NUTRIENT DIGESTIBILITY AND GROWTH RESPONSE OF RAINBOW TROUT (*Salmo gairdneri*) FED DIFFERENT CARBOHYDRATE TYPES

by

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SUMMARY

Seven groups of fingerling rainbow trout (*Salmo gairdneri*) were fed for 10 weeks on 0%, 10%, 20% and 30% of cassava or rice in isonitrogenous diets.

Optimum growth and food utilization was at 20% dietary cassava. High fiber content of the control diet did not supress protein digestibility in this group. Rather, at all levels, protein digestibility was good and remained between 84.4% and 90.1%. However, in the control group, carbohydrate digestibility was very poor. The cassava diets which had the highest digestible energy as carbohydrate produced the best growth performance, food utilization and protein sparing. At the levels studied, the dietary carbohyrates produced no hyperglycamic effect on the fish. There was no evidence of drastic adverse effects on the tissue and liver composition of the fish receiving these carboydrates.

INTRODUCTION

Some difficulties have been encountered in trout nutritional studies when this fish is fed with carbohydrate containing diets. Phillips, et al., (1948) using glucose, maltose, sucrose, cooked corn starch and raw corn starch as dietary carbohydrate sources for trout reported high glycogen in livers of trout fed these carbohydrate diets. They then recommended 9% and later between 9-12% (Phillips, et al., 1956) of dietary digestible carbohydrate for trout. The ability of their fish to utilize the different carbohydrate sources, of course, varied. More recently, (Abel, et al. 1979), starch more than glucose was observed to promote glucokinase activity and to decrease phosphoenolpyruvate carboxlkinase in trout liver. Rainbow trout has also been shown to utilise efficiently, higher levels of dietary carbohydrate (Luquet, 1971; Furuichi & Yone, 1971; Bergot, 1979; Lin et al., 1977, 1978). Edwards, et.al. (1977) using diets which contained 31.9% 35.5% and 43.6% of digestible carbohydrate (NFE) showed the best growth, condition factor and food conversion efficiencies in the group receiving 31.9% of NFE. They however, reported a healthy condition in all the fish.
Cassava and rice are relatively cheap carbohydrate sources in the tropics (Onwuka, 1980). If well utilized by trout, these carbohydrate sources could be economical in the production of trout diets. Isonitrogenous diets with varying levels of cassava and rice were therefore fed to rainbow trout for 10 weeks, and the response of the fish to these practical diets monitored.

MATERIALS AND METHODS

Rainbow trout (*Salmo gairdneri*) fingerlings collected from Midland Fisheries, Nailsworth, Glaucestershire, were quarantined for 10 days (Onwuka, 1980) and then used for this investigation. Seven experimental diets were formulated as shown in Table 1. Before the formulation, the cassava (non-toxic variety obtained as dried chips from Malaysia) and rice (long-grain prefluff, Overseas Trading Co., Bradford) were milled and analysed. Each contained 73.99% and 75.09% respectively of hydrolysable carbohydrate. The 7 diets were analysed (Table 2) and fed twice daily at a total of 2% body weight per day for 10 weeks to the experimental fish.

Before the onset of the experiment, the fish were individually marked by cold-branding with liquid nitrogen, given five days to acclimate and then weighed, and stocked at 20 fish per tank in white plastic tanks contained in a water recycling system (Ufodike & Matty, 1983). The temperature of the system was maintained at 12°C ± 1.0°C. Weighing of fish was carried out fortnightly thereafter, during which time they were stripped antero-posteriorly for faeces (Windell et al., 1978). Faeces for each group per fortnight were pooled, dried in an oven (present at 105°C) for 24 hours, and used for digestibility estimation after the method of Furukawa and Tsukahara (1966). Before each handling, fish were anesthetised using benzocaine (Onwuka, 1980). At the end of the 10 weeks experimental period, a random sample of 10 fish per tank were taken for blood plasma glucose estimation and proximate tissue assay.

Blood, liver, muscle and faecal hydrolysable carbohydrate were determined using the method of Murat and Serfaty (1974), or slight modifications of this method (Onwuka, 1980). The liver and carcass moisture, crude fat, protein and total ash were determined using slight modifications of the standard AOAC methods (AOAC, 1975) as earlier discussed (Onwuka, 1980). Crude fibre was estimated by difference. Energy in the diets (Table 2) was computed using standard values for enegy of combustion of fat, protein and starch (9.4, 5.6 and 4.2 cal/g respectively), and the nutrient digestibility values obtained in this research. Fat was assumed to be 95% digested.

RESULTS

All fish fed actively and appeared healthy.

Growth performance

The growth response of rainbow trout fed cassava and rice are respectively shown in Figs. 1 and 2. With the cassava diet the best growth response was achieved at 20% inclusion. A 30% dietary cassava when compared to 20% cassava significantly ($P > 0.05$) depressed growth rate of fish. When compared to the control 10% dietary cassava does not significantly ($P > 0.05$) affect growth rate.

With the rice diets, no significant difference ($P > 0.05$) in growth is obtained at the different levels of inclusion (Fig. 2). Thus at levels between 0% and 30% rice does not appear to be toxic to rainbow trout. The highest specific growth rate (SGR) was obtained in fish on 20% and 30% cassava.

Food utilization

The Food conversion Ratios (F.C.R.'s) were good in all fish (Table 3) the best value being obtained with 20% dietary cassava. There was no significant difference ($P > 0.05$) between the FCR's of the control fish and the RC-5 group. The trend of results obtained for the protein Efficiency Ratio (PER), and Apparent Net Protein Utilization (NPU) very closely follow those obtained for the FCR.

Blood glucose values (Table 3) reveal no evidence of prolonged hyperglycaemia in fish fed cassava and rice.

In the control fish plasma glucose is significantly ($P > 0.05$) low. This could possibly be due to lack of sufficient digestible carbohydrate in the diet. The composition of the liver and rest of the carcass (Table 4 & 5) show no evidence of drastic changes brought about by the carbohydrate diets.

Results from digestibility studies show that the carbohydrate in the cassava diet is better digested than that in the rice diet (Fig. 3). The control diet contains only a trace quantity (1.34%) of digestible carbohydrate (Table 2). With the inclusion of cassava or rice to the diets, carbohydrate digestibility increases by at least 70% The apparent digestibility of dietary protein appears good in all groups, and ranges between 84.4% and 87.5% (Fig. 4).

Table 1. - Composition of test diets fed to rainbow trout (g/100g diet)

Components	Diets designations						
	Cc-1	Cc-2	Cc-3	Rc-4	Rc-5	Rc-6	Oc-7 (control)
Cassava	10.00	20.00	30.00	-	-	-	-
Rice	-	-	-	10.00	20.00	30.00	-
White fish-meal	45.00	45.00	45.00	45.00	45.00	45.00	45.00
Casein	10.00	10.00	10.00	10.00	10.00	10.00	10.00
D-Cellulose	20.00	10.00	-	20.00	20.00	-	30.00
Mineral Mix[1]	4.00	4.00	4. 00	4.00	4.00	4.00	4.00
Vitamin Mix[1]	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Corn Oil	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Cod Liver Oil	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Chromic oxide	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Carboxy methy- Celluse (binder)	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Totals	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[1]As in Ufodike & Matty (1983).

Table 2. - Proximate composition of experimental diets from biochemical assay (% weight)

Ingredients	Diets						
	Cc-1	Cc-2	Cc-3	Rc-4	Rc-5	Rc-6	Oc-7 (control)
Moisture	5.49	5.95	6.26	5.36	6.48	6.82	5.04
Protein	41.76	41.35	41.63	43.46	43.57	42.85	41.34
Fat	12.28	12.32	12.09	12.25	11.97	11.97	10.61
Carbohydrate[1]	11.15	18.25	26.62	9.18	19.51	26.01	1.34
Ash	9.86	10.02	10.38	9.01	9.07	9.41	8.76
Su-totals	80.54	87.89	96.98	79.29	90.60	96.96	67.09
Fibre[2]	19.16	12.11	3.02	20.71	9.40	3.04	32.91
Cr_2O_3[3]	0.50	0. 49	0.51	0.53	0.53	0.52	0.50
Energy[4]	344	370	379	344	354	371	299

1. Hydrolysable carbohydrate
2. Computed as difference between subtotals & 100
3. Presented on dry-weight basis
4. Kcals/100g of diet.

Table 3. - Growth and food utilization of rainbow trout fed different levels of cassava and rice for 10 weeks

Mean values	Diets								
	Initial	Cc-1	Cc-2	Cc-3	Rc-4	Rc-5	Rc-6	Oc-7	± SEM
Initial weight (g)	-	28.75^{a}	29.63^{a}	31.06^{a}	31.32^{a}	32.17^{a}	32.58^{a}	30.86^{a}	2.370
Final weight (g)	-	79.92^{a}	95.78^{d}	78.86^{a}	84.97^{c}	85.88^{c}	83.37^{b}	80.12^{a}	0.929
Weight gain (%)	-	177.80^{b}	224.00^{c}	153.90^{a}	171.30^{b}	166.96^{b}	155.89^{a}	159.62^{a}	3.268
S.G.R.[1]	-	1.12^{a}	1.34^{d}	1.36^{d}	1.13^{a}	1.23^{c}	1.28^{b}	1.24^{c}	0.033
F.C.R.[2]	-	1.44^{d}	1.14^{a}	1.42^{d}	1.38^{c}	1.24^{b}	1.30^{bc}	1.27^{b}	0.037
P.E.R.[3]	-	1.69^{a}	2.00^{d}	2.03^{d}	1.74^{b}	1.84^{c}	1.78^{b}	2.04^{d}	0.028
Apparent NPU[4] (%)	-	34.60^{b}	43.71^{c}	35.95^{b}	37.80^{b}	35.62^{b}	29.72^{a}	46.10^{c}	1.085
Blood glucose (mg%)	59.90^{b}	57.90^{b}	65.10^{b}	68.70^{b}	56.71^{b}	60.90^{b}	66.90^{b}	36.00^{a}	1.817
H.S.I.[5]	1.58^{c}	1.43^{a}	1.61^{c}	1.81^{d}	1.60^{c}	1.40^{a}	1.61^{c}	1.48^{b}	0.019

Figures in the same row having the same superscript are not significantly different ($P > 0.05$)

1. Specific growth rate
2. Food conversion ratio
3. Protein efficency ratio
4. Net protein utilization
5. Hepato-somatic index.

Table 4: - Initial and final composition of liver of rainbow trout fed different levels of cassava and rice

Final (% wet weight basis)

	Initial	Cc-1	Cc-2	Cc-3	Rc-4	Rc-5	Rc-6	Oc-7	± SEM
Moisture	75.50[a]	76.53[a]	75.56[a]	75.61[a]	77.68[a]	76.51[a]	77.09[a]	74.55[a]	0.56[1]
Carbohydrate[1]	7.80[d]	6.02[b]	6.95[c]	7.80[d]	5.59[a]	7.50[d]	6.80 [c]	5.55[a]	0.09
Fat	0.65[b]	0.94[d]	0.89[cd]	0.61[ab]	0.83[c]	0.66[b]	0.54[a]	0.93[cd.]	0.10
Protein	14.26[a]	14.59[a]	14.31[a]	13.91[a]	14.90[a]	13.82[a]	13.26[a]	14.52[a]	0.50
Ash	1.55[a]	1.95[a]	1.51[a]	2.88[b]	1.76[a]	1.62[a]	2.59[b]	3.78[c]	0.03
Total	99.76	100.03	99.22	100.81	100.76	100.11	102.08	99.33	

Figures in the same row having the same superscripts are not significantly different (P 0.05)

[1]Total glucose and glycogen

Table 5: - Initial and final carcass composition of rainbow trout fed different levels of cassava and rice

Final (% wet weight basis)

	Initial	Cc-1	Cc-2	Cc-3	Rc-4	Rc-5	Rc-6	Oc-7	± SEM
Moisture	73.20[a]	74.15[a]	73.19[a]	73.86[a]	73.98[a]	73.19[a]	75.14[a]	71.34[a]	0.862
Carbohydrate[1]	0.70[b]	0.72[b]	0.72[b]	0.87[c]	0.74[b]	0.74[b]	0.65[b]	0.46[a]	0.038
Fat	4.85[a]	5.08[a]	4.87[a]	4.96[a]	4.24[a]	4.97[a]	4.74[a]	4.85[a]	0.184
Protein	18.45[b]	17.61[a]	19.17[c]	18.15[b]	18.69[b]	18.92[b]	17.40[a]	20.95[b]	0.080
Ash	2.86[a]	2.54[a]	2.39[a]	2.30[a]	2.56[a]	2.40[a]	2.25[a]	2.72[a]	0.569
Total	100.06	100.10	100.34	100.14	100.21	100.22	100.18	99.96	

Figures in the same row having the same superscripts are not significantly different (P 0.05)
[1]Total hydrolysable carbohydrate.

DISCUSSION AND CONCLUSION

Some of the previous works in which the unavailability of carbohydrates to Rainbow trout was reported have been conducted using diets consisting either wholly or partially of semipurified or poor quality protein. Such protein sources have been shown to cause nutritional disorders. The use of some refined carbohydrate sources have been shown to cause growth retardation (Inada, et al., 1963; Hastings, 1968; Austreng, et; al. 1977) However , the dietary inclusion of up to 50% starch and/or dextrin or 20% glucose has been shown to be well tolerated by salmonids, and the differences in tolerance levels has, in the main, been attributed to the intestinal carbohydrate digesting ability of the animals (Buhler & Halver, 1964, Luquet, 1971). The poor carbohydrate digestibility in our control fish probably suggests that a "threshold" quantity of digestible dietary carbohydrate was necessary to trigger off amylase digestive activities in the gut of rainbow trout. Such low carbohydrate digestibility in fish fed diets containing only trace quantities of digestible carbohydrate (2%) have been previously observed (Ufodike & Matty, 1982, 1983) Low protein digestibility has been reported in fish fed high fibre containing diets (Kitamikado, et al., 1979). It however appears unlikely that the high fibre content in some of our diets had an over-riding effect on the protein digestibility. Besides, examination of the rectal contents of the fish revealed no evidence of diarrhoea or inconsistency of the rectal content of fish on the high fibre diets. The results from food and protein utilization (Table 3) tend to suggest that an optimum level of dietary digestible carbohydrate is required for best conversion of feed into flesh. That is at a certain level of inclusion of digestible carbohydrate into the diet, maximum energy is trapped from the dietary carbohydrate to enable most of the energy from protein to go in body building. The value of carbohydrate to the fish, which is basically for the supply of metabolic energy is thus important.

Metabolic energy produced as heat is usually regarded as being a waste to the fish (Cowey & Sargent, 1979). With an adequate supply of dietary carbohydrate, the process of gluconeogensis (evidenced by the presence of tissue carbohydrate in the control fish whose trace quantities of dietary hydrolysable carbohydrate were very poorly digested), would be minimised. Hence, dietary protein would be spared, as shown in this research.

Cassava could be a good and cheap source of dietary carbohydrate for trout.

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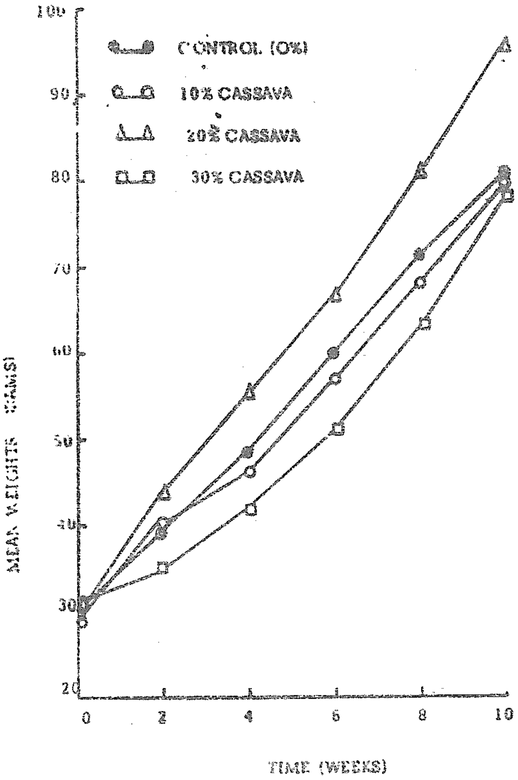
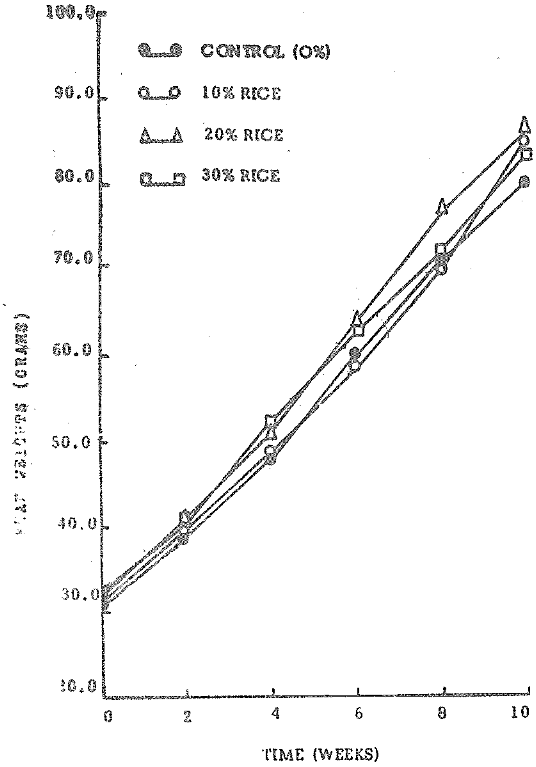


Fig. ? Effect of different levels of dietary cassava on weight gain of Rainbow Trout



Effect of different levels of dietary Rice on weight gain of Rainbow Trout

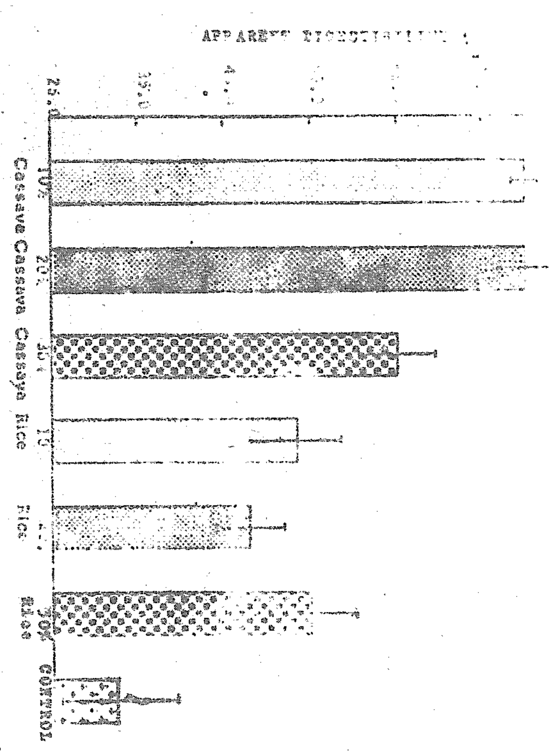
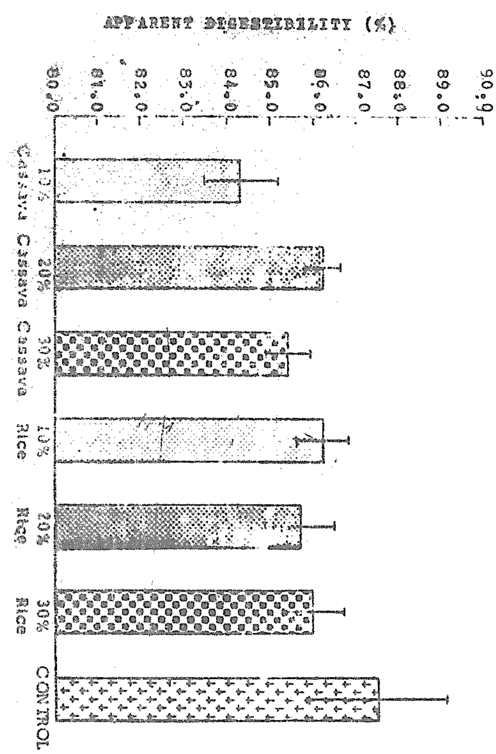


Fig. 3 Apparent digestibility of dietary carbohydrate in Rainbow trout fed cassava and rice



...digestibility of dietary protein in Rainbow Trout fed cassava and rice