

A Preliminary Investigation Into the Use of Edible Fishery By-products as Sources of Nutrients for Fish and Livestock Feeds on Zanzibar, Tanzania

J.M. Akil¹, M.J. Bryant², N.S. Jiddawi³

¹Ministry of Agriculture, Natural resources, Environment and Cooperatives, P.O. Box 159, Zanzibar, Tanzania; ²Department of Agriculture, School of Agriculture, Policy and Development, The University of Reading, P.O. Box 237, Reading RG6 6AR, UK; ³Institute of Marine Sciences – University of Dar es Salaam, P.O. Box 668, Zanzibar Tanzania

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Abstract—A survey, to measure the quantity of edible fish waste (gills and guts) available per year, was conducted on Unguja Island, Zanzibar between December 2003 and February 2004. Seventeen samples from commercially important fish genera and species were collected from five landing sites ('dikos') in five districts of the Island, dissected and the amount of wastes quantified as percentage of individual body weights. Reliable data on annual catches (tonnage) of the selected species or genera were used to extrapolate total amounts of fish waste produced. Separate samples (gills and guts) were isolated and treated as (1) boiled and sun dried and (2) sun dried without boiling; and analyzed to determine fat (EE g/100gDM), mineral (ash g/100gDM) and protein (CPg/100gDM). In addition, bulky fish wastes (mixed gills+guts) were collected from the same sites, boiled, sun dried and stored for further feeding trials and duplicate samples analyzed. Results show percentage fish waste (%Ww) between individual genera and species varied significantly (10.47 ± 0.93 ; $P < 0.001$). Average annual fish waste produced is 2.040t out of total 1.84, 1.81, 1.79 and 2.72 thousand tonnes from the years 2001, 2002, 2003 and 2004 catches respectively. The body parts of fish significantly determined fat and mineral composition (LSM for gills = 10.85 ± 1.486 g/100gDM EE vs. guts = 15.45 ± 1.486 g/100gDM EE; $P = 0.033$ and LSM for gills = 23.49 ± 1.494 g/100gDM mineral vs. guts = 14.27 ± 1.494 g/100gDM Ash; $P < 0.001$), while treatment (boiling at 95 - 105°C) had no effect on both fat, protein and mineral. Significant variation in overall protein content between species (LSM = 57.68 ± 2.33 ; $P < 0.001$) is observed. Slight dispersions between sites for mineral (LSM = 29.1 ± 2.01 g/100gDM) and fat (LSM = 13.93 ± 1.05 g/100g DM) showed up in bulky wastes. It was concluded that valuable quantity of fish waste is available to reduce the limiting protein supplementation problem in both livestock and fish farming in the western Indian Ocean region. However, additional on-station and on-farm studies are required to measure the intakes and effects of the supplement on milk yields and growth performances.

INTRODUCTION

The high costs and seasonal inadequacy of feeds are collectively the most limiting factors in the performance of the livestock industry in developing countries (Makkar, 2000) and indeed, in both

semi-intensive and intensive aquaculture (Lim *et al.*, 1997).

Diverse methods used to preserve fish waste to be used in animal feeding systems are widely practiced. These may include cooking fish and pressing the cooked mass to remove most of the

oil and water (McDonald *et al.*, 2002) or preserving the by-catch (scrap, heads and offal) in the form of silage (Smith, 1977). However, despite the high demand for protein and other nutrients for livestock and aquaculture, little work has been done on the use of the by-product on the Zanzibar islands.

Reported here are the results of a preliminary survey conducted on Zanzibar between December 2003 and February 2004, aimed at the quantification of the annual edible fish waste (gills and guts) produced and the determination of their macronutrient contents; protein, fat and ash. The long-term objective of the study was to create opportunity for the development of new feeding packages for livestock keepers and aqua-culturists in the WIO region; a particular emphasis being widening the use of fish waste as an important animal feed resource in the area.

Further to this survey, other on-station and on-farm studies are being conducted to measure the intake, digestibility, nitrogen balance and production performance in dairy cows. Discussions to extend the use of the fish waste in the fish diets at Makoba fish farm in Zanzibar are underway.

METHODOLOGY

Sample collection sites

Sample collection was done in five landing sites “dikos” of the island of Unguja, Zanzibar - namely from: Kizimkazi, Mazizini, Malindi, Chwaka and Mkokotoni (Figure 1) between December 2003 and February 2004.

Measurement of the annual available fish waste

- Fish dissection and calculation of percentage wastes per species:

Each of the 17 commercially important fish species or genera on the islands was dissected and weighed to obtain the total body weights (Tw) and the corresponding edible wastes (Ww) (gills+guts). The percentage fish wastes were calculated as follows:

$$(\%Wsp1) = \frac{Ww1}{Tw1} \times 100$$

Where:

%Wsp1 = Percentage waste from species 1
Ww1 = Weight of fish wastes from species 1
Tw1 = Total weight of fish (species 1)

- Extrapolation of the annual fish waste harvests based on the total annual catches (kg) of each of the 17 species, was as follows:

$$\%Wsp1 \times Tc1$$

Where:

Tc1 = Total catches (kg) of specie 1 per year

- Calculation of the total wastes produced per year, was based on:

$$\sum Ww1 + Ww2 \dots\dots\dots Wwn$$

Chemical composition of the edible fish wastes

- Separation of samples from body parts (gills and guts) of the selected fish species and genera were treated as follows:

- Un-boiled + Sun dried
- Pre-boiled (at 95 – 105°C for 10 – 15 minutes) + Sun dried

- Random sampling of the pre-boiled (at 95 – 105°C) and sun-dried bulk fish waste (gills+guts) from selected areas “dikos” in five Districts of Unguja Island.
- Laboratory analysis on samples for dry matter (DM), crude protein (CP), fat (EE) and mineral content (as described by Pilgrim, 1999; Pearson, 1976; and ATA Website respectively).

Statistical analysis

The raw data from the fish waste yield and chemical composition were entered and stored in Microsoft Excel for Windows® XP Professional which provided computation facility required before imported to statistical software for analysis.



Fig. 1. Locations of sample collection sites and Zanzibar along the Tanzania coast

Independent factors; body part and treatment were used to investigate variability of the chemical composition between the samples. The analysis of variance was used to analyse the data according to the General Linear Model procedure of the Minitab Statistical Package (Release 14, 2005).

RESULTS

Percentage wastes produced from individual fish species

The percentages of fish waste yields (%Ww) of the identified species varied significantly (10.47 ± 0.93 ; $P < 0.001$) from the least (3.82) to the highest (17.69) species (Table 1).

Table 1. Percentage fish waste yields from individual species

	Fish species (with local names)	Av. Waste yields (%)	Av. Gills: Guts ratio (kg)
1	<i>Gerres spp.</i> ('chaa')	10.23	1:1.6
2	<i>Nemipterus spp.</i> ('koana')	10.77	1:2.1
3	<i>Lutjanus fulviflamus</i>	10.03	1:2.6
4	<i>Lethrinus spp.</i>	9.67	1:1.8
5	<i>Lutjanus argentimaculatus</i>	15.92	1:4.3
6	<i>Epinephelus chlorostigma</i>	10.25	1:2
7	<i>Sphyraena spp</i>	11.97	1:4.1
8	<i>Auxis tapeinosoma</i>	17.69	1:2.1
9	<i>Scomberomorus commerson</i>	5.84	1:2.1
10	<i>Carangoides spp.</i> ('kolekole')	14.06	1:2.6
11	<i>Upeneus sulphurous</i>	8.08	1:1.8
12	<i>Hipposcarus spp.</i>	3.82	1:1.8
13	<i>Rastrelliger kanagurta</i>	12.05	1:1.6
14	<i>Stolephorus spp.</i> ('saadini')	9.09	1:2.6
15	<i>Sardinella spp.</i>	8.07	1:2.8
16	<i>Caesio caeralataureus</i>	5.06	1:1.6
17	<i>Siganus spp.</i>	15.42	1:8.2
18	Other demersal/pelagic spp.	9.66	-

Annual fish waste yields

Four years of catch data records (2001 – 2004) show an average annual catch of 22,773.6t corresponding to 2,040.1t of the fish waste produced. However, in the most recent year (2004), a sharp increase of approximately 6,503t and 676t above average of

the fish catch and fish waste yield respectively were observed (Figure 2).

Chemical composition of the body parts

The body part of the fish (gills or guts) is a significantly determining factor for mineral, as shown in Table 2, (gill = 23.49 ± 1.494 , gut = 14.27 ± 1.494 ; $P < 0.001$) and fat (gill = 10.85 ± 1.486 , gut = 15.45 ± 1.486 ; $P < 0.05$) composition (g/100g DM) in fish. Treatment (boiling) had no influence on the amount of protein, fat and mineral contained in the sample.

Table 2. Least Square Mean for body parts and treatment

		CP(g/ 100g DM)	EE(g/ 100g DM)	Mineral g/100g DM)
Body part	Gills	57.42	10.85	23.49
	Guts	59.84	15.45	14.27
	SEM	2.039	1.486	1.494
	P-Value	0.404	0.033	<0.001
Treatment (boiling)	Boiling	59.65	12.85	17.90
	No boiling	57.62	13.45	19.86
	SEM	2.039	1.486	1.494
	P-Value	0.484	0.778	0.357

CP = Crude Protein, DM = Dry Matter, EE = Ether Extracts

Species variation in overall protein content

An overall protein content (g/100g DM) of the identified species varied significantly (57.68 ± 2.33 ; $P < 0.001$), with the lowest and highest levels being CP 37.52 and 70.98g/100g DM respectively (Figure 3).

Chemical composition of the bulky fish wastes from five landing sites of Zanzibar

There are no significant variations between five collection sites in terms of protein (Table 3), although a slight dispersion from means is observed in ash (29.1 ± 2.01) and fat (13.93 ± 1.05) content (g/100g DM) of fish.

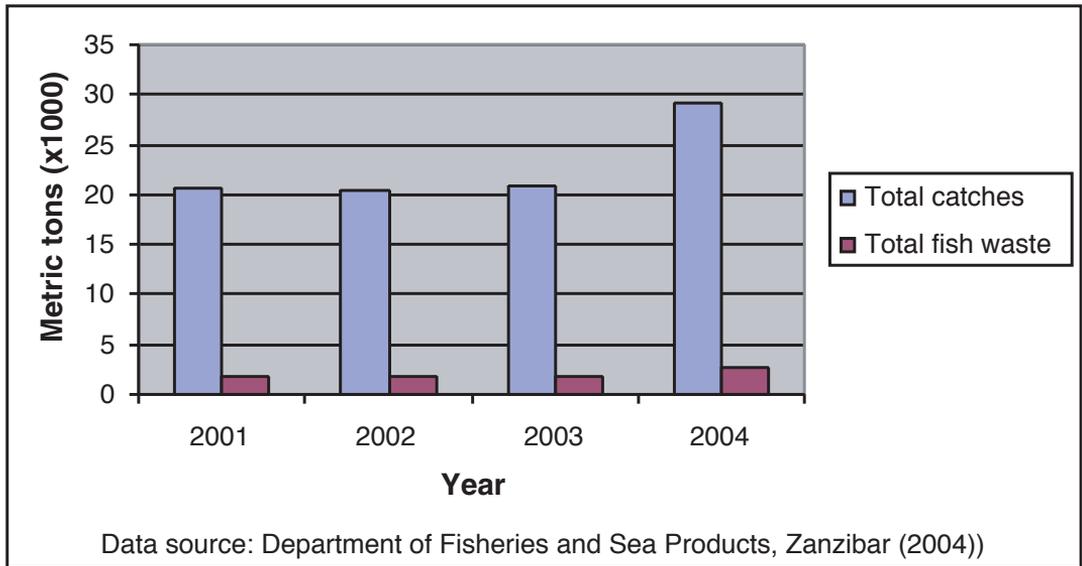


Fig. 2. Annual fish catch and fish waste yield (2001-2004)

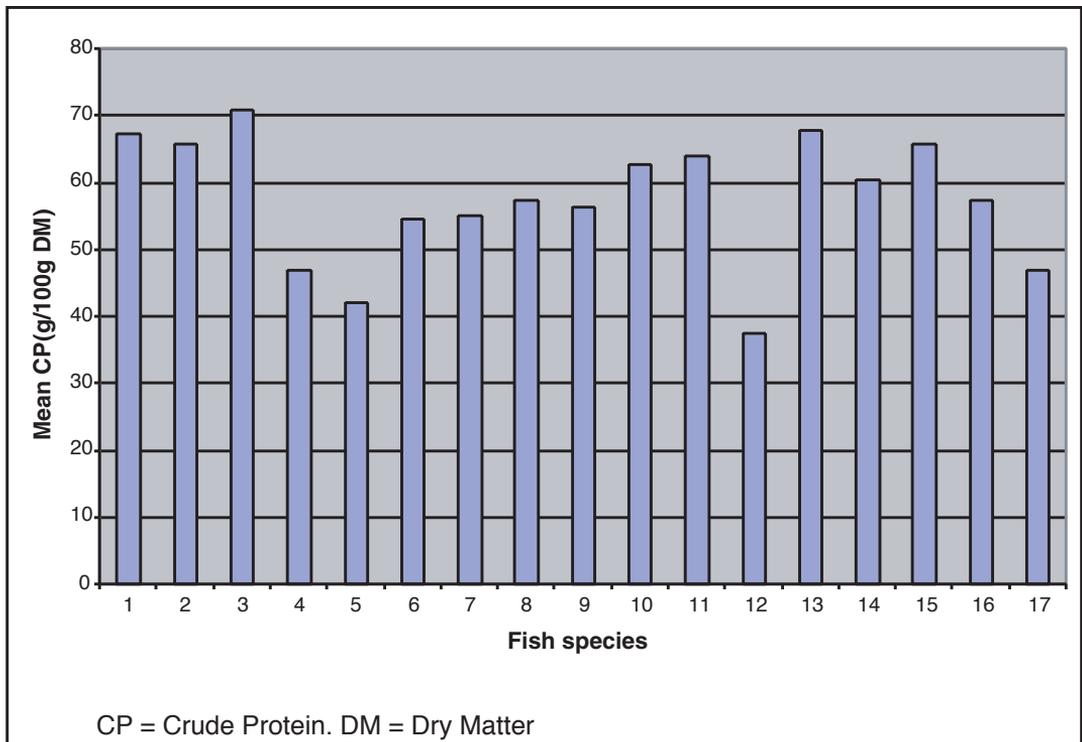


Fig. 3. Average protein content from individual fish species

Table 3. Nutrient composition of the fish waste from five landing sites

Landing Site (‘diko’)	Av. CP (g/100gDM)	Av. EE (g/100gDM)	Av. Mineral (g/100g DM)
Kizimkazi	53.54	16.04	24.89
Chwaka	52.66	9.96	35.65
Mkokotoni	59.21	14.55	25.85
Mazizini	51.77	13.94	31.69
Malindi	55.25	15.15	27.41
Mean	54.49	13.93	29.1
SEM	1.31	1.05	2.01

CP = Crude Protein, DM = Dry Matter, EE = Ether Extracts

DISCUSSIONS AND CONCLUSION

Variation in percentage waste weights between fish species is due to the differences in their body sizes and the internal organs (FAO, 1985). The compact body, fleshiness and proportionally small offal size of *Hipposcarus* species, rendered it the lowest fish waste yielder. In contrast, other species such as *Auxis tapeinosoma*, *Lutjanus argentimaculatus* and *Siganus* spp. had a relatively high proportion of the fish waste yield.

A fairly constant fish catch trend is evident from year 2001 through 2003. However, a sharp increase is observed in the year 2004, whereby an improved marine conservation strategy which includes strict prohibition and replacement of the destructive fishing gears, education of fishermen, enhanced record keeping and improved management of the landing sites “dikos” in recent years is expressed as a major reason (DFSP *pers com.*, 2005). The amount of correspondingly fish waste produced also reached its highest quantity in 2004.

From the results (Section 3.3 above), a clear reciprocal relationship between fat and ash content in gills and guts exists. While the main reason for high ash content in gills (>10 – 22%) as estimated by McDonald *et al.* (2002) is thought to be the presence of supporting “gills arches” containing high proportion of calcium and phosphorous and a number of desirable minerals including manganese, iron and iodine (Mc Donald *et al.* 2002), a high concentration of fat in the liver of the herrings and lean fish (FAO, 1986) is probably a major contributing factor for a high fat content in guts.

The little effect of treatment (boiling at 95 – 105°C) on the amount of fat, protein and mineral would in turn have advantage of reducing histamine problem in fish, without affecting the quality of the meal (Reyes *et al.*, 1991). According to this author a timely heating prevents the decomposition process that influence the histamine production in fishmeal. A relatively short heating time (10 – 15minutes) is also less likely to cause any adverse effect on digestibility and protein quality (Mc Donald *et al.*, 2002).

Although the study reported here showed no significant variation in protein content between the three major fish groups, extremes were observed between the carnivorous e.g. *Lutjanus fulviflamus* (70.98g/100g DM) and herbivores e.g. *Hipposcarus* spp. (37.52 g/100g DM), most probably due to the influence of the gut contents present during sampling.

As discussed in the above section, the amount of ash and fat are highly dependent on the proportions of gill and gut contained in the sample. Variations between the gill:gut ratios of different species landed are probably a major contributing factor for the differences observed between the two chemical components.

A considerable amount of fish waste is exploitable on Unguja Island and indeed other areas within the western Indian Ocean region. This seems a sustainable and cheap animal by-product that can best be utilized as source of protein in both livestock and fish farming in the area. However, the use of fish waste may be limited by a number of factors mainly associated with collection of the fish waste, timely processing and quality control. In this regard, further studies are needed to measure and control microbiological spoilage and oxidation of lipids during handling by fishermen, and in transport and sun drying. The results also beg for further investigations on the utilization of fish waste as source of nutrients for fish and livestock feeds.

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