Nutritional value of cabbage and kikuyu grass as food for grass carp, *Ctenopharyngodon idella* Val.

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Growth was more rapid among grass carp, *Ctenopharyngodon idella* Val., fed on cabbage, *Brassica* spp., than among those fed on kikuyu grass, *Pennisetum* spp. – despite the lower protein content of cabbage (11,9% *vs* 20,3%). The relative condition factor of fish fed on cabbage was also better. Proximate analysis was carried out and digestibility coefficients were obtained for the protein, fibre, ash and fat contents of both feeds. Cabbage was better digested and more efficiently utilized than grass with a feed conversion ratio of 3,3 compared to 9,7 for grass. Cabbage is a superior feed compared to grass for raising grass carp and a suitable low-cost alternative to commercial preparations.

Graskarp, *Ctenopharyngodon idella* Val., wat op kool, *Brassica* spp., gevoer is het 'n vinniger groeitempo getoon as dié wat op 'n dieet van kikuyugras, *Pennisetum* spp., was – nieteenstaande die laer proteïeninhoud van kool (11,9% *vs* 20,3% van gras). Die relatiewe kondisiefaktor van die vis wat met kool gevoer is, was ook beter as by dié wat met gras gevoer is. Die proteïen-, vet- en ruveselinhoud, sowel as die verteringskoëffisiënte, is vir albei voedselsoorte bepaal. Kool is beter verteer en meer doeltreffend deur die visse verbruik as gras, met 'n voedselsomsettingsverhouding van 3,3 in vergelyking met 9,7 vir gras. Kool is 'n beter voedsel as gras vir die grootmaak van graskarp en is 'n bruikbare lae-koste alternatief vir voedselsoorte wat kommersieel vervaardig is.

Keywords: Cabbage, digestibility, grass carp, kikuyu grass (*Pennisetum*).

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Introduction

The grass carp, *Ctenopharyngodon idella* Val., is a rapid growing, phytophagous, cyprinid fish indigenous to the large rivers of China and Siberia (Lin, 1935). The ability to turn large quantities of a wide variety of plant material into good quality protein has made this species an important aquaculture candidate worldwide (Bailey, 1972; Chaudri, Murty, Dey & Reddy, 1976; George, 1982; Opuszynski, 1972). Grass carp were introduced into Southern Africa in 1974 for aquaculture purposes and thrived under local conditions (Prinsloo & Schoonbee, 1986). Although the fresh water fish industry in Transkei is still in its infancy, it has the potential to supply the nation with comparatively cheap, good quality protein. In the Transkei, farming is the main economic activity (Anon, 1980). After harvesting, crop wastes are ploughed into the ground. Many of these wastes, particularly cabbage leaves, could successfully be utilized to raise grass carp (Prinsloo & Schoonbee, 1987).

Although preliminary work by Prinsloo & Schoonbee (1987) has shown that grass carp can be raised under local conditions on cabbage and grass, it is not known whether these feeds are equally suitable. The aim of this study was to examine in the laboratory the efficiency with which grass carp utilize the main nutritional constituents of cabbage waste and kikuyu grass and, in this way, to get a more precise assessment of the nutritional value of these low-cost feeds.

Materials and Methods

Grass carp fingerlings were obtained from the Umtata Dam Fish Research Station at five months of age (approx. 3—5 g) and were maintained in six 200*l* glass aquaria. Each tank was covered with netting to prevent the fish from jumping out and was fitted with an air lift under-gravel filter which covered one third of the base. This filtration system had been used extensively prior to this study and proved to be adequate (Prinsloo & Schoonbee, 1986). Half of the water in each tank was replaced with fresh water once a fortnight. The aquaria were kept in a constant temperature room at 27 ± 1°C in a 12 h light/dark cycle. Twelve fish were allocated to each tank and allowed to acclimate for two weeks prior to the start of the experiment. During this period they were fed on the experimental diet.

Two experimental diets were tested (three tanks per diet): kikuyu grass, *Pennisetum clandestinum* Hochst, and the outer leaves of cabbage (*Brassica* spp.). Food was chopped to a size of about 3 × 3 mm diameter and fed at 50% of the fish's biomass (based on fortnightly weighing). Fish were fed once a day. The feed refusal was measured daily by siphoning out the debris on the bottom of the aquaria which was collected on a sieve (mesh size 250 μm) in order to separate food remains from faeces. Water removed in the process was returned to the aquaria. Food remains retained by the sieve was dried and weighed. Once a fortnight, fish were weighed and fork lengths were measured.

A representative sample of each batch of cabbage and grass was dried in an oven at 60°C, ground and analysed for dry matter, total nitrogen, ether-extractable material and ash using standard AOAC (1970) procedures. Digestibility was estimated fortnightly by feeding the fish once and collecting all the faeces until no more was excreted. Digestive coefficients were then calculated by the

quantitative method of Tunnison, Brockway, Maxwell, Dorr & McKay (1942). The experiment covered a 10-week period.

Results and Discussion

Proximate analysis of cabbage and kikuyu grass

Kikuyu grass had higher protein, fibre and dry matter content than cabbage. However, the two diets were similar with respect to fat and ash content (Table 1). Gohl (1981) reported a protein content of 24% in kikuyu grass, slightly higher than the 20% recorded in this study. This discrepancy may be explained by the difference in maturity of the leaves analysed.

Table 1 Proximate composition (%) of cabbage and kikuyu grass (dry matter basis) fed to grass carp

	Cabbage	Kikuyu grass
Dry matter	12,3	18,3
Crude fibre	13,4	23,4
Crude protein	11,9	20,3
Fat	3,1	3,2
Ash	9,0	10,7
Nitrogen-free extract (calc.)	62,6	42,4
Sample size	5	5

Feeding and digestibility of feeds

The chopped cabbage was relished by the fish, and in general was completely consumed, while about 20% of the grass remained uneaten. It seems likely that the lower intake of kikuyu grass may be attributed to its higher fibre and dry-matter content, since Hickling (1966) found that grass carp could not cope with a food bolus containing more than 12% dry matter. Moreover, adult fish may be better able to utilize more fibrous food such as grass than the juveniles used in this study.

No significant difference between means of replicates were found ($P \geq 0,05$) using a two-tailed '*t*' test. Hence the data for each treatment were pooled. Total digestibility of cabbage and kikuyu grass was found to be 50,9% and 31,2%, respectively (Table 2). This implies that, in the case of cabbage, about half the material taken in is used and about half is passed out as faeces, similar to the findings of Hickling (1966). The protein of cabbage was easily digested but not that of the kikuyu grass. This agrees well with findings of Shireman, Colle & Rottman (1978) that high protein content does not necessarily indicate diet superiority. Although 36% of the fat in kikuyu grass was digested, fat present in the cabbage appeared to pass through undigested. In the absence of a detailed analysis of these lipids, the reasons for this difference in digestibility remain unclear. The digestibility coefficients reported must be accepted as approximate values, as the nutrient composition of faeces samples taken out of the water may have been affected by leaching (Smith, Peterson & Alfred, 1980; Windell, Flotz & Sarokon, 1978). Crude fibre did not appear to be digested. This finding was not unexpected since there are no enzymes in the gut to act on cellulose and grass carp probably rely heavily on the mechanical breakdown of cell walls to expose the cell contents (Van Dyke & Sutton, 1977).

Table 2 Digestibility coefficients (%) of cabbage and kikuyu grass (dry matter basis)

	Cabbage	Kikuyu grass
Total digestibility	50,9	31,2
Apparent protein digestibility	76,1	66,0
Fat	0,0	36,0
Crude fibre	0,0	0,0
Sample size	5	5

Average feed conversion efficiency (the ratio of dry feed consumed to wet weight gain) was 3,3 for cabbage and 9,7 for grass. These are comparable with the value of 6 reported by Domaniewski (1979) for succulent wastes like cabbage. Feed conversion ratios of 4,2 for cabbage and 6,3 for grass have been reported for grass carp raised in ponds (Prinsloo & Schoonbee, 1987). Their results are not strictly comparable, since the fish were fed at a lower rate (30% of biomass daily) and these authors have included in their calculation of feed conversion ratio the yield from a small number of other fish kept with the grass carp.

Although a fixed feeding rate of 50% was chosen, this was in practice close to *ad lib.* for both cabbage and grass since there was always grass, and occasionally cabbage left over. Furthermore, doubling the feeding rate of cabbage to 100% did not produce a similar increase in growth rate.

Values of 3,1 and 10,8 were obtained for the apparent protein efficiency ratio of cabbage and kikuyu grass respectively. This suggests that the protein in cabbage was efficiently utilized. The digestibility coefficients and lower feed conversion efficiencies suggest that kikuyu grass is inferior to cabbage as a food for these fish.

Growth and condition of fish

Growth depends on the amount of energy surplus in the diet to the energy requirement for basal metabolism (Stanley, 1974). In addition to food intake, a variety of physical factors such as temperature, water quality, volume of water per fish and degree of crowding affect the growth of fish (Brown, 1957). Although measuring the growth of fish in aquaria gives a good indication of relative value of different diets, the absolute growth rates are probably lower than those which could be expected under large-scale, less stressful production conditions.

Grass carp grew on both diets, but best when fed cabbage, with a mean gain of 0,37 mm d^{-1} and 0,09 g d^{-1} when compared with 0,04 mm d^{-1} and 0,02 g d^{-1} for kikuyu grass (Figure 1 & Table 3). The growth rates of fish fed on kikuyu grass were significantly lower ($P \leq 0,05$) than for

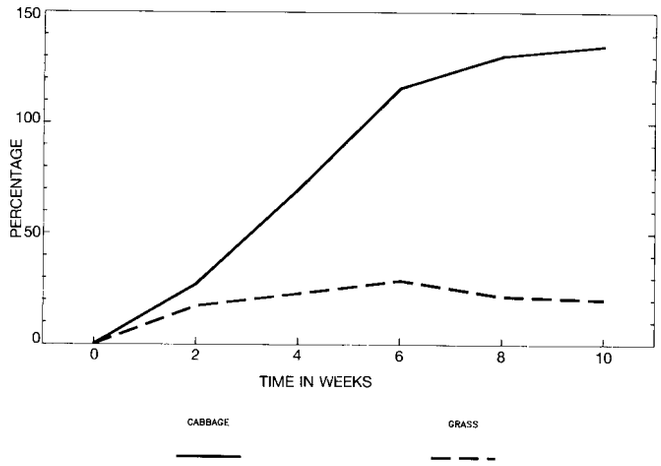

Figure 1 Growth rate of grass carp fed cabbage leaves and kikuyu grass for 10 weeks expressed in weight gain as a percentage of initial weight of fish.

Table 3 Average daily growth ($\bar{x} \pm SD$) of grass carp fingerlings fed cabbage and kikuyu grass

	Cabbage	Kikuyu grass
Mass (g)	0,09 ± 0,04	0,02 ± 0,03
Fork length (mm)	0,37 ± 0,19	0,04 ± 0,03
Sample size	36	36

those fed on cabbage throughout the study. Grass carp fed on cabbage doubled in weight during the first 21-day period, and grew well for the entire experimental period of 70 days, whereas those fed on kikuyu grass lost weight towards the end of the experiment. The relative condition factor (Le Cren, 1951) of the fish fed on cabbage (1,05) was significantly higher ($P \leq 0,01$) than those fed grass (0,96). Moreover, towards the end of the experiment, the condition factor of fish fed on cabbage declined (0,98), possibly as a result of overcrowding. However, the relative condition of fish fed on grass was poorer, with a value of 0,60 during the last seven-day period of the experiment.

Although Prinsloo & Schoonbee (1987) found that pond-raised adult fish fed cabbage grew at similar rates to those fed grass, these diets were given at only 30% of the fish's biomass per day. The present study suggests that, for cabbage, this rate is far below the optimum and may explain why the fish fed on cabbage were not able to greatly outperform those fed on grass (Prinsloo & Schoonbee, 1987).

The apparent unpalatability and poorer quality of grass relative to cabbage suggest that grass is not suitable for raising grass carp without the need for supplementary feeding. Cabbage is widely produced on both a subsistence and commercial scale by local farmers. At the Ncora Irrigation Scheme an estimated 20 t ha^{-1} of unutilized cabbage waste is left after harvesting (Prinsloo & Schoonbee, 1987). There seems to be a large, reliable supply of cabbage waste available to permit grass carp to be raised on this low-cost feed without the need for expensive commercial supplements.

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