

**Proceedings of the Summer Institute in
Recent Advances in Finfish and Shellfish Nutrition**

11 TO 30 MAY 1987



**CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
Dr. SALIM ALI ROAD
COCHIN-682 031**

SUMMER INSTITUTE IN
RECENT ADVANCES IN FINFISH AND SHELLFISH NUTRITION

11-30 May, 1987

CARBOHYDRATE REQUIREMENTS OF FINFISH AND CRUSTACEANS

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INTRODUCTION

Nutrition supplies the raw materials for the maintenance of life. Some materials are used for the formation of body tissues (anabolism) and some for the production of energy (catabolism). Foods may be classified as energy and growing foods carbohydrates (CHO), fats and proteins and non energy foods (Minerals, vitamins, water and oxygen). Nutrition of fish has received attention for many years. The nutritional value of a diet is measured by the presence of necessary elements and catalysts an abundant supply of the anaxillary foods and a proper balance between the energy and growing foods. A proper balance between the energy and growth foods assures an adequate supply of both energy and raw materials for optimum anabolic activity which in addition to growth includes tissue repair, reproduction and the formation of essential body products.

Phillips et al. (1948a) reported for trout the digestion of carbohydrate that of glucose 99%, maltose 92%, Sucrose 73%, Lactose 60% and Starch 57% and Raw starch 38%. They also reported that the levels in the diet under their experimental conditions was limited to 12% digestible carbohydrate because the additional amounts caused a deposition of excess of liver glycogen. It was suggested that higher

levels of carbohydrates was unable to utilise by the trout physiologically. Buhler and Halver (1961) found that chinook salmon tolerated relatively high levels of dietary carbohydrates without the development of abnormal conditions. Schaeperclaus (1933) suggested carbohydrate as a source of energy for carp and reported digestibility of from 30 to 92%. Philips et al. (1966, 1967) showed that carbohydrates were utilized for energy by trout and thus spared protein for protein purpose in the body. Kitamikado et al. (1965b) found that large amounts of starch in the diet of rainbow trout decrease the digestion of protein and therefore decreased the amount available for metabolism. The carbohydrates are stored as immediate reserve energy by showing increased liver and muscle glycogen. However the reported studies shows that there was increased body fat after feeding surplus carbohydrate. The carbohydrate absorbed by trout assumed that the digestive enzymes sucrase, maltase, lactase and amylase are present in the tract. The maltase activity was higher than sucrase and lactases.

McGeachin and Debnam (1960) demonstrated a relatively high amylase activity in the digestive tract of number of fresh water fishes. Kitamikado and Tachino (1961a) found an amylase activity in the digestive tract of rainbow trout that was less than that of carp but more than that of eel, reflecting differences in the feeding habits between fish species. Kenyon (1925) found a similar relationship in an abundance of the starch-digesting enzyme amylase was present in the intestinal mucosa of carp but almost none in Pickerel. Fish (1962) correlated the digestive enzymes with normal diet. In predominantly herbivorous Tilapia, amylase activity was distributed throughout the gastrointestinal tract, but carnivorous perch the pancreas was the only source of amylase. The inability of fish to mobilise liver glycogen

rapidly under circumstances such as starvation suggests either a paucity of phosphorylase or that metabolic and hormonal factors restrict the activity of the enzyme. Nagai and Ikeda (1972) experimented carp subjected to either regain oxidized glutamate rapidly and glucose slowly, deduced that aminoacids are a superior energy sources to glucose for carp and that energy utilization in the fish resembles that in a diabetic mammal.

Singh and Nose (1967) reported the carbohydrate digestibility was measured in young rainbow trout using the indirect method i.e. reference to the concentration of carbohydrate in diet. Glucose, sucrose, lactose were easily digested and absorbed and their digestibility remained nearly constant regardless of the level in diet. Dextrin and potato a starch were far inferior to the above mentioned sugars in their digestibility, the rate being 77 and 69% respectively at 20% carbohydrate levels in diet and their digestibility had a negative correlation to the concentration of starch in diet.

Nagai and Ikeda (1971) have shown for the carps that under starvation the conversion of lipid to glycogen in hepatopancreas and temporary increase of the blood, glucose levels were found at the same time. During breeding the carbohydrate content in diet increased or protein decreased, glycogen in hepatopancreas increased while lipid in hepatopancreas and blood glucose level decreased. This suggests that carp unlike in mammals that carbohydrate is hardly converted to lipid but that protein is principally converted to lipid where as carbohydrate does not precede either protein or lipid as energy sources but certain amount of it is necessary for the activity. They also showed by conducting experiments by using lablend carbon (^{14}C) and found that Glucose 6 - ^{14}C was incorporated in to glycogen in all

groups but oxidised to $^{14}\text{CO}_2$. When more than 50% of protein was contained in diet, oxidation of glucose 6- ^{14}C decreased remarkably and at the same time blood glucose and extent of randomization of ^{14}C in glucose was increased. From these observations it was suggested that carp possesses the active and reversible Embdon-Meyerhof path way but that glycogen is not a principal storage depot of energy.

Carbohydrate levels of about 25% in the diet is as effective as fat for the survival of channel catfish, rainbow trout and Plaice Singh and Nose (1967) explained high levels of starch in a sharp fall in digestibility for the thus species. Chion and Ogino (1957) has demonstrated 85% ingested starch was digested by the species 18-48% only. Cellulose activity was demonstrated by Sticknery and Shunaway (1974) in the digestive tracts of several finfish species of estuarine forms. These cellulose activity was associated with the micro-flora in the alimentary tract. The hepatic hexokinase isoenzymes of six species of fin were studied by Nagayama and Ohshima (1974) but no isoenzyme which resembled mammalian glucokinase was detected. Glucose dehydrogenase activity in liver of carnivorous fish is said to be four to seven times that in mammalian livers, whereas the activity in herbivorous fishes is similar to that of mammals (Nagayama et al., 1973). Hexokinase activity in different organs from various species of fish has been measured by several workers. Hexokinase (+ glucokinase) activity in rat liver is about 10 fold higher than in the liver of fish that in rate kidney about 3 fold higher than in fish kidney. This appears one of the prime reasons for the inability of fish to metabolize glucose rapidly.

Hexokinase activity in tissues of fish and rat

	<u>Liver</u>	<u>Heart</u>	<u>Kidney</u>	<u>Muscle</u>
Grass carp	0.28	3.58	0.99	0.19
Carp	0.29	1.99	0.88	0.29
Rainbow trout	0.52	1.45	0.99	0.19
Eel	0.25	3.14	0.94	0.17
Rat	2.5	6.1	2.8	2.0

Nagayama et al. (1972) have attempted to assess the relative ability (Latest activity) of four species of fish to metabolise glucose on the basis of the total hepatic activity of certain enzymes in fish of unit weight. On this criterion species rated in the order grass carp, eels, carp and rainbow trout. Fish do not mobilize liver glycogen rapidly when they are starved Nagai and Ikeda (1971a) found that blood glucose and liver glycogen levels of carp which have been starved for 22 days were not significantly different from those of carp which had been given diet varying markedly in gross composition. Even after 100 days without food appreciable amount of glycogen (1.5%) remained in carp liver. This phenomenon is common to other species such as European and Japanese eels.

The carbohydrate and protein interaction was found to be 45-40% respectively (Kandasami et al., unpublished) for mullets (Liza macrolepis).

CARBOHYDRATE REQUIREMENTS OF CRUSTACEA

Carbohydrates digestion in crustacea has been demonstrated by Kooiman (1964) and presence of carbohydrates including amylase, maltase, saccharase, chitinase and cellulase shown later may be from the bacteria in the

intestine. Metabolically carbohydrates are important in Kerbs cycle, in glycogen storage in chitin synthesis and in the formation of steroids and fatty acid. Wheat starch, dextrin and oyster glycogen are completely assimilated by Palaemon serratus (Forster and Gabboh, 1971) potato starch whether cooked or uncooked is less digested. Addition of 20% glucose to a menhaden based diet for Penaeus oztecus reduced growth rate (Andrews et al., 1972). It was postulated that dietary glucose was rapidly but inefficiently utilised for energy metabolism, whereas the glucose from digested poly saccharides was absorbed more slowly and effectively. Inclusion of 40% corn starch in casein based diet for Penaeus duorarum produced faster growth than 10 or 0% starch (Sick and Andrews, 1973). Deshimaru and Kurski (1974 a) obtained increased growth rate with P. japonicus though 6% dextrin inclusion in a casein-based diet. 6 and 12% addition of glycogen had a proportionately similar effect whether in the presence of dietary lipids or not.

While shrimp can utilize CHO efficiency varies according to sources. Partial digestion of cellulose takes place and extracellular chitinase enable digestion of chitin from dietary sources or from cast exuvial. The ability to digest specific sources of CHO varies between species. Starch seems to be more efficiently utilised than glucose.

The role of CHO and of its sources will become more important as dietary protein levels are lowered. Rahman, Kanazawa and Teshima (1979) have studied the effect of dietary CHO on the body weight gain, survival, PER and the hepatopancreatic glycogen and serum glucose levels of the prawn P. japonicus. The highest weight gain was obtained in the diet contained 19.5% maltose as CHO source. Growth of prawn was poor in high levels of monosaccharids, glucose or

galactose as compared i.e. maltose and the polysaccharids soluble starch, potato starch, dextrin and glycogen. Feeding with diet containing glucose or galactose for 30 days resulted in high glycogen level in hepatopancreas. Also the serum glucose level increase quickly after oral administration of glucose and remained at high after 24 hours whereas after the administration of di and poly saccharids it increased maximum after 3 h and then decreased to the pre-test levels.

Deshimaru and Yone. (1978) have studied the carbohydrate requirements of the prawns P. japonicus and observed that the poorest feed efficiency and high mortality were found with the group fed on diet containing glucose. Also the diets containing starch and dextrin produced high mortality. On the other hand the two groups maintained on the diets with glycogen and sucrose had a low mortality. From this it was concluded that sucrose and glycogen are desirable sources of dietary CHO for the prawn while glucose is unsuitable.

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