83

Digestible protein sparing effects of digestible lipids in *Clarias gariepinus*

Orire, A. M.

Abstract

A digestibility trial was carried out on Clarias gariepinus fingerlings 2.25 ±0.05g for 4 weeks. The results indicated significant difference (P<0.05) between the gross and digestible diets as out of 20% lipid/protein fed only 17.75 was digestible. It was this quantity that apparently spared 22.58 % out of 30% protein fed for growth. The groundnut oil based diets also showed significant difference (P<0.05) between the gross nutrients fed and actual digestible. From the result only 16.80/25.22 % out of 20/ 30 % dietary groundnut oil and dietary protein fed respectively. The palm oil based diets also exhibited similar trend protein/lipid ratio 15/35 only 12.87/29.52 dietary palm oil and dietary protein respectively was digestible. However, there was no significant difference (P>0.05) in the digestible groundnut oil and palm oil. Therefore, the digestible lipids in this study were significantly lower than the gross diets fed.

Keywords: Protein/lipid ratio, gross nutrient, C. gariepinus, palm oil.

Introduction

Some combination of n-3 and/or n-6 fatty acids are required in the diets of all animals including important cultured fish and shrimp or prawn (Watanabe, 1982; Sargent et al., 1990). Linoleic acid (18:2n-6) is an important essential fatty acid (EFA) for mammals and is converted in vivo to the physiologically more active arachidonic acid (20:4n-6) (Lands, 1986). However, recent studies on the nutritional requirements of marine fish and shrimp have shown that fatty acids of the n-3 family have greater EFA value for these species than fatty acids of the n-6 family (Castell, 1981; Watanabe, 1982; Xu et al., 1993). Digestibility of lipids ranges from 85 to 95% in most fish species (NRC, 1993). For carp these values oscillate between 83 and 90% (Kirchgessner et al., 1986), between 64 and 94% for channel catfish (Andrews et al., 1978), and around 93% for tilapia (*O. niloticus*) (Hanley, 1987). Generally, most fish digest protein and fats well, and the energy in them is available to the fish.

Materials and Methods

- **Experimental system.** All experiments were carried out in a recycling water system in the Laboratory of the Department of Water Resources, Aquaculture and Fisheries Technology of School of Agriculture and Agricultural Technology, Federal University of Technology, Minna. The system consisted of 32 cylindrical self cleaning centrally drained tank units (with lids) of 50-Litres capacity. Water was supplied to each tank at a rate of 1-L min-1 from a 500-L header tank. Water drained from the tanks through central standpipes into a series of bio-filtration tanks. The water was then pumped up to a 500-L header tank where it is released by gravitational force into the tanks. About thirty percent of the water in the system was replaced biweekly with freshwater to maintain water quality.
- **Experimental fish.** Six-week old fingerlings of mean weight 2.25 ±0.05g of *C. gariepinus* was obtained from the hatchery unit of Jumik Farm Kaduna, Kaduna State. Completely randomized design was used in the experiment, where treatments were of one variable; ingredient incorporated being the variable. The fishes and treatments were randomly assigned to tanks in triplicate. The fishes were randomly assigned into groups of 15 fishes and each group was placed in an individual 50-L tank
- **Experimental diets.** Nine experimental diets and one commercial reference diet [(CRD)—Copens catfish feed from Netherland)] were used for the feeding trial. The experimental diets were formulated using equational method

of two unknowns. The diets were formulated to contain three levels of protein (P) and lipids (L) ratios (40P: 10L, 35P: 15L and 30P: 20L %), using three lipid sources; Fish oil, palm oil and groundnut oil. Freshwater fish oil was obtained from Fakun village in New Bussa, Niger State, palm oil procured from Bosso market in Minna, while the groundnut oil was obtained from a groundnut oil processor in Minna. Fishmeal of Danish origin was used as the protein source and was obtained from Makolo fishfeed store in Minna. The prepared diets were kept in a refrigerator for preservation. The formulated diets and the proximate analyses of the diets are shown in Table 4.1.2

- **Experimental practices.** Digestibility trial was carried out for 8 weeks. The feacal matter was siphoned once daily as described in section 3.4.4. The fecal matter was weighed fresh before kept in oven at 60°C for 24 hours. The dried fecal matter was kept in a polyethylene bag to be preserved in a refrigerator (4°C) for apparent digestibility coefficient analysis.

Digestibility Analysis

- **Acid-insoluble Ash (AIA).** The acid-insoluble ash of the diets and fecal samples were determined according to Cockrell et al. (1987). Fish within each group were pooled for carcass analysis. All samples were analyzed in triplicate. The diet and the fecal samples were ashed at 600°C for 6 hours. After which they were boiled with 250 ml 10% hydrochloric acid (Hcl) for 5-10 minutes. The solution was filtered through ashless filter paper and thoroughly washed with hot water. The filter paper including the residue on the filter paper were then put into a dry crucible and placed in a muffle furnace at 600°C for 2 hours. The resulting acid insoluble ash were cooled and weighed.

$$\%\ Acid\text{-}insoluble\ ash = \frac{Weight\ of\ acid - Insoluble\ ash}{Weight\ of\ sample\ taken} x \frac{100}{1}$$

This was conducted as described in sections 3.6.1.7 and 3.9.

- **Apparent digestibility coefficient (%) and Derived digestible protein sparing effects of digestible lipids.** The apparent digestibility coefficient (ADC) of diets was evaluated according to Maynard et al. (1979) and Bondi (1987) as follows using acid-insoluble ash (AIA) as internal indicator as reported by Church and Pond (1988).

$$\left[\%\ ADC = 100 - \frac{100x\ \%\ AIA\ in\ dietsx\ \%\ Nutrients\ in\ \ feces}{\%AIA\ infeces\ x\ \%\ nutrient\ \ in\ \ diets}\right]$$

Derived Digestibility Percentage

$$Derived\ \ digestibility\ for\ lipids = ADC\,(\%)\,Lipids\ X \frac{Crude\ Lipid\ fed}{100}$$

$$Derived\ \ digestibility\ for\ protein = ADC\,(\%)\,Lipids\ X \frac{Crude\ Protein\ fed}{100}$$

Statistical Analysis

Results of carcass composition, the evaluation of biological parameters, and all other data obtained were subjected to one way analysis of variance (ANOVA) using Turkey's test (Steel and Torrie, 1980) at 5% probability level. Multiple parameter means comparison of treatments was according to Duncan multiple range tests (Duncan, 1955). All statistics analyses including regression were executed using the software Minitab Release 14 and graphical analyses were plotted with Excel 2007.

Table 1: Diets formulated and their proximate compositions.

	Fish oil-based diets Lipid/Protein ratios			Groundnut oil-based diets Lipid/Protein ratios			Palm oil-based diets Lipid/Protein ratios			
Feedstuffs	10 L: 40P	15L:35P	20L:30P	10 L: 40P	15L:35P	20L:30P	10 L: 40P	15L:35P	20L:30P	CRD
Fishmeal	40.73	29.70	16.95	40.73	29.7	16.95	0.73	29.70	16.95	
Fish oil	54.27	65.31	78.05	0.00	0.00	0.00	0.0	0.00	0.00	
G/Nut oil	0.00	0.00	0.00	54.27	65.31	78.05	0.00	0.00	0.00	
Palm oil	0.00	0.00	0.00	0.00	0.00	0.00	54.27	65.31	78.05	
V/Mineral	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	
Total	100	100.01	101	100	100.01	100	100	100.01	100	
Proximate										
Crude protein	39.45	34.28	29.65	41.35	34.35	29.76	39.8	34.64	29.56	44.89
Crude fat	11.26	15.22	20.29	10.61	16.39	18.99	10.11	16.96	19.78	11.88

Feedstuffs	Fish oil-based diets Lipid/Protein ratios			Groundnut oil-based diets Lipid/Protein ratios			Palm oil-based diets Lipid/Protein ratios			
	10 L: 40P	15L:35P	20L:30P	10 L: 40P	15L:35P	20L:30P	10 L: 40P	15L:35P	20L:30P	CRD
Crude fibre	8.51	5.42	4.81	8.60	6.76	5.32	8.71	7.65	6.43	5.62
Ash	18.25	17.96	16.37	17.23	15.32	14.10	19.30	8.23	16.21	10.12
NFE	21.41	15.58	26.10	21.17	23.89	28.90	20.76	29.98	26.79	18.26
Moisture	1.12	1.54	2.78	1.04	3.29	2.61	1.32	2.54	1.23	9.23
Total	99.69	100	100	99.8	100	100	100	100	99.61	100

Result

Derived digestible lipids and protein. The apparent digestibility coefficient percentage (ADC %) values shown in Table 4.5.1 was used to derive the digestible lipids and digestible protein shown in Table 4.3. Table 1 shows the derived digestible protein (DP) sparing effects of derived digestible lipids (DL) which out of the gross L/P ratio of 10:40 fed to *C. gariepinus*, only 4.04:30.82 was digestible; at 15:35 L/P ratio, only 12.77:25.92 was digestible while at 20:30, only 7.75:22.58 was digestible. For the groundnut oil based diets, from the gross diets of 10:40 fed, only 6.25:30.94 was digestible, at 15:35, 10.94:24.12 was digestible while at 20:30, only 16.80:31.09 was digestible. As for the palm oil based diets, there was disparity in the gross and digestible diets fed. At 10:40, only 8.20:31.09 was digestible, at 15:35, 12. 87: 29.52 while at 20:30, only 15.21:22.18 was digestible in *C. gariepinus*. The expectation was that these derived digestible protein and lipids gave the growth response observed under the gross values (Table 2)

Table 1: Apparent digestibility coefficient (ADC %) of nutrients in *C. gariepinus* diets.

ADC (%)	Fish oil			Groundnut oil			Palm oil			
	10L:40P	15L:35P	20L:30P	10L:40P	15L:35P	20L:30P	10L:40P	15L:35P	20L:30P	CRD
Crude protein	77.04^{c} ±0.01	74.07^{f} ±0.01	75.25^{d} ±0.01	77.36^{c} ±0.01	68.91^{de} ±0.01	84.05^{b} ±0.01	77.72^{c} ±0.01	84.34^{b} ±0.01	73.93^{e} ±0.01	85.52^{a} ±0.01
Lipid	80.38^{f} ±0.01	85.11^{a} ±0.01	88.75^{f} ±0.01	62.45^{e} ±0.01	72.91^{d} ±0.01	84.02^{b} ±0.01	81.99^{a} ±0.01	85.80^{a} ±0.01	76.07^{c} ±0.01	78.54^{b} ±0.01
Ash	17.60^{ef} ±0.01	18.13^{b} ±0.01	11.35^{e} ±0.01	10.57^{d} ±0.01	12.73^{d} ±0.01	11.82^{c} ±0.01	14.62^{f} ±0.01	13.98^{c} ±0.01	12.23^{a} ±0.01	15.23^{c} ±0.01
NFE	8.33^{c} ±0.01	6.50^{d} ±0.01	4.00^{e} ±0.01	3.33^{f} ±0.01	7.00^{d} ±0.01	6.67^{d} ±0.01	6.50^{c} ±0.01	11.67^{a} ±0.01	10.01^{b} ±0.01	4.32^{e} ±0.01
DM	8.29^{f} ±0.01	36.84^{b} ±0.01	12.87^{e} ±0.01	16.39^{d} ±0.01	46.06^{a} ±0.01	31.31^{c} ±0.01	19.80^{c} ±0.01	17.50^{d} ±0.01	16.55^{d} ±0.01	30.54^{c} ±0.01

Means on the same row carrying letter (s) with different superscript (s) are significantly different from each other ($p<0.05$).

Table 2: Digestible protein sparing effects of digestible lipids in *C. gariepinus*.

Parameters	Fish			Groundnut oil			Palm oil			CRD	SD ±
	10L:40P	15L:35P	20L:30P	10L:40P	15L:35P	20L:30P	10L:40P	15L:35P	20L:30P		
	DL 12.77: DP 30.82	DL17.75: DP 25.92	DL 8.04: DP 22.58	DL 6.25 : DP 30.94	DL 10.94: DP 24.12	DL16.80: DP 25.22	DL 8.20: DP 31.09	DL 12.87: DP 29.52	L15.21: DP 22.18		
Mean initial carcass weight (g)	2.58^{a} ±0.26	2.52^{a} ±0.26	2.54^{a} ±0.33	2.57^{a} ±0.24	2.52^{a} ±0.53	2.51^{a} ±0.21	2.52^{a} ±0.42	2.54^{a} ±0.20	2.37^{a} ±0.42	2.27^{b} ±0.07	0.30
Mean final carcass weight (g)	3.85^{c} ±0.68	3.04^{bc} ±0.78	2.73^{bc} ±0.42	2.66^{bc} ±0.30	2.76^{bc} ±0.25	8.08^{a} ±8.72	5.19^{b} ±2.10	8.08^{a} ±7.91	2.73^{bc} ±0.80	2.99^{bc} ±0.41	3.81
Mean weight gain (g)	1.27^{c} ±0.93	0.52^{d} ±0.54	0.19^{cd} ±0.10	0.90^{d} ±0.06	0.23^{cd} ±0.35	5.57^{a} ±8.56	2.68^{b} ±2.43	5.53^{a} ±7.94	0.36^{cd} ±0.61	0.72^{d} ±0.48	3.80
SGR (%/day)	0.72^{c} ±0.48	0.34^{bc} ±0.52	0.15^{b} ±0.06	0.06^{b} ±0.04	0.13^{bc} ±0.05	2.09^{a} ±1.73	1.29^{ac} ±0.91	2.07^{a} ±1.68	0.25^{bc} ±0.03	0.49^{bc} ±0.29	0.90
FCR	1.21^{d} ±0.45	2.97^{c} ±1.78	3.64^{b} ±1.01	6.56^{a} ±0.00	4.61^{b} ±1.06	2.85^{c} ±2.27	1.00^{d} ±0.71	1.29^{d} ±1.16	2.45^{c} ±0.49	4.24^{b} ±2.72	1.58
PER	3.62^{c} ±1.26	2.37^{d} ±1.31	2.17^{d} ±3.21	0.32^{f} ±0.02	0.85^{e} ±0.19	5.52^{b} ±8.48	5.05^{b} ±4.58	8.78^{a} ±12.61	1.40^{de} ±0.28	0.61^{e} ±0.41	5.43
ANPU(%)	73.83^{a} ±0.01	9.17^{f} ±0.01	16.15^{e} ±0.01	17.75^{b} ±0.01	44.02^{c} ±0.00	44.02^{c} ±0.1	25.00d^{d} ±0.01	63.33^{b} ±0.01	15.73^{e} ±0.58	64.34^{b} ±0.05	0.18
Survival (%)	66.67^{b} ±20.82	73.33^{ab} ±5.77	80.00^{a} ±17.32	76.67^{ab} ±11.55	73.33^{ab} ±11.55	56.67^{c} ±40.41	40.00^{e} ±30.00	43.33^{d} ±28.87	10.00^{f} ±0.00	76.67^{a} ±5.77	21.06

Means on the same row carrying letter(s) with different superscript(s) are significantly different from each other ($P<0.05$). Key: DL=Digestible lipid, DP=Digestible protein.

Discussion

The digestible lipids and protein showed variation between the gross diets fed and the actual digestible diets. Of the 20% ...il fed only 17.75% was found digestible. This apparently was the amount that spared 22.58 % out of 30% protein fed ...growth. The trend showed great difference between the gross diets fed and the amount available for digestion. The result ...owed that the fish could not utilize total nutrients fed. The groundnut oil based diets also showed disparity between the gross ...ients fed and actual digestible. From the result only 16.80 % and 25.22 % out of 20 % and 30 % dietary groundnut oil and ...ary protein fed respectively. The palm oil based diets also exhibited similar trend. The palm oil based diets spared protein ...0:35 L/P ratio but from this quantity fed, 12.87:29.52 dietary palm oil and dietary protein respectively was digestible. The ...estible lipids in groundnut oil and palm oil did not affect the digestible protein levels in the diets which is agreement with ...findings of other studies in other species (Lorico–Querijero and Chiu, 1989) and *C. gariepinus* (Machiels and Henkel, ...; Appleford and Anderson, 1997). Therefore, the digestible lipids in this study were significantly lower than the gross ...ets fed. Therefore, feeding at digestible levels would further reduce waste of resources.

Conclusion

There was a significant difference between the gross diets fed and actual nutrient digested. It is the digestible nutrients that ...ually resulted in muscle development, therefore, feeding the digestible component of the diet will be used directly by the ...mal for metabolic development.

REFERENCES

Appleford, P. and Anderson, T. A. (1997). Apparent digestibility of tuna oil for common carp (*Cyprinus carpio*): Effect of inclusion level and adaptation time. *Aquaculture*, 148, 143–151.

Bondi, A. A. (1987). *Animal Nutrition*. New York: John Wiley & Sons. 504pp.

Castell, J. D and Tiews, K. (1980). Standardization of methodology in fish nutrition research, Hamburg, Germany, March 21–23, 1979. EIFAC Technical Paper 36:24.

Church, D. C. and Pond, W. G. (1988). *Basic Animal Nutrition and Feeding*, 3rd edition. 572pp.

Cockrel, L, Halliday, D. Morgan, D. J. (1987). Studies on the nutrition of marine flourish: Utilization of various dietary proteins by plaice (*Pleuronectes platessa*). *British Journal of Nutrition* 31, 297–306.

Duncan, D. B. (1955). Multiple range and multiple F-Test. *Biometrics* 11:1–42.

Hanley, F. (1991). Effects of feeding supplementary diets containing varying levels of lipid on growth, food conversion, carcass composition of Nile tilapia, *O. niloticus Aquaculture*, 93, 323–334.

Lorico–Querijero, B. V. and Chiu, Y. N. (1989). Protein digestibility studies on *O. niloticus* using chromic oxide indicator. *Asian Fisheries Science*, 2/2: 177–191.

Machiels, M. A. M. & Henken, A. M. (1985). Growth rate, feed utilization and energy metabolism of the African catfish, as affected by dietary protein and energy content. *Aquaculture*, 44: 271–284.

Maynard, L. A., Loosli, J. K., Hintz, H. F. and Waener, R. G. (1979) *Animal Nutrition*. 7th ed. New York: McGraw–Hill, 620.

Kirchgessener, M., Hurzinger, H. and Schwartz, F. J. (1986). Digestibility of crude nutrients in different feeds and estimation of their energy content for carp (*Cyprinus carpio*), *Aquaculture* 58:185–194.

Lands, W. E. M. (1986). *Fish and Human Health*. Academic Press, New York. 170pp.

Watanabe, T. (1982). Lipid nutrition in fish. *Comparative Biochemistry and Physiology*. 73B: 3–15.

Xu, X. L., Ji, W. J., Castell, J. D. and O'Dor, R. K. (19903). The nutritional value of dietary n-3 and n-6 fatty acids for Chinese prawn (*Panaeus chinensis*). *Aquaculture*, 118: 277–285.