish (separated into weight groups) and for the head, viscera, flesh and residual portions separately. Data are reported for lipid content, fatty acid composition, crude protein, true protein, amino acid composition, ash and moisture content.

Introduction

Large stocks of *Haplochromis* spp. (family Cichlidae) are present in many lakes in Africa. In Lake Victoria there are over 150 species of *Haplochromis* forming a species flock and in any commercial catch a large number of species are present. Fish stock assessment studies of Lake Victoria carried out in the early 1970s indicated that *Haplochromis* constituted about 80% by weight of the fish stock with a potential annual yield of about 200000 tonnes. Although the *Haplochromis* stock has since declined in shallow waters, the deepwater stock (below 20 m) is thought to be large enough to permit a much higher *Haplochromis* catch than the present total annual catch of about 50000 tonnes (CIFA, 1982).

In Uganda, the main method of processing *Haplochromis* is sun-drying, although some large fish are sold fresh or hot-smoked. In general, demand for *Haplochromis* is low compared with other commercially exploited fish, such as *Tilapia* spp. and *Bagrus* spp., and this is in part due to the small size of *Haplochromis*—i.e. typically 70–110 mm in length.

Proposed increases in landings of *Haplochromis* in Uganda necessitate the development of alternative methods of preservation and processing as a means of creating demand and extending its consumption to the population in the inland areas (CIFA, 1982; Dhatemwa, Hanson & Knowles, in press). Information about the chemical composition of *Haplochromis*, including distribution of components and variation in chemical composition with fish size and with season, is important in determining the most effective methods for utilizing this resource.

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Materials and methods

Fish samples

Four batches of *Haplochromis* were caught by bottom trawling (depth 25–45 m) from the Kitubulu-Nsazi, Uganda, inshore fishing ground of Lake Victoria during May, October and November 1980, and February 1981. The fish were frozen, packed into insulated boxes and flown to the U.K. They were kept in cold store (−25°C) until analysed. Most of the analytical work was carried out on the February batch.

Grouping and portioning of Haplochromis

Thawed fish were weighed (to the nearest 0.1 g) and the total length (including caudal fin) of each fish was measured (to the nearest mm). The fish were sorted into four weight groups: Group I: 5.9 g and less; Group II: 6.0–8.9 g; Group III: 9.0–13.9 g; and Group IV: 14 g and above. These four weight groups corresponded approximately to total lengths of: 80 mm and less, 81–89, 90–99 and 100 mm and above, respectively.

Analyses were carried out either on the whole fish or on samples taken after dividing the fish into head, viscera, flesh (skinless) and residual portions. The head portion was removed by a single cut immediately behind the pelvic and pectoral fins. Any visceral material cut off with the head portion was removed and included with the viscera.

Representative samples for each weight group were taken after passing the whole fish (fifty to 500 fish depending on the weight group) or the portions (from fifty to 500 fish) several times through a mincer.

Proximate analysis

Lipid content was determined by a modified Bligh and Dyer technique (Hanson & Olley, 1963). Crude protein content (total N×6.25) was determined by the Kjeldahl technique. Ash content was determined to 500°C. Moisture content was determined by drying samples to constant weight at 105±2°C. Analyses were carried out in triplicate.

Fatty acid composition

Lipid was extracted by the modified Bligh and Dyer method using chloroform containing 0.01% BHT and the solvent as evaporated using a rotary evaporator and vacuum pump at room temperature.

Methylation. One hundred to 150 mg of lipid was saponified by adding 2 ml toluene and 4 ml sodium hydroxide in methanol (1.5 : 228 w/v) in a 50 ml round-bottomed flask and refluxing for 30 min. After cooling, 5 ml boron trifluoride/methanol (12–14% w/v) was added and the mixture was refluxed for a further 30 min. The methyl esters were extracted 3 times with 35 ml portions of hexane, dried with anhydrous sodium sulphate and concentrated using a rotary evaporator.

Gas chromatography. Chromatographic analysis was carried out using a 2 m column packed with 10% SP 2330 on Chromosorb WAW 80-100 operated at 155–230°C. The methyl esters were identified by comparison with two standards: 'PUFA I' supplied by Chromatography Services, Hoylake, and GLC Reference Mixture No. 3 (No. 32246) supplied by Chrompack U.K., Ltd. Analyses were carried out in triplicate.

True protein and non-protein nitrogen

True protein was determined by the method outlined by Cutting (1969). Approxi-

mately 2 g of sample was accurately weighed and ground (pestle and mortar) with 10 ml of 15% trichloroacetic acid solution (TCA). The TCA soluble material was recovered by filtration and the solid residue was washed with four 10 ml portions of 15% TCA. The nitrogen content of the residue (true protein nitrogen) was determined by the Kjeldahl technique. Non-protein nitrogen was calculated as the difference between the total nitrogen of the sample and the true protein nitrogen. True protein content was calculated as true protein nitrogen × 6.25. Determinations were carried out in triplicate.

Amino acid composition

The samples were hydrolysed using the standard 6 M hydrochloric acid method. The amino acids were separated and the amounts determined using an LKB amino acid analyser with norleucine as an internal standard.

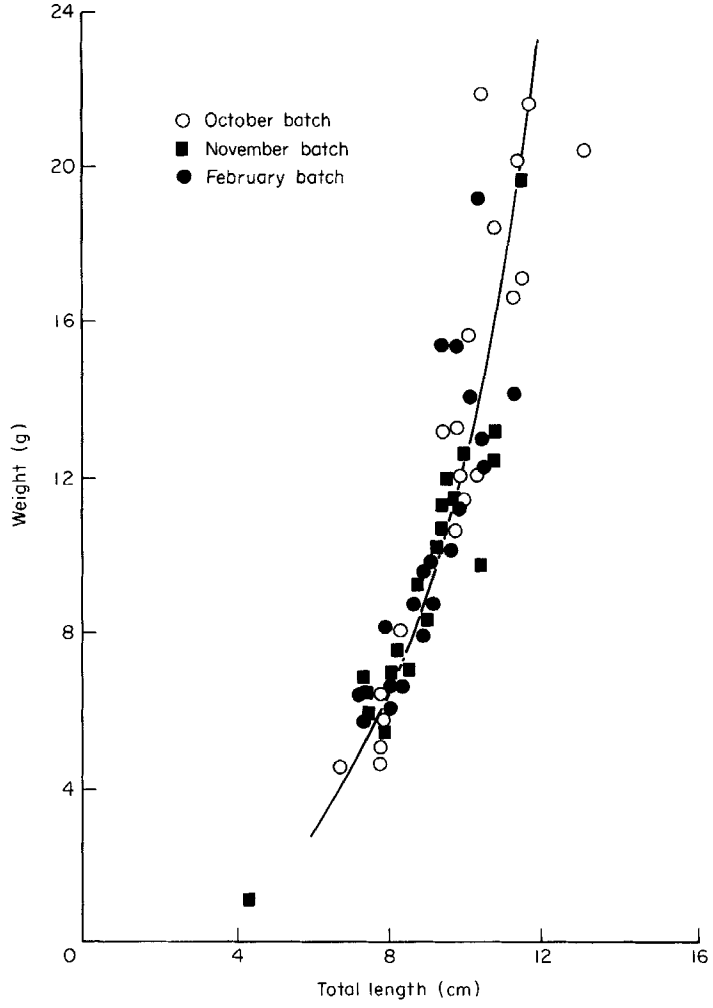

Figure 1. Relationship between weight and total length for *Haplochromis* taken randomly from the October, November and February batches.

Table 1. Weight group distribution and weight composition (February batch)

	Weight group distribution*		Weight composition (% of whole fish)†				
	Number of fish (%)	Weight of fish (%)	Head	Viscera	Flesh	Residue	Flesh + residue
Group I (5.9 g and less)	8.6	4.5	36.2	10.5	—	—	53.3
Group II (6.0–8.9 g)	61.9	50.5	36.7	9.0	28.1	26.2	54.3
Group III (9.0–13.9 g)	19.7	21.7	36.0	10.4	25.4	28.2	53.6
Group IV (14 g and above)	9.8	23.3	36.9	9.6	—	—	53.5

*For a sample of 1000 fish taken randomly from the whole batch.

†For eighty-six fish in Group I, 619 fish in Group II, 197 fish in Group III and ninety-eight fish in Group IV.

Table 2. Proximate analysis data (February batch)*

Sample	Lipid (%)	Crude protein (%)	Ash (%)	Moisture (%)
Whole fish				
Group I	5.0 (0.6)	16.0 (0.9)	5.1 (0.4)	70 (4.0)
Group II	6.0 (0.2)	16.4 (0.3)	5.4 (0.1)	71 (0.4)
Group III	5.7 (0.6)	17.1 (0.7)	5.8 (0.6)	74 (1.7)
Group IV	4.4 (1.1)	16.8 (0.7)	5.1 (1.1)	71 (0.4)
Average†	5.5	16.6	5.4	72
Group II				
Head	8.9 (0.6)	15.0 (0.5)	8.7 (0.1)	69 (0.2)
Viscera	12.7 (0.7)	10.8 (0.4)	1.6 (0.1)	79 (0.4)
Flesh	1.6 (0.8)	19.2 (0.7)	1.1 (0.1)	77 (0.1)
Residue	4.2 (0.3)	17.2 (0.7)	7.6 (0.6)	70 (1.0)

*The percentages are the averages of three determinations; standard deviations are given in parentheses.

†Weighted average calculated using the weight group distribution data in Table 1.

Results and discussion

No attempt was made to divide the batches of *Haplochromis* according to species or groups of species since members of the *Haplochromis* spp. flock are very similar in appearance and cannot easily be distinguished (Greenwood, 1974). However, it was possible to show by gel electrophoresis (Mackie, 1980) that the batches did contain large numbers of species (Ssali, 1981). Rather than analyse according to species, a size parameter was used. Dividing catches according to size before processing could be commercially viable if the chemical composition of the fish varied significantly with size. Weight was chosen as the grouping parameter since it could be measured rapidly and since it correlated well with other size parameters—e.g. length. A plot of weight against length gave a smooth curve typical of those found for single species (Fig. 1).

The smallest fish (5.9 g and less) were placed in Group I. The majority of the fish, present in the relatively narrow weight range of 6.0–8.9 g, were placed in Group II. The remaining fish, which varied widely in weight, were placed in Group III (9.0–13.9 g) and Group IV (14 g and above). The weight group distribution data given in Table 1 for

Table 3. Percentage lipid content and lipid distribution for the February batch (separated into weight groups)

Sample	Group I	Group II	Group III	Group IV
Lipid content (%)				
Head	7.8 (1.1)	8.9 (0.6)	8.1 (1.6)	6.0 (0.8)
Viscera	9.8 (4.2)	12.7 (0.7)	12.7 (1.6)	9.0 (7.4)
Flesh	—	1.6 (0.8)	1.3 (0.1)	—
Residue	—	4.2 (0.3)	4.1 (0.7)	—
Flesh + residue	2.2 (0.4)	2.9 (0.2)	2.7 (0.3)	2.6 (1.5)
Whole fish	5.0 (0.6)	6.0 (0.2)	5.7 (0.6)	4.4 (1.1)
Lipid distribution (%)				
Head	56	55	51	50
Viscera	21	19	23	19
Flesh	—	8	6	—
Residue	—	18	20	—
Flesh + residue	23	26	26	31

*The percentages are the averages of three determinations; standard deviations are given in parentheses.

Table 4. Percentage lipid content and lipid distribution for four batches (not separated into weight groups)

	Lipid content (%)*				Lipid distribution (%)		
Batch	Head	Viscera	Flesh + residue	Whole fish	Head	Viscera	Flesh + residue
May	—	—	—	4.7 (0.6)	—	—	—
October	10.0 (0.5)	16.0 (1.3)	3.3 (0.2)	6.6 (0.2)	55	18	27
November	8.4 (0.5)	13.3 (0.8)	2.9 (0.2)	5.8 (0.2)	54	19	27
February	8.0 (0.5)	11.7 (1.8)	2.8 (0.4)	5.5 (0.3)	53	20	27

*Averages of twelve determinations, i.e. triplicates for each weight group; standard deviations are given in parentheses.

the February batch are typical of those found for the other batches. On average, Group I constituted about 5–10% by weight of each batch, Group II about 50% and Groups III and IV about 20% each.

From the data given in Table 1 for the proportions of head, viscera, flesh and residue, it can be seen that for all four weight groups the head and viscera together represented almost half of the total weight of the fish, and the flesh was less than 30% of the total weight.

Proximate analysis data for the February batch are given in Table 2 for whole fish for the four weight groups, and for head, viscera, flesh and residue for Group II. The data for the four weight groups do not differ significantly ($P > 0.05$) for any of the constituents. The average values for crude protein and moisture (16.6 and 71% respectively) are close to the values (16.0 and 69.9%) reported by Meynell (1979) for chisawasawa, a mixture of *Haplochromis* and *Lethrinops*, from Lake Malawi. The average lipid content (5.5%) is lower than the 8.0% reported by Meynell and 8.7% by Disney (1974) for chisawasawa, but higher than the 3.15% obtained for *Haplochromis* from Lake Victoria (Tanzanian sector) (C.M. Dhatemwa, personal communication). However these lipid results cannot be compared directly because of the different

Table 5. Percentage fatty acid composition (February batch)*

	Whole fish				Group II			
Fatty acids	Group I	Group II†	Group III	Group IV	Head	Viscera	Flesh	Residue
C14:0	5.0	5.2	4.6	3.2	5.9	3.1	3.0	6.0
	(0.2)		(0.1)	(0.1)	(0.3)	(0.1)	(0.4)	(0.3)
C16:0	23.3	22.4	20.8	21.7	21.6	25.8	21.9	21.5
	(0.4)		(0.1)	(0.6)	(0.6)	(0.1)	(0.6)	(0.6)
C18:0	5.1	5.6	5.3	5.4	5.1	5.8	7.9	5.8
	(0.2)		(0.2)	(0.1)	(0.1)	(0.1)	(0.2)	(0.1)
ΣSaturates	33	33	31	30	33	35	33	33
C16:1	16.6	18.9	18.8	17.6	19.9	17.9	12.8	19.6
	(0.2)		(0.5)	(0.2)	(0.1)	(0.5)	(0.1)	(0.4)
C18:1	10.0	12.7	13.1	19.8	10.3	22.4	9.8	11.0
	(0.2)		(0.3)	(0.7)	(0.1)	(0.3)	(0.2)	(0.4)
C20:1	3.9	3.1	2.9	1.4	3.7	1.4	1.7	3.0
	(0.9)		(0.1)	(0.1)	(0.1)	(0.1)	(0)	(0.2)
C24:1	0.8	1.0	0.6	0.5	1.3	0.5	0.8	0.7
	(0.1)		(0.1)	(0.1)	(0.6)	(0)	(0.1)	(0.1)
ΣMonoenes	31	36	35	39	35	42	25	34
C18:2	2.1	2.2	2.4	2.9	2.4	2.0	1.5	2.3
	(0.1)		(0.1)	(0.2)	(0.1)	(0.2)	(0.1)	(0.3)
C20:5	3.9	2.9	3.4	1.7	3.1	1.8	3.2	3.1
	(0.1)		(0.1)	(0.1)	(0.4)	(0.1)	(0)	(0.2)
C22:5	4.0	3.3	4.0	2.4	3.7	2.1	3.5	3.4
	(0.1)		(0.3)	(0.3)	(0.1)	(0.1)	(0.1)	(0.1)
C22:6	9.1	5.6	6.8	6.0	5.2	3.6	11.4	6.3
	(0.3)		(0.2)	(0.4)	(0.5)	(0)	(0.3)	(0)
ΣPolyenes	19	14	17	13	14	10	20	15
C20:4/C22:1‡	3.6	2.5	3.4	2.6	2.8	2.2	5.2	3.2
	(0)		(0.1)	(0.1)	(0)	(0)	(0.1)	(0.1)
Unidentified GC peaks	6.2	7.0	6.1	7.9	6.3	5.9	10.1	8.9

*The percentages are averages of three determinations; standard deviations are given in parentheses.
†Calculated from the data obtained for the head, viscera, flesh and residue.
‡Overlapping GC peaks.

species and fishing grounds involved and because the lipid content of *Haplochromis* appears to show some seasonal variation, as mentioned below.

The low lipid levels in the flesh, and relatively high levels in the head and viscera, were confirmed by the lipid content and distribution data given in Table 3 for the different weight groups (February batch) and in Table 4 averaged over the four weight groups for the different batches. For all four weight groups, 50% or more of the lipid was found in the head with an average for the batch of 53%. Similar results were obtained for the October and November batches. The uneven distribution of lipid within the fish has important processing implications, as discussed below. The lipid content of the whole fish showed a variation between batches of only about 2%, with the highest value being obtained for the October batch (6.6%) and lowest value for the May batch (4.7%).

The fatty acid composition of the whole fish lipid (Table 5) did not vary significantly

Table 6. Crude protein, true protein and non-protein nitrogen content (February batch)

Sample	Crude protein* (%)	True protein* (%)	Non-protein nitrogen† (%)	Non-protein nitrogen† % of total N
Whole fish				
Group I	16.0 (0.9)	13.5 (0.3)	0.40	16
Group II	16.4 (0.3)	13.9 (0.7)	0.40	15
Group III	17.1 (0.7)	13.5 (1.1)	0.58	21
Group IV	16.8 (0.7)	13.3 (1.6)	0.56	21
Average‡	16.6 (0.3)	13.7 (0.6)	0.46	17
Group II				
Head	15.0 (0.5)	12.6 (0.4)	0.38	16
Viscera	10.8 (0.4)	6.9 (0.8)	0.62	36
Flesh	19.2 (0.7)	16.8 (0.7)	0.38	13
Residue	17.2 (0.7)	14.8 (1.7)	0.38	14

*The percentages are the means of three determinations; standard deviations are given in parentheses.

†Calculated from the crude protein and true protein analytical data.

‡Weighted average calculated using the weight group distribution data in Table 1.

between weight groups. For Group II, the flesh was found to contain a higher proportion of polyenes and lower of monoenes than the whole fish, presumably reflecting the higher unsaturation normally found in phospholipid in fish compared with triglyceride (Ackman, 1974). The fatty acid composition of the whole fish lipid does not differ appreciably from those of commercial fish oils (Windsor & Barlow, 1981).

Table 7. Amino acid composition, g amino acid/100 g crude protein (February batch)*

Amino acid	Whole fish		Group II	
	Group II	Group IV	Head + viscera	Flesh + residue
Aspartic acid	9.6	8.6	9.1	9.9
Threonine	4.4	4.1	4.1	4.7
Serine	4.5	4.0	4.6	4.5
Glutamic acid	15.1	14.6	13.0	16.4
Proline	5.1	4.9	5.6	4.8
Glycine	8.9	8.2	10.5	7.9
Alanine	7.5	7.7	7.3	7.7
Valine	4.6	4.1	4.5	4.7
Methionine	2.8	2.6	2.5	3.0
Isoleucine	4.2	3.9	3.6	4.6
Leucine	7.3	6.8	6.4	7.9
Tyrosine	3.3	2.9	3.2	3.3
Phenylalanine	4.0	3.8	3.9	4.1
Histidine	2.1	2.0	2.0	2.3
Lysine	7.6	7.4	6.7	8.2
Arginine	6.9	5.9	6.8	7.0

* Duplicate determinations did not differ for any of the amino acids by more than ±5%.

Table 8. Weight composition and distribution of selected components in Group II fish (February batch)

	Head	Viscera	Head + viscera	Flesh	Residue	Flesh + residue
Weight composition (%)	36.7	9.0	45.7	28.1	26.2	54.3
Component distribution (%)						
Crude protein	34	6	40	33	28	61
True protein	33	4.5	37.5	34	28	62
Lysine	—	—	35	—	—	65
Lipid	55	19	74	8	18	26
Ash	57	2.5	59.5	5.5	35	40.5

The crude protein, true protein and non-protein nitrogen content did not differ significantly between weight groups (Table 6). The average whole fish crude protein content of 16.6% is around the middle of the range of values obtained for whole fish (Meinke, 1974; Windsor & Barlow, 1981). For the Group II fish, the viscera had the highest non-protein nitrogen content and lowest protein content, presumably as a result of protein breakdown by digestive enzymes. The residue contained almost as much protein as the flesh and a similar proportion of non-protein nitrogen. The non-protein nitrogen content of the flesh is within the typical range for teleost fish (Simidu, 1961).

The amino acid composition of the Groups II and IV whole fish (Table 7) did not differ significantly, although slightly lower values were obtained for Group IV reflecting the lower true protein content of that sample. The higher lysine and methionine content of the flesh and residue fraction compared with the head and viscera fraction is due to the high myofibrillar and low connective tissue content of the flesh. This was apparent from analysis of the flesh alone, which gave higher values for lysine and methionine (9.8 and 3.2 g/100 g of crude protein) and lower values for the major constituent amino acids of collagen, proline and glycine (3.2 and 4.9 g/100 g of crude protein).

The uneven distribution of lipid and protein in *Haplochromis* is of importance with regard to processing. For example, for Group II fish (Table 8) removing the head and viscera results in the remaining material (about 54% by weight) having only 26% of the total lipid content of the whole fish, but over 60% of the protein and an even higher proportion of the total lysine content. The lipid-rich head and viscera fraction would be suitable for industrial processing—e.g. oil extraction. The flesh and residue farction, with a relatively low lipid and high protein content, would be more suitable than the whole fish for processing into human food products in which rancidity development could be a problem.

Conclusion

The analytical data obtained in this study on deepwater species of *Haplochromis* from Lake Victoria indicate that: (i) the chemical composition of the fish does not vary significantly with fish size, (ii) the average lipid content of the whole fish is about 5.5% and appears to vary little with season, and (iii) over 70% of the lipid content of the fish is present in the head and viscera.

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