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LITERATURE SURVEY

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The nutrition of fish has gained attention since many years. Atkins (1908) reported the death of trout fed on an all-dry diet. Death was prevented by the addition of fresh meat. Planned studies on the preparation and testing of fish feeds started during the early part of this century. But comprehensive investigations on the subject started during the later half of the century. Initially, most of the investigations were restricted to cold water fishes. During the past forty years the interest in fish growth and nutrition has increased dramatically, but, because the experimental design has often been governed more by the practical than the ideal, direct comparison of the results obtained by different investigations is often impossible.

2.1. NUTRITIONAL REQUIREMENTS

Qualitatively, the nutrient requirements of fish are same as those of the higher animals. However, many different levels of nutrients are used quantitatively to optimize the production of fish subject to variations in stocking density, initial age and weight, water quality and management practices. The data reported by different research laboratories and commercial fish farms may be understood using examples of fish growth obtained by the ingestion of prepared diets which meet certain nutrient targets.

2.1.1. Protein:

Experiments carried out on Chinook salmon about 30 years ago by De Long *et al.* (1958) showed an increased in dietary protein requirements with temperature. They were the first to use casein-gelatin diets to study optimum protein level in feed for fish. Nail and Shell (1962) and Hastings (1969) studied on protein requirements of channel catfish. Dupree and Sneed (1966) recorded on optimum growth of channel catfish on a 35% protein diet at 20^0C, whereas, 40% protein level at 25^0C.

Hastings and Dupree (1969) used protein levels of 10 - 50% at 10% increment in the diets for channel catfish stocked in aquaria and ponds. They found that in aquaria, fish attained maximum growth with 40% protein food and that foods containing more protein depressed growth. In ponds no maximum protein level was observed and growth increased on all foods with increasing protein level, although to a lesser degree with foods exceeding 30% protein. Ogino and Saito (1970) and Nose and Arai (1972) use casein as the only source of protein in the feed for common carp and eels respectively. For common carp, the optimum protein level in the feed was 38% at 23^0C (Ogino and Saito, 1970) and for eels, 48% at 25^0C (Nose and Arai, 1972).

Hepher *et. al.* (1971) showed that a pellet of 22.5-25.0% crude protein was optimum for fishpond culture in Israel. Cowey *et al.* (1972) found the optimum dietary protein level for plaice, *pleuronectes platessa* to be 52% when freeze dried cod-muscle was used as the source of protein. Possompes (1973) used a dietary protein range of 21.60% in experiments on rainbow trout and found a linear increase in weight gain with an increasing protein inclusion rate. Most of the papers published on protein requirement of rainbow trout (*Salmo gairdneri*) showed best growth with protein content between 40 and 50%. Luquet (1971), Tiews *et.al.* (1972), Gropp *et al.* (1974) and Satia (1974) have all found best growth with protein content between 47 and 50% , while Zeitoun *et al.* (1973), Cho *et al.* (1976) and Austreng (1978) found best growth with a protein content between 40 and 45%. Austreng and Refstie (1979) fed groups of rainbow trout fingerlings from five different families and five inbred groups with four isocaloric diets containing 24,33,42 and 51% of protein level and found that fish growth rate increased with increasing dietary protein content.

Prather and Lovell (1973) found that optimum growth of channel cat fish was achieved with 29% protein food when total energy was 2200 Kcal Kg^{-1} and that increasing food energy to 2860 Kcal Kg^{-1} permitted the fish to use a 42% protein food and attain considerably more growth. Schuster (1949) and Hastings (1975) found that in milkfish, *Chanos chanos* ingestion of 100 g of food containing 20% protein (dry weight) resulted in a gain of 8 gm of protein. Ogino *et.al.* (1976) found that dietary protein was most effectively utilized for growth at near 100 g of absorbed N per 100 g of body weight per day. Varghese *et al.* (1976) recorded a better growth of common carp when fed on protein rich pellets containing 31% protein. Dabrowski (1977) reported the optimum protein level in the diet for grass carp fry as 41-43%. Davis and Stickney (1978) observed that the growth rate of *Tilapia aurea* was the best when fed on diets containing 36% protein level. Takeunchi *et. al.* (1978) found the optimum level of dietary protein and lipid for rainbow trout as 35% and 13% respectively. Teng *et. al.* (1978) reported an optimum protein level of 40% dietary protein in case of estuary grouper, *Epinephilus salmoides.* Halver (1978) observed that gross protein requirements are the highest in the initial feeding stages and decrease as the fish size increases. Teshima *et.al* (1978) used casein as the only protein source in the diet of *Tilapia zilli* and found the optimum protein level to be 35-40%. Mazid *et al.* (1979), however, found the optimum dietary protein level to be 30% in the same fish. They also reported that the body weight gain increased in proportion to the dietary protein levels within the range of 00-35%. Lim *et. al.* (1978) reported that the optimum protein level for fry of *Chanas chanos* was 40%. They recorded a slower growth rate in the fish fed diets containing 50% and 60% protein levels than that fed 40% protein level. Sen *et.al.* (1978) found that optimum protein level in the diet for spawn, fry and fingerlings of carps to be 45%. Takeuchi (1979) reported higher protein levels of 28-35% in the diets for warm water fish.

Janucey (1982) recorded the minimum dietary protein level of 40% producing maximum growth of *Sarotherodon massambicus.* Jauncey and Ross (1982) found that for *Sarotherodon niloticus* of 06-30 g body weight, the fish fed a dietary protein level of 25% produced 85% of the maximum specific growth rate exhibited by the same fish fed a dietary protein level of 30%. Viola and Arieli (1982) in Israel showed that the protein pellets (30% crude protein) significantly improved growth and feed conversion by 27% on the average in carp and 20% in case of tilapia. Viola and Zohar (1984) found that feeds containing 30% protein resulted in better growth and feed conversion in market size hybrids of tilapia (*Oreochromis*) than the usual 25% feed. They also found that there was an advantage with the 35% protein diet in growth performance in summer. Tan (1983) recorded an increased growth rate of *Osphronemus gouramy* fed with pelleted feed containing 40% protein which was 7 to 8 times faster than those fed yam leaves.

De Silva and Parera (1984) determined the dry matter and protein digestibility coefficients in *Sarotherodon niloticus* fry maintained on four artificial diets with protein content ranging from 9.6%-30.4% at different salinity. Michales and Henken (1985) used 20-40% crude protein level in the diet for the African cat fish, *clarias gariepineus* and observed that growth rate, metabolizability and protein gain increased as protein in take increased. Henken *et.al.* (1986) found that the protein requirements of the African catfish were higher of higher temperature. The highest protein diet (50%) produced significantly less growth than any of the other experimental diets used by them. Alexis *et al.* (1986) fed the rainbow trout of approximately 1.0 g initial average weight with four pairs of diets containing four different combinations of by-products differing in protein content from 40-49%. They did not find any Uniformity in the response of fish towards the protein increase in the diet.

Tabachek (1986) found that the dietary combination of 54% protein with 20% lipid maximized weight gain and feed efficiency in the Arctic charr *Salvelinus alpinus.*

Demael *et al.* (1988) found that during six months carps were raised in earth basins in the region La Dombes (France). The control group feeds on the production of biotope. The second group also receives commercial carp food at 2.2% of body weight daily. The control group only doubled its initial weight during the experiment. These fishes show hypokalemia and low muscular glycogen percentage. The carps of the second group multiplied initial weight by 18. They show lipid and glycogen excess in liver and muscle after 4 months. At the end of the experiment when the food protein percentage has decreased, the carps have only an excess of hepatic glycogen. The alimentary ration furnishes to these carps too many calories. The fish density (200 fishes in 400 m super (2)) is good when carp are fed daily with commercial food but this density is too great when fishes eat essentially zooplankton. Fuellner (1988) showed that in the branch for carp pond management in Koenigswartha belonging to the freshwater fisheries Institute in Berlin - Friedrich shagen feeding experiments were conducted with carp (*Cyprinus carpio*) in the range of water temperature between 22^0C and 8.5^0C shorter droppings of temperature practically showed no effects on growth and feeding efficiency, when feeding intensity still remains high. In pond management, it will therefore not be necessary to reduce rations relating to short decreases of temperature. A growth limit for carps with a weight of 150 to 400g, which were fed a commercial pellet feed containing 24% crude protein, exists at 10.4^{0}C. This limit clearly depends too from content of crude protein in the rations. Silva and Gunasekera (1991) found that the published data on growth in Indian & Chinese major carps catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), grass carp (*Ctenopharyngodon idella*), big head carp (*Aristichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) in relation to the dietary protein content, where the total energy content of the diets was 16-20 Kg g^{-1} and at least 10% of the protein source was from fish meal, were utilized in this study. The relationship of rate of growth is best described by a second-order curve. The dietary protein content at which maximal growth accrued was 45% and the economically optimal dietary protein content was 31%. The significance of these findings from an aquaculture point of view is discussed and the findings are compared with those from a similar study with tilapia fish. Hertz *et al.* (1992) found that Fish fed a low protein (LP) diet for a period of 12 weeks attained a 24% lower weight gained compared to fish on a high protein (HP) diet. Fish fed HP had higher levels of serum cortisol, higher activity of liver PEPCK and, subsequently, exhibited higher rate of gluconeogenesis. Serum FFA was higher in LP fed fish, indicating that mobilized lipid may substitutes for protein as an energy source. No differences were found in the rate of protein synthesis and the characteristic slow glucose clearance was only slightly lower in the HP diet. Different starch sources affected the growth in fish fed LP but not HP diets. Continuous injection of either insulin or bovine growth hormone (bGH) had no effect on fish fed HP but improved the growth rates in fish fed LP upto that achieved in HP, indicating that glucose utilization was improved at LP. Oral administration of bGH or insulin to fasted carps resulted in a substantial absorption (2-3%) with only a minimal loss of their biological activities. Co-administration of the hormones with biological detergent, 7-deoxycholate increased the absorption upto 1000 fold, while absorption was impaired in the presence of food in the gut. Thus, administrating biologically active proteins in the presence of detergent may serve as a need approach for affecting growth, reproduction and immunization.

Ahmed *et al.* (1993) found that socio-economic survey was carried out on a sample of 333 households from among the owners and operators of small water bodies (ponds and ditches) in two sub districts or thanas : Kapasia (the target area for development of aquaculture) and Sreepur / the control area with no development initiative for aquaculture) in the district of Gazipur, Bangladesh. The report also provides in formation about fish markets in the two Thanas. Fish traders in 21 Village markets, 15 from Kapasia and 6 from Sreepur, were surveyed. Comparison of land and assets as well as income of the households indicated very little variation between the two thanas as far as the owners and operators of small water bodies are concerned. Similarly, education, occupation, consumption pattern and resource use pattern of there households differed only slightly. It was also revealed that these persons enjoyed a higher socio- economic status than the rest of the community. In both thanas, pond owner and operator households consumed relatively higher amounts of fish and other animal protein than the national average. On the average, fish represented nearly 70% of the total consumption of animal protein by the respondent household in both the thanas, quite similar to the national average Faturoti *et al.* (1996) showed that an investigation was carried out on the growth performance of

Indian major carps Catla (*Catla catla*), Mrigal (*Cirrhinus mrigala*), Rohu *(Labeo rohita*), under polyculture system with clarias (*Clarias gariepinus*) and tilapia (*Oreochromis niloticus*) using a 30.0% crude protein supplementary feed for 120 days in earthen ponds. Experimental fish were stocked at the rate of 10,000 fish ha^{-1} at the following polycultural combination for treatments 1-5, respectively: 1) clarias, tilapia, catla 2:1:2; 2) clarias, tilapia, mrigal – 2:1:2; 3) clarias, tilapia, rohu – 2:1:2; 4) clarias, tilapia, catla, mrigal, rohu – 2:1:2:2:2; 5) catla, rohu, mrigal – 1:1:1. They were fed twice daily between the hours of 9.00 and 16.00 daily at a total of 3% of their body weight using pelleted feed containing 30% crude protein for a period of 120 days. Treatment 4 was the most suitable polycultural combination with the best growth performance Alam *et al.* (1996) found that three indigenous carp species, *Catla catla* (Ham.), *Labeo rohita* (Ham.) and *Cirrhinus mrigala* (Ham.), and two exotic carp species, *Cyprinus carpio* and *Hypophthalmichthys molitrix* (Val.), were stocked together at a total density of 6000 fish ha super (-1) in the ratio of 11:22:14:14:11, respectively. Three pelleted feeds, maize gluten (MG), Cotton seed (CS) and fish meal (FM), were fed at 5% of the body weight of fish per day. The crude protein content of each feed was different. Growth rates for exotic species were significantly higher ($P<0.05$) on all feeds than growth of indigenous species. The best growth for both exotic and indigenous carps was achieved on fishmeal. Supplemental feeds made from locally available materials can enhance fish culture in Pakistan.

2.1.2. Lipid :

Dietary lipid serves both as source of metabolic energy and of polyunsaturated fatty acids essential for membrane structure and function (Cowey and Sargent, 1979). Experiments with cultured fish have shown that the optimum lipid intake is essentially similar to that of wild fish. A major reason for supplementing the diets of cultured fish with lipid is to spare the oxidation of dietary protein as an energy source. Combs *et al.* (1962) and Lowler *et al.* (1966) demonstrated a spearing action of peanut oil for protein on the diet of chinook salmon. Most of the experiments have been carried out on channel cat fish and rainbow trout to determine the level of dietary lipid that affords the maximal protein sparing effects. Yone *et al.* (1971) showed that crude diets containing 10% lipid resulted in superior growth and feed efficiency than similar diets containing 20% lipid. Stickney and Andrews (1971, 1972) observed that more rapid growth can be obtained in channel cat fish, *Ictalurus punctatus* on diets containing upto 10% lipid added as beef tallow, olive oil or menhaden oil than from vegetable oils when the fish are reared in their optimum temperature range (27-30^{0}C). Lee and Putnam (1973) raised rainbow trout at 12^{0}C) on diets containing upto 24% dry weight or herring oil and recorded excellent feed and energy conversions as well as growth rate. Artherton (1975) studied the effect of different levels of dietary lipid on the growth of rainbow trout. The fish were fed with two types of fat presented by cod liver oil lard at various levels. The results indicated that when cod liver oil was used as fat supplements, the food in take and weight gain was affected. Adron *et al.* (1976) fed the diets to turbot (*Scophthalmas maximus*) containing upto 9% dry weight lipid added largely as capelin oil at 15^{0}C and found that the weight gain and protein utilization of the fish increased upto the maximum level of the lipid in the diet. Higuera *et al.* (1977) and Reinitzetal (1978) reported the influence of high dietary lipid level on protein utilization in the rainbow trout, *Salmo gairdneri*, Viola and Rappaport (1979) studied the effect of feeding seven sources of lipid varying in the type of fatty acids at levels of 5% of the diet on the growth of carp and found that all the oils accelerated growth by 15-30% and the highest average weight occured when the diet was supplemented with the soybean fatty acids. Kubaryk (1980) tried to established optimal protein, energy ratio for Juvenile *Tilapia nilotica* by varying oil level upto 14% Viola and Amidan (1980) however, raised doubts on the capability of Tilapia to utilize oil efficiently on the basis of preliminary trials at the experimental station for intensive fish culture, Ginosar, Israel. Farkas *et al.*(1980) fed the carp on diets differing in total fat as well as linolenic acid content at different temperature and found a high depression of fat in the fish in low temperature as compared in high temperature. Ramchandra Nair and Gopakumar (1981) tested the inclusion of 5% of different oils in diets for *Tilapia mossambica* fry and found changes in the fatty acid profiles of the body fats after 6 months.

Reinitz and Yu (1981) found no adverse effect from the partial replacement of either soybean oil or fish oil with animal fat in diets fed to rainbow trout held for 182 days at 11^0C. Viola *et al.* (1981) observed that supplements of oil to the diet of carp *Cyprinus carpio,* increased gains by 50-80%. Viola and Arieli (1983) studied the effect of oil supplements to practical diets for *Tilapia* and found that the fat content of visceral of parts was increased by oil supplements but not the fat content of the remaining carcass. Davis and Robinson (1986) observed a significant depression in the juvenile Cray fish *Procambarur acutus acutus* when fed the diets, containing 9% or more lipids. There were, however, no significant differences in growth cray fish fed the diets containing 0-6% lipid. Tabachek (1986) showed that in the Arctic charr, *Salvelinus alpinus*, protein efficiency ratio and protein retention were directly related to the dietary lipid and inversely related to the dietary protein. Stickney and Wurts (1986) fed the fingerlings of blue Tilapia with a series of nine semi purified diets containing 0.0, 2.5, 5.0, 7.5 or 10% lipid in the form of menhaden or cat fish oil and observed best food conversion from the fish fed the 10% menhaden oil diet.

Huang *et al.* (1993) observed that this experiment carried out a quantitative analysis on blood biochemical components of silver and bighead carps, cultured with ammonium chloride, Urea and ammonium bicarbonate or organic fertilizer. The result indicates that, ammonium chloride could promote the growth of silver bighead carps, raise the blood-sodium and blood-sugar contents, increase free amino acid level in blood plasma of which, valine, leucine, and lysine is greater. Gui *et.al.* (1994) found that the dynamic changes of some blood parameters and oxygen consumption rate were determined in hybrid carp, mirror carp, silver carp, bighead carp and grass carp survived through the winter in northern China and raised at different water temperature (13^0C similar to -2^0C) under laboratory conditions. Based on the physiological changes, the cause of death for different kinds of wintering carps, the cold-resistance and survival ability through the winter were analysed. It was recommended that fragility of red blood cell (RBC), Plasma glucose content and plasma total lipid be used as physiological in for evaluation of survival ability of wintering fishes in northern China, Wu *et al.* (1995) showed that this paper deals with a comparison for the serum protein content and composition of silver carp, bighead carp, grass carp, hybrid carp and mirror carp during wintering in the northern China by the electrophoresis scanning technique of cellulose acetate membrane. The results show that: 1) The serum albumin contents of the five fishes are decreased as a result of a fall in temperature in wintering period. The decreased percentage are hybrid carp (48%) > grass carp (41.2%) > mirror carp (40.8%) > bighead carp (33.0%) >silver carp (31.5%). The changes of serum globulin contents in hybrid carp, bighead carp are obvious and the decrease rate are hybrid carp (21%)> bighead carp (16.8%) 2) the contents of serum albumin, serum globulin - 1 are globulin -2 in hybrid carp infected with lipid or thosis disease reduce significantly, and the contents of serum gamma - globulin increase considerably in comparison with that in the normal one.

2.1.3. Carbohydrate

Although carbohydrates are the cheapest source of food energy, they are not all equally well utilized by all animals. They supply less energy per gram than either lipid or protein. It has been seen that carbohydrate upto level of 25% in the died is as effective as fat as an energy source for several species of fish (channel cat fish, rainbow trout, plaice Cowey and Sargent, 1979). There are no actual carbohydrate levels recommended for fish requirements as they are capable of synthesizing carbohydrates from dietary lipid sources. However, carbohydrates are included in feeds as protein sparing energy sources, bulking and as binders. Schaeperclause (1933) suggested carbohydrate as a source of energy for carp and reported digestibilities from 32-92%. One of the first investigations on carbohydrate utilization by salmonids was made by phillips *et al.* (1948). They concluded that trout diets should not contain more than 12% digestible carbohydrates, higher levels resulting in low growth, 'high - glycogen' livers and increased mortality. Since the works of Phillips *et al.*(1948), various studies have shown that trout can utilize carbohydrate as a source of energy. Buhler and Halver (1961) found that Chinook Salmon tolerated high levels of dietary carbohydrate without the development of abnormal conditions. Tiemeier *et al.* (1965) found a sparing action of carbohydrate on protein when fed to channel catfish. Kitamikado *et al.* (1965) found that large amounts of starch in the diet of rainbow trout decreased the digestion of protein and therefore, decreased the amouont available for metabolism. Singh and Nose (1967) showed that higher levels of starch resulted in a sharp fall in digestibility for rainbow trout. Chiou and Ogino (1975) however, recorded high values for the digestibility of starch by carp. Nagai and Ikeda (1971) found that carbohydrates exceed neither protein nor lipid when these nutrients are mobilised as energy source. Luquet (1971) found that diets containing 30% protein and 50% raw corn starch could produce the same growth and better PER than diets with twice as much protein in rainbow trout. Shimeno (1974) showed that when carp were fed diets containing 3-47% of carbohydrate (starch) and 28-63% of protein (fish meal), the digestibilities of energy carbohydrate and protein were almost constant at any level of dietary carbohydrate being 87-91% and 88-89% respectively. Tiews *et al.* (1976) and Pieper and Pfeffer (1978) showed that trout can utilize the carbohydrate sources such as precooked gelatinized starch, sucrose and glucose. Edwards *et al.*(1977) fed group of rainbow trout fingerlings from 10 different families with each of three diets similar in protein and energy content but differing in the percentage of metabolizable energy present as carbohydrate and found best growth on the diet with the lowest (17%) and worst on the diet with the highest (38%) level of metabolizable energy from carbohydrate.

Rychly and Spannhof (1979) studied the digestibilities of three experimental diets of casein - gelatine basis with varying levels of carbohydrate and protein content after feeding to rainbow trout and observed that digestibility of the whole diet decreased significantly with increasing carbohydrate and decreasing protein level in the diet. Bergot (1979) fed rainbow trout with two levels (15 or 30%) and two sources (glucose or starch) of carbohydrates and concluded that under certain experimental condition, trout can tolerate upto 30% glucose in the diet and can use it for energy needs. Eckhardt *et al* (1981) use different sources of carbohydrates (wheat, potato and maize starch, sucrose and micronized wheat) in combination with white of egg in synthetic rations for carp. They found that wheat starch proved the most suitable carbohydrate for synthetic rations. The studies of Hilton and Alkinson (1982) showed that the optimum level of digestible carbohydrate (cerelose, D-glucose) in isocaloric and isonitrogenous practical diets for rainbow trout was 14% of the diet.

Hilton *et al.* (1983) studied the effect of increased dietary fibre on the growth of rainbow trout and concluded that dietary fibre levels for rainbow trout should be less than 10% of the diet. Anderson *et al.* (1984) fed the juvenile *Oreochromis niloticus* with experimental diets at three levels (10%, 25% and 40%) of dietary carbohydrate containing glucose, sucrose, dextrin, starch and α- cellulose and found that growth and carcass fat increased as the level of glucose, sucrose, dextrin and starch was increased from 00-40%. Contrastly, as α–cellulose was increased from 00-40%, growth, food conversion, NPR, carcass fat and condition factor were reduced. Mukhopadhyay *et al.* (1986) observed a steady increase in PER concomitant with increases in carbohydrate and gross energy in the diet for *Clarias batrachus* indicating a protein sparing action of dietary carbohydrate. Degani *et al.* (1986) used wheat meal, bread meal, soluble corn starch, native potato starch and sorghum meal as different carbohydrate sources in 30% isonitrogenous diets for European eels and determined the growth, body composition and feed utilization of the fish. They recorded similar protein percent in whole carcass for all diets but percent of fat was higher with potato starch. Feed conversion, protein metabolism and energy retention were however, higher for eels fed wheat meal or bread meal than the other carbohydrates. Degani (1987) determined the influence of different dietary carbohydrate sources on soluble protein, enzyme activity (aldolase) and glucose concentration in muscle and liver of European eel, *Anguilla anguilla.*

2.1.4. Energy

The energy levels in fish feeds have not been treated seriously because a deficiency or excess of energy will not affect the health of fish appreciably and practical feeds prepared with commonly available in gradients are not likely to be extremely high or low in energy. Energy is essential in that it contributes to the utilization of all nutrients in a diet. Schaeperclaus (1933). Showed that the total energy required varied with the species. Phillips and Brockway (1959) reported similar energy requirement for brook, brown and rainbow trout. Winberg (1960) stated that between 14% and 33.1% of the calories consumed were deposited in the tissues of pike, indicating a usage of energy between 67 and 86%. Tiemeier *et al.* (1965) determined that 1700 Kcal were required to produce a pond (3740 Kcal Kg^{-1}) of channel cat fish. Fowler *et al.*(1966) found that the diet containing 2350 Kcal Kg^{-1} reared chinook Salmon at a rate of 1.81 Kg of food per Kg of fish produced, was equivalent to 4700 Kcal Kg^{-1} of fish produced. Levels and sources of energy in fish rations can significantly affect fish growth and are of definite economic importance in commercial feeds (Halver, 1972). Adron *et al.* (1976) fed seven diets containing 350g protein Kg^{-1} with energy level varying from 1860 to 3150 Kcal Kg^{-1} to groups of turbot and found that weight gain and protein utilization increased with increasing dietary energy level at a constant dietary protein level. Sen *et al.* (1978) showed that the optimum growth of Indian Major Carp fry at a gross energy level of 492 Kcal $100g^{-1}$ might perhaps be due to the maximum metabolizable energy of feed containing 45% casein and 26% dextrin. Takeuchi *et al.* (1979) found that when carp were fed on various diets containing different amounts of carbohydrate and at a fixed protein level of 32%, the enrichment of the digestible energy (DE) content of 320 to 460 Kcal 100 g^{-1} diet (by addition of lipid at levels of 05-15% to the diets) resulted in improvement in growth feed conversion or the value of net protein utilization (NPU). They concluded that both carbohydrate and lipid have good food value for carp as dietary energy source. Viola *et al.*(1981) observed that for carp, carbohydrate may supply a large part of the necessary energy and therefore, oil in the diet is not necessary. Daniels and Robinson (1986) studied the effects of Different dietary levels of protein and energy on growth and body composition of juvenile red drum, *Sciaenops ocellatus* grow in low salinity environment. Data from their experiments indicated that 1.70 x 10^4 KJ g^{-1} and 1.72 x 10^4KJ g^{-1} of dietary energy were adequate for good growth and high quality body composition at 22 to 26^{0}C and 26 to 33^{0}C respectively. Mukhopadhyay and Hajra (1986) studied the intestinal protein break down and liver protein synthesis in air-breathing cat fish fed isonitrogenous diets having variable energy levels. They showed that the caloric density should preferably remain arround 383 K cal 100g^{-1} of feed in *Clarias batrachus* at 33% protein level for better weight gain.

2.1.5. Vitamin :

The recommended dietary levels of vitamins for certain cold water fish have been included in a publication of National Research Council (1973). Those for warm water fish are included in the publications of several workers. Wolf (1951), Phillips *et al.* (1955, 1956,1958), Halver (1957) and coates and Halver (1958) determined the need of trout and salmon for 10 numbers of vitamin B complex. Dupree (1966) established the necessity of channel cat fish for some of the fat and water soluble vitamins. Phillips and Livingstone (1966) found a seasonal variation in the requirement of brook trout for pyridoxine. The requirements of young carp for most of the water soluble vitamins were reported by Japanese workers (Aoe and Masuda, 1967 a, b; Aoe *et al.* 1967, a, b, c; Aoe *etal.*, 1968; Aoe *et al.*, 1969; Aoe *et al.*, 1971; Ogino, 1965; Ogino *et al.* 1970). Halver and Coates (1957) deviced a casein - gelatine diet for estimation of requirement of most vitamins in which different levels of each vitamin were provided, with other vitamins being fixed at a specific composition level. Arai *et al.* (1972) established the essentially of water soluble vitamins for young eel *Anguilla japonica*. Lovell (1973) and Andrews and Murai (1975) proved the essentiality of ascorbic acid for channel cat fish which has been conclusively demonstrated by growth studies. Lovell and Li (1978) demonstrated that channel cat fish fingerling required a dietary source of vitamin D for normal growth and some mineralisation. Butthep *et al.* (1985) studied the specific water soluble vitamin requirements of the cat fish *Clarias batrachus* on the basis of growth and mortality. Suhenda and Djajadiredja (1985) determined the need for supplementation of vitamin premix in common carp fingerling diet and the effects of varying levels of vitamin premix on growth, survival, feed efficiency and protein retention.

2.1.6 Minerals :

Mineral requirements of fish are very difficult to determine because the fish have the ability to absorb ions from the external environments. For trout and carp, standard mineral salt mixture is used in test diets for laboratory animals have proved adequate. These contain calcium, phosphorus, potassium, chloride, magnesium, iron, manganese, zinc, copper, iodine, cobalt and florine (Hastings, 1979). Arai *et al.*(1971,1974) have found that the eel, *Anguilla japonica* required about twice the mineral level as salmonids, upto 0.8% in a diet of purified ingredients. Ogino and Takeda (1976) found that both common carp and rainbow trout grew on a purified diet containing calcium as low as 30.0 mg. per 100 g but with adequate amount of phosphorus. Andrews *et al.*(1973) opined that the inclusion of high levels of fish meals in rations for cultivated fish obviated the need for supplements of calcium and phosphorus. They, in experiments with channel cat fish made variations in both dietary levels (calcium 0.5-2.0%, phosphorus 0.5-1.2%) and dietary ratios of these minerals. The optimal levels of available calcium and phosphorus for better growth were recorded to be 1.5% and 0.8-1.0% respectively. Ogino and Takeda (1976) estimated the optimal level of phosphorus for growth of carp to be with I the range of 600 to 750 mg per 100g of diet. They dietary calcium level was found to have low effect on the requirement of phosphorus. Ogino *et al.* (1979) investigated on the availability of dietary phosphorus in carp and rainbow trout. Takeuchi and Nakazoe (1981) studied to effects of dietary phosphorus on lipid content and it's composition in carp. Onishi *et al.*(1981) and Nakamura (1982) studied the effects of dietary phosphorus and calcium content on the absorption of phosphorus in the digestive tract and changes in the hepatopancreatic enzyme activities respectively. Viola *et.al.*(1986) recommended a minimum of 0.4% available phosphorus for intensive carp culture. Ogino and Chiou (1976) have shown a magnesium requirement of 0.04-0.05%% in the dry diet of carp. Evtushenko(1994) showed that the dynamics of micro elements (Fe, Mn, Cu, Zn)content in different organs tissues (liver, white skeleton muscles, blood) of common carp (*Cyprinus carpio*) grown in Kiev warm water fish farm (Ukraine) had been studied. It has been found that these indices change and are differentially oriented in different tissues. They have phase characteristics. This phenomena may be probably explained as a result of changes of needs in microelements in common carp's organism depending on intensity of metabolic processes.

2.2. DIETARY PROTEIN SOURCE

The high biological value of fish meal for many cold water and warm water fishes has led to a considerable dependence on this commodity incomplete commercial fish diets for higher fish production. In recent years, the supply of good quality fish meal has become uncertain and also it's price has gone up rapidly. Several attempts have therefore, been made to substitute other proteins either wholly or in part for fish meal but such substitutions have sometimes resulted in a market fall in growth rate (Cowey and Sargent, 1979). Replacement of fish meal in the diets of warm water fish species has not received much attention. Since plant proteins are cheap and easily available, they seem to be most appropriate replacement of fishmeal. Cowey *et al.* (1971) replaced approximately half of the protein in a 40% cod meal protein diet with soybean meal and found a depressed growth rate and protein utilization in the plain, *Pleuronectes platessa*. Hepher *et al.* (1971) reported that carp fed on diets containing fish meal grew better than those fed on diets containing soybean meal. Andrews and Page (1974) replaced the dietary menhaden meal isonitrogenously by soybean meal in diets (35% protein) for channel cat fish and found a depressed growth and food utilization even though the soybean meal was supplemented with methionine, cystine and lysine to the levels found in fish meal. By contrust with the experiments of Andrews and Page (1974), Ramsay and Ketola (1975) achieved marked improvements in the growth rate of rainbow trout with a diet containing 40% crude protein with soybean meal as the sole protein source by supplementation with amino acids. Krishnandhi and Shell (1967) however, found a good growth of channel cat fish on a 30% protein diet containing 50:50 mixture of soybean and casein proteins as they did no a diet containing casein alone. Cho *et al.* (1974) showed that the herring meal content of the diet for rainbow trout could be reduced from 35% to 18% with soybean meal without concomitant loss of protein utilization.

Koops *et al.* (1976) replaced fish meal isonitrogenously at two protein levels (39 and 47%) with either soybean meal or soybean protein in the diets of rainbow trout. They found a depressed growth at higher levels of replacement but 25% of the dietary fish meal could be replaced by soybean protein. Davis and Stickney (1978) found that at a level of 36% protein, *Tilapia aurea* grew well when fish meal was replaced with soybean meal. All the diets in their studies were supplemented with methionine to bring it's total in the diet to 1.1%. Dabrowski and Kozak (1979) fed the grass carp fry with the diets based on fish meal and soybean meal during a period of 70 days and obtained best results with a diet containing 40% of fish meal when growth increment, PER and apparent UPU amounted to 20.08, 1.26 and 20.3 respectively. Atack *et al* (1979) reported that soybean protein concentrate was poorly utilized by carp as the sole protein source in 30% protein rations.

Viola *et al.* (1981) performed experiments with carp in cages and in experimental ponds using pelleted diet with 25% crude protein. Fish meal was the only source of protein in the control diet. They found that substitution of most or all of the fish meal by soybean meal supplemented by 10% oil, 0.4% methionine and 0.4 - 0.5% lysine helped to achieved gains and protein and energy retentions equal to those of the control rations. Partial replacement (40% of the fishmeal) in pond required only supplementation of 5% oil and methionine to attain equal growth performance. Jackson *et al.* (1982) tested Copra, groundnut, soya, sunflower, rapeseed, cottonseed and leucaena meals individually at various inclusion levels in comparison with control diet (30% protein) containing fish meal for male tilapia in a series of three trials. All the protein sources except leucaena promoted reasonable growth even at high dietary inclusion level. At the 25% plant protein level, the diet containing oil seed meals resulted comparable growth to the fish meal control, whereas at the 50% levels, growth rate was lower with Copra, groundnut and soya lower growth rates were recorded at 100% plant protein levels than the controls (cotton seed, soya and groundnut in declining order). Viola and Arieli (1983) found that soybean meal could be used to replace upto half of the fish meal in tilapia feeds of 25% protein control without requiring any other supplements.

In addition to the soybean meal, several other protein sources have been examined in fish feed. Ogino and Chen (1973) determined the biological values of proteins from animal sources such as egg yolk, casein and white fish meal and found the values to be higher than those from vegetable sources. Akiyama *et al.*(1984) fed chum salmon, *Onchorhynchus keta* swimming fry with fish meal diets supplemented with silk worm pupae powder (5%), dried beat liver (5%), krill meal (5%) or earthworm powder (5%) at the expense of fish meal or substituting glucose (13%) for dextrin. They recorded best growth performance and feed efficiency with earth worm diet. Substitution of glucose and supplementation of silk worm pupae or beaf liver failed to improve the growth rate but significantly improved feed efficiency. Viola and Zohar (1984) evaluated poultry meat meal, feather meal, single cell protein ('Pruteen'), dehulled cotton seed meal and urea as sources of protein in the feed of market size hybrid of tilapia (*Oreochromis*). They found that poultry meal, 'pruteen' and cotton seed meal as replacement for 10% fish sustained growth at an equal rate.

Feather meal at this level of replacement reduced growth by 7.0% and urea reduced growth proportionately to it's rate of inclusions. Venkatesh *et al.*(1986) showed that animal protein component was better source of protein in the diet of *Clarias batrachus* for satisfactory growth. They suggested that fish meal and silk worm pupae may be incorporate in the operational diet of the fish with advantage. Austreng (1979) evaluated blood as a good source of protein in fish diets. Blood protein have been tested in diets for salmonids by several authors. Fowler and Banks (1976) replaced fish meal with spray dried blood meal in starter diet for chinook salmon, *Onchrhynchus tschawytscha.* They recorded a positive effect when upto 5% of the fish meal was replaced by blood meal. But there was a pathological effect when as much as 17.5% of the fish meal was replaced by blood meal. Von Schulz *et al.*(1982) compared casein gelatin (75:25) protein in a standard died to a blood - feather meal protein (50:50) in test died for rainbow trout. When one third of the standard protein was substituted for the test protein, there was little difference in weight increase but when two-third or all standard protein were substituted, the weight increase was reduced. Asgard and Austreng (1986) tested blood from the slaughtering of cattle as a protein source in moist diet for large rainbow trout (*Salmo gairdneri*) and salmon (*Salmo salar*). They used control diets constraining fish offal and binder meal in the test diets. Blood replaced half the amount of raw fish or fish offal which represented nearly 20% of the protein in the feed. They found no negative effect with respect to weight increase, health, body composition or organoleptic properties of the fish when blood was used in the diet or when formic acid was used as preservative instead of freezing the fresh commodity. Teshima *et al.*(1986) used casein-Gelatin (3:1), Casein, Gelatin, albumin and a mixture of casein and crystalline amino acids (1:1) as protein sources in diet of *Tilapia niloticus* and found a higher nutritive value of caseingelating (3:1) and casein as a protein source. Janson and Spanhoff (1987) studied on the utilization of *Neomysis integer* by rainbow trout parr under brakishwater condition and found that *Neomysis* Pellets were just as efficient as conventional feed in respect of growth.. The feeding efficiency was comparable with that of obtained with krill.

Attempts have also been made to evaluate unconventional sources of dietary protein for fish. Hepher *et al.*(1978) recorded a better growth of fish with a soybean - fish meal diet when soybean meal was replaced by algal meal (an unspecified mixture of *Chlorella and Euglena*) isonitrogenously, than soybean meal diet. Meske and Pfeffer (1977) developed a diet consisting a mixtre of soybean meal, acid whey powder and fat in a ratio of 4:5:1 plus vitamins and trace elements for carps. This feed was found to be superior to a fish meal based trout diet in terms of growth and utilization. Lukowicz (1978) replaced fish meal with meal of Antarctic Ocean krill (*Euphasia superba*) in carp diets and found that krill meal was comparable with that of fish meal.

Meske and Pfeffer (1978) reported the replacement of casein by krill meal in carp diets. They recorded optimum growth with diets containing 40% protein and a casein to krill ratio of 5:5. Schlumberger and Labat (1978) fed carp fry on moist diets prepared from industrial waste. Paper mill wastes and two different powder wheys were mixed with fish meal, cod liver oil, urea, starch and vitamins. The high mineral and fibre content in paper mill waste resulted in extremely poor growth and food consersion. Kausar and Khan (1992) showed that effect of three types of feeding systems was studied on the growth of *Cirrhinus mrigala* and *Labeo rohita.* The average body weight of *C. mrigala* a *L. rohita* at the time of stocking was 10.5 g and 7.0 g, respectively. Fish were reared for a period of one year. Average weight gain of

C. mrigala and *L. rohita* in pond fed with biogas waste + fertilizer was found as 289.5g and 343g, respectively. However, the fish in ponds supplemented with cotton seed meal + rice bran exhibited body weight gain as 463.5g and 493 g, respectively. Medda *et al.*(1993) found that supplemental feeding of two major Indian carps, *Catla catla* and *Labeo rohita* during their early developmental periods by a suitable combination of vitamins, amino acids and rice bran resulted in a differential impact on three important growth parameters, namely length, weight and protein content of the species. Two-way analysis of variance test revealed a significant group and feed specific variation of the relative growth rate of the two species in response to the experimental feeding. The main effects and their interaction experienced a significant specific growth rate pattern variation implying an instantaneous or specific rate of growth identified by the difference in natural logarithm of the initial and final weight over the period of experimentation. Analyses also revealed both length and weight wise significant variation of the main effects and their interaction in response to the feed treatment on the two carps.

Rafael *et al* (1993) the authors studied and experimental diet containing whey, swine blood, fish and hatchery wastes, orange pulp, carrots bagasse, manure and food residues from a food processing factory. During six months the length and weigh of the fish were measured. A 1/10 of Ha. pond divided by a middle meshwork was used. Tilapias (*Oreochromis aureus*) and Israeli *carps* (*Cyprinus carpio - specularis*) in a polyculture were homogeneously distributed in each pond side (2 fish m^{-3} of water) to receive either commercially available food (purina) or experimental feed stuffs. Both diets were isocaloric and isopoteinic. Daily supplies throughout 6 months corresponded to 1-3% of fish biomass. Biomass, body weight and size of the experimentally fed animals were higher than controls. Conversion rate of experimental group was similar to control. The waste made diet might efficiently substitute for the commercial diet. Rice *et al.* (1994) found that one of the major expenses in any fish culture operation is the cost of feeds for the fish, and the profitability of many operations is frequently tied to the cost of feed. Hatchery production of fish larvae most often requires the expensive production of live food (Phytoplankton and Zooplankton), because artificial diets are either not available or are grossly inadequate. Artificial diets are available for growout of fingerlings and adults of most cultured fish species, but they may be less than optimal because they had been formulated for another species. For example, in the United States, commercially formulated diets are available for cat fish and salmonids, but these diets have been used without modification to feed other species of fish, including hybrid striped bass, tilapia, carps and others. Less than optimum diets for growout of fingerlings will result in lowered growth rates and excessive waste, either by excessive fecal material, excessive urinary nitrogen, or uneaten food. Thus, less than optimum diets are not only wasteful in terms of money spent on feed, but they can cause increased waste management problems. The key challenge of producing production feeds is the maximization of fish growth with a minimization of waste. Anicie *et al.* (1995), that the experiment was performed from August 20 to October 2 1991 in four 2200^{-m} super (2) ponds, each of which was stocked with 10,000 8.7 g one year old carp fingerlings. The fish in two control ponds were fed on 32% protein pellets, while those in the other two ponds received the same pellets with 40 ppm of a nutritive antibiotic (virginiamycin). The water level was 180 cm and it's quality was good. At harvesting, there were no significant differences (P>0.05) among the individual masses of carps from the four ponds. Food conversion rate was better in ponds where the nutritive antibiotic was applied (6.8 - 17.0%) and survival was 8% higher but this was not statistically significant (P>0.05). Relatively low effects of the growth promoters could be due to the low stocking density [4-5 fish m^{-1} super (2)], which allowed natural food to predominate. This fact confirms the results of other researchers, who believe that the high nutritive value of natural food diminishes the nutritive activity of virginiamycin. Miah *et al* (1996) showed that the experiment was made to determine the effects of various inputs viz; organic manure (X sub (1)), inorganic fertilizers (X sub (2)), supplementary feed (X sub (3)), lime (X sub (4)), and pond size (X sub (5)) on fish yield (Y). A simple correlation coefficient (r) was found out between yield (Y) and each of the five independent variables (X sub (1) to X sub (5)) under treatments T sub(1) and T sub (2). The first treatment (T sub (1)) consisted of supplementary feed (100% rice bran) and second treatment (T sub (2)) consisted of supplementary feed (25% mustard oil cake plus 75% rice bran). The results of the co-efficient correlation were X sub (3) (4 sub (1) = 0.99, r sub (2) = 0.99), X sub (1) (r sub (1) = 0.93, r sub (2) = 0.91) and X sub (2) (r sub (1) = 0.76, r sub (2) = 0.75) and showed highly positive correlation (P<0.01) with fish yield. Pond size (X sub (5)) showed positive correlation (P<0.05) with fish yield in case of T sub (1) but it showed significant effect in T sub (2). Lime (X sub (4)) showed negative correlation with fish yield. Among the inputs supplementary feed, organic manure and inorganic fertilizers had significant effect on fish yield in farmer's ponds. The average fish yield obtained was 1, 640 and 2, 795 kg ha^{-1} 7 $months^{-1}$ under the treatments T sub (1) and T sub (2) respectively.

Analysis of variance showed significant difference (P<0.05) in fish yield under both the treatments and among the publications. Economic analysis revealed a net profit of 52,015 and 87,621 TK ha^{-1} 7 $months^{-1}$ in treatments T sub(1) and T sub(2) respectively. The predicted average yield equation are also presented in this papers.

Wu *et al.* (1996) observed with a compound ecological preparation (a living bacterium preparation of *Arthmobacter* sp. and *Lactobacillus casei*) used as pilled ration additive, a trial of raising overwintering for hybrid carps ability was carried out in 1994. After 30-50 days, the test and control fish groups was infected with pathogenetic bacteria under lower temperature condition. The experimental result showed that the survival rate of the test group with lethal dose 50% (LD sub (50)) was apparently higher than that of the control and the serum total protein and r-globulin, serum glucose content and total lipid, fragility of RBC brain AchE, leucocyte phagocytosis, etc. were all higher than those of the control too.

2.3 SUPPLEMENTARY FEEDING IN INDIA

Most of the work done in India on supplementary feeding are concentrated on feeding the fry at the hatchery or nursery stage. Soon after stocking, the feeding requirements of spawns of Indian Major Carps are large. Hence, the availability of food becomes a limiting factor in high density rearing. This can be overcome by supplementing the natural food with suitable artificial diets (Jhingran, 1983). The commonly used supplementary feeds for carps consist of mixture (1:1) of rice bran and one of the locally available oil cakes. Mitra and Mahapatra (1956) conducted experiments on major carp fry with different quantities of Zoopankton, phytoplankton, cowdung and oil cake and found that survival was highest with oil cake and lowest with cowdung. Das (1958) found that when carp spawn was reared in manured nurseries providing various artificial feeds with different combinations of protein, fat, carbohydrate, vitamins etc., maximum growth was obtained with the feed having a combination of hydrolysed protein and carbohydrate (50:30). According to Mitra and Das (1965), til oil cake, rice powder and black gram account for higher survival and yields of carp spawn than rice bran. According to Lakshmanan *et al.* (1967), an artificial feed comprising a mixture (N:P:C mixture) of dried finely powdered and sieved aquatic insects, back swimmers, small prawn and shrimps and cheap pulses, in the ratio of 5:3:3 gives better results in enhancing better growth and survival of the spawn than the rice bran and mustard oil cake mixture Chakraborty *et al.* (1973) conducted experiments on the usefulness of various feet mixtures *vis-a-vis* zooplankton in spawn rearing and found that zooplankton alone was the best food for *Catla catla*. *Labeo rohita* and *Cirrhinus mrigala*. Among the various feeds, namely mustard oil cake - rice bran mixture, groundnut oil cake - wheat bran mixture, silkworm papae (tasar silk worm), soybean and plant waste, soybean gave the best results in *Catla catla* and silk worm papae and groundnut oil cake - wheat bran mixture in *Labeo rohita* and *Cirrhinus mrigala*. Sen (1974) suggested feeding the carp spawn with finely powdered mixture of an oil cake and rice bran preferably groundnut oil cake and rice polish (1:1 by weight). Chakraborty and Kar (1975) observed that protein concentrate containing 55% protein to be an acceptable feed by mrigal spawn and common carp fry. Tripathi *et al.* (1979) obtained a high survival (over 80%) of spawn using a diet comprising a mixture of fish meal, groundnut oil cake and rice bran (1:1:1) containing 26.7% protein and 32.5% carbohydrate with an energy content of 300 Kcal per 100g. Sinha and Saha (1980) fed the fingerlings of Catla, rohu, mrigal, silver carp, grass carp and common carp with a commercial fish feed and obtained a gross and net productions of 4636 kg and 4483 kg ha^{-1} $year^{-1}$

respectively which was well comparable to production obtained by feeding mustard oil cake and rice bran mixture. Kowrtal *et al.* (1982) demonstrated the importance of weaning of hatchlings of catla, rohu and mrigal on artificial diet and the utility of microglobular fish feed with high protein (58%) and low carbohydrate (18%) level for better growth and survival under tropical conditions, Venugopal and Keshavanath (1984) studied the influence of conventional feed and three formulated diets on the proximate composition of muscle of three carps catla, mrigal and common carp. They found to definite influence of the diets on the ash and carbohydrate level of fish muscle.

Das (1959) found enhanced survival rate of major carps spawn with a diet consisting of B_{12} and cobalt nitrate combined with stomach extracts of goats. Das and Krishnamurthy (1960) recorded bother survival of carp fry during the first month of their life with antibiotics and B-complex. Das (1960) demonstrated that when carp spawn were fed by standardised preparation of yeast, vitamin B12, ruminant stomach extracts with cobalt nitrate and ruminant stomach alone, significant differences in the survival rate were observed.

Reddi *et al* (1971) found quite satisfactory growth of carp spawn fed with poultry pollets containing 16.0% of protein supplemented with vitamin A, B_{12} and D_3. Sen and Chatterjee (1979) used 15 different growth promoting substances and found that cobalt chloride at 0.01 mg Starch at 3.44 mg, boron 1.00 mg and manganese at 0.01 mg day^{-1} per fish enhanced the survival and growth and survival of rohu fry significantly. Mahajan and Sharma (1976) observed a better growth and survival of common carp and rohu fed with the diet containing vitamin and antibiotics. A combination of B-complex and yeast gave the best results in terms of survival and growth.

Various authors have suggested a use of powdered algae and aquatic weeds as fish feed. Experimental trials have shown that green algae (Gupta and Ahmed, 1966; Singh, 1970; Singh and Bhanot, 1970 and Singh *et al.*, 1979) and fresh *Spirodela polyrhiza* (whole plant) and leaves of *Nymphoides cristata* (Patnaik and Das, 1969) are highly nutritive and cheap feeds for carp. Patra and Roy (1988a) obtained a better growth of *Labeo rohita* by feeding a pellet containing 90% powdered *Hydrilla verticillata* than that obtained by feeding a mixture of rice bran and mustard oil cake.

Sehgal and Joshi (1975) reported improved technique of artificial feeding of the brown trout (*Salmo trutta fario*) and rainbow trout (*Salmo gairdneri*) in Kashmir to control whirling disease associated with malnutrition. Sehgal *et al* (1976) conducted experiments in Kashmir trout farm on the efficiency and cost of dry compound pelletised feed in relation to conventional feed. They found better conversion of dry pelleted feed compared to conventional feed (dry silk worm pupae).

Few experiments have also been carried out on the nutritional requirements and supplementary feeding of mullets. Different feed mixtures using low cost ingredients were formulated in varying proportions recording 05 - 10% better growth in *Liza tade* (Roy, 1980; Roy and chakraborty, 1980) and 10% in case of *Liza parsia* (Karmakar *et al.*, 1980). Chakraborty *et al* (1981) conducted experiments to study the effect of fertilization and supplementary feeding on the growth and survived of *Liza parsia*. They recommended a mixture of wheat flour and fish meal (1:1) as a supplementary feed in addition to fertilizer during nursery rearing of *L. parsia* considering both growth and survived.

Work on the preparation of practical pelleted feeds for use in cultural operation is very much limited. Varghese *et al.* (1976) conducted feeding experiments with protein rich pelleted feed (containing fishmeal, rice bran, groundnut oil cake, rice flour and mineral mix) for common carp and found 50% more production compared to those fed with a mixture (1:1) of rice bran and groundnut oil cake. Jayaram (1978) recorded maximum growth of catla and common carp with pelleted feed containing silk worm pupae as major source of protein. Rohu, on the other hand, registered the highest growth with pellets incorporating fish meal as the major source of protein.

The work on nutritional requirement and supplementary feeding of air breathing fishes are very limited. Tripathi and Sharaf (1974) carried out experiments to evolve artificial feed for *Clarias batrachus*. Pal *et al.* (1977) conducted an experiment with six different types of feeds (wheat flour, rice bran, soybean powder, prawn meal, zooplankton and cooked hen egg) on three day old spawn of *Anabas tertudineus* and found that the young larvae could be reared upto fry stage of 15 day old on cooked egg diet with over 70% survival. Reddy and Sakuntala (1979) used oligocheat worm, *Tubifex tubifex* as food for *Heteropneustes fossilis* and studied the effects of different feeding rates on food intake, growth and conversion efficiency. A cheap feed has been formulated for *Clarias batrachus* in the form of compost of cowdung, mustard oil cake and water hyacinth (Workshop report, CIFRI, 1982). Niamat and Jafri (1984) studied the growth response and survival of air-breathing cat fish *Heteropneustes fossilis* fed compounded pelleted diets and recorded a 100% survival with pelleted feed. Patra and Roy (1988b) fed four formulated pelleted diets containing 25%, 30%, 35% and 40% crude protein levels using carcass waste as the major protein source. They recorded better growth and feed conversion rate in *Clarias batrachus* with a diet of 40% crude protein level. Bhat *et al.* (1986) observed that utilization of locally available material suitable for feeding carps is one of the easy means to reduce the cost of production with this objective, 2 new fish feeds were formulated: deoiled soyaflour (Pellets B) and squilla meal (Pellet SM). These diets were evaluated in relation to a fish meal-based diet (Pellet FM) by the growth performance of rohu, common carp and silver carp. The average growth of all 3 species grown on fishmeal-based diet was marginally superior to that obtained with the other 2 diets, without any statistical difference at 5% level of significance. Renukaradhya and Varghese (1987) found that the four dry pelleted feeds containing 20%, 30%, 40% and 45% protein were formulated incorporating casein as the main source of protein for use in carp nutrition studies. The caloric content in all the feeds was maintained constant. This test has revealed that the diet containing 20%, 30% and 40% protein had better stability than that containing 45% protein. This was due to the relatively higher fat content in the former three diets. However, all the feeds were sufficiently stable at the end of one hour in which time carps are known to utilise supplementary diets.

Sharma *et al.* (1987) showed the experiments were conducted to determine the biological performance of some organic and inorganic feeds on common carp fingerlings (*Cyprinus carpio*) growing under sub-mountain conditions in Himachal Pradesh. Four different feeds were used, alone or in combination, namely: gobar gas slurry, silk worm pupae meal, mustard cake and wheat bran, and feed pellets. Maximum growth was recorded for carps fed as the gas slurry + silk-worm pupae meal, followed by those fed on the gas slurry + feed pellets. Phadate and Srikar (1988) showed that three formulated feeds (protein-rich, carbohydrate-rich and lipid-rich) were fed ad libitum for 60 days to fingerlings of *Cyprinus carpio*, *Catla catla* and silver carp *Hypophthalmichthys molitrix* and starved thereafter for 10 days to study their effect on growth and digestive protease activity. Protease activity was highest in all 3 species when they were fed on protein-rich feed. Carbohydrate-rich feed had a slightly stimulating effect, while lipid-rich feed had a slightly stimulating effect, while lipid-rich feed had a marked negative effect on the enzymatic activity. Growth was higher on protein-rich feed, followed by lipid-rich and carbohydrate-rich feeds. The extent of growth correspondent to protein content in the feeds. During the starvation period, there was a decrease in the activity accompanied by stagnation in growth. Deb and Varghese (1988) showed that the equal number of fingerlings of Catla, rohu, mrigal and common carp stocked together increment cisterns at a total density of 8000 fishes ha^{-1} were fed pelleted feeds incorporated with 17 alpha-methyl testosterone (MT) at concentration of 0, 1, 3 and 5 mg kg^{-1} (ppm) diet, for 90 days, while catla, rohu and common carp grew faster in 1 ppm MT treatment, mrigal responded better to 3 ppm treatment. Difference in growth between the treatments was significant, excepting between control on 5 ppm treatment. Fishes receiving 1 ppm MT showed higher food conversion efficiency. Ramaiah *et al.* (1989) found that the present report deals with the effect of sulphomerazine, sulphadimidine and sulphadiazine on the growth of mrigal (*Cirrhinus mrigala*) fed 20 mg. Suphonamide 100g $fish^{-1}$ day^{-1}. These drugs were chosen as they attained rapid and higher tissue concentrations both in rohu and mrigal fingerlings and inhibited *in vitro* 3 strains of fish pathogenic bacteria, *Aeromonas hydrophila*, *Pseudomonas fluorescens* and *Proteus vulgaris* isolated from diseased carps.

Sharma *et al.* (1990) found that the changes in protein, lipid and carbohydrate levels in the larvae of 3 Indian major carps viz., *Catla catla, Labeo rohita* and *Cirrhinus mrigala*, were studied to understand their relative importance in energy metabolism during the early stages of development. Total proteins increased with development, indicative of a role in morphogenesis. Lipids showed steady decline with development suggesting utilization for the energy needs to the larvae. Glucose did not show a consistent trend, but glycogen declined with development. Thus lipids appear to be the principal source of energy during larval development in the Indian major carps. Jadhao and Prasada (1991) found that this is aimed at investigating the use of less expensive diets in growth of fingerlings, of *Labeo rohita* such as feeds prepared from the waste of abattoirs and fish markets, eg. goat viscera and fish viscera respectively in combination with rice bran. The results suggest that feeding spawn of major carps with ground nut oil cake and rice polish in 1:1 proportions gives better survival and growth. The growth rate was highest when the fingerlings were fed with fish viscera in combination with rice bran, as compared to the fingerlings fed with goat viscera in combination with rice bran or ground nut oil cake in combination with ricebran. Khan *et al.* (1991) observed this study evaluates the nutritional efficacy of locally available by-products of vegetable oil industry (oil cakes) in dietary formulations for *Labeo rohita* fingerlings. Six different iso-caloric 3% crude protein ratio of 7.63 cal g^{-1} protein, were formulated. These were fed six days a week, twice daily at 0800 and 1600h., at the total rate of 4% body weight. Water temperature during trial was 26 plus or minus 1 degree C. The soybean oil cake, which is locally available at low cost, can be used as one of the potential dietary feed stuffs in developing cost effective artificial feed for the fingerling of *L. rohita* and other Indian Major Carps. Murthy and Devaraj (1991) showed that the use of the floating aquatic weed, *salvinia*, in feed for grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) fingerlings was studied. Both *salvinia* based feed (SF) and control feed (CF) was fed at the rate of 5% of the body weight of fish in an experiment conducted for 112 days in 20 m super (2) cement cisterns with triplicates for each treatment. Statistical analysis of results indicated that there was no significance at 5% level between the fishes fed by *salvinia* based feed and control feed on their growth. Bandyopadhyay *et al.* (1991) studied in this investigation an attempt was made to study the growth, survival and production to grass carps *Ctenopharyngodon idella* by rearing in the plastic cages. Fish were reared in three circular cages (each volume of 3 cu.m.) made up of hollow aluminium frame enclosed with nylon net (6mm mesh) installed in a 2 ha. Water body. Grass carp fingerlings were stocked at 33, 50 and 67 per cu.m in different cages. The total production range of *C. idella* was found higher than *Cyprinus carpio* and *Catla catla* as reported from cage culture in Indian water. Murthy and Varghese (1993) showed that a growth study was conducted to determine the quantitative dietary requirement of the essential amino acid, lysine for the growth of the India Major Carp, *Labeo rohita* (Rohu) juveniles. Six isonitrogenous purified diets incorporating casein and gelatin as intact protein supplemented with crystalline amino acids were formulated. This formulated diet were fed to rohu twice a day for 8 weeks. Maximum growth and survival and lowest FCR was obtained at 2.24% of the diet which was taken as optimum dietary requirement level for rohu for lysine. Except loss of appetite resulting depressed growth rate, other nutritional deficiency was observed. Medda *et al.* (1993) showed that the supplemental feeding of two major Indian Carps, *Catla catla* and *Labeo rohita* during their early developmental periods by a suitable combination of vitamins, amino acids and rice bran resulted in a differential impact on three important growth parameters, namely length, weight and protein content of the species. Two-way analysis of variance test revealed a significant group and feed specific variation of the relative growth rate of the two species in response to the experimental feeding. Analysis also revealed both length and weight wise significant variation of the main effects and their interaction in response to the feed treatment on the two carps. Devi and Vishwanath (1993) found that the *Osteobrama belangeri* (Valenciennes) is a medium sized carp endemic in the Chindwin Drainage of Yunnan (China), Burma (Myanmar) and Manipur (India). This paper also reports on an attempts to artificial feeding of the advanced fry of the fish with different formulated dry feed pellets incorporating different proportions of the protein rich aquatic fern *Azolla pinnata* and fish meal. The results show that balanced protein, vitamin and mineral seemed to promote growth rather than only quantity of protein in diets in case of *O. belangeri*. Keshavanath and Matty (1994) conducted two experiments in a circulating system. In the 1^{st} experiment to 84 days duration, 10 mg kg^{-1} diet Sumach induced significantly higher growth, but not 20 mg kg^{-1} diet. Both doses of pure HCG (Sigma Chemicals Ltd.) tried (1 and 2 mg kg^{-1} diet) were ineffective. In the second experiment, growth produced by 5 mg/kg. died pure HCG and 10 mg kg^{-1} diet Sumach were comparable and significantly higher than the rest after 42 days, indicating higher potential of pure HCG. The findings are significant as they reveal that a protein hormone like HCG is capable of growth promotion in carp when administered orally. Das *et al.* (1994) studied that the fishmeal was partly replaced with locally available plant leaf powders, *Eichhornia crassipes* (Pellet E), *Colcocasia esculenta* (Pellet C) and *Gliricidia macalata* (Pellet G) and the pelleted feeds prepared separately were fed to the Indian major carp *Catla catla* and *Labeo rohita* and the growth performance was compared with fish meal based control diet (pellet FM) for a period of 112 days. The best growth of catla was recorded in pellet protein content of the species. 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FM followed by pellet C, E and G treatments, respectively. However, rohu registered maximum growth in pellet C followed by pellet G, E and FM treatments during the experimental period.

Singh and Kumar (1996) showed that the fortification of conventional feed with fish meal (25%) and nuvimin (0.6%) increased the survival rate of Indian Major Carp fry to 96 - 99% in laboratory. The survival rate of rohu fry in newly constructed ponds were significantly higher (13.6%) with fortified test feed as compared to conventional feed of groundnut oil cake + rice bran (7.3%). But under laboratory conditions addition to nuvimin in the diet resulted in nutritional deformities viz. lordosis in mrigal fry and stunted growth and loss of appetite in fry of rohu, catla and also mrigal which may be due to lack of vitamin C and calcium and/or phosphorus in nuvimin formula. However, addition of 25% fish meal is significantly in growth and survival of carp fry in field as well as in laboratory conditions. Pandey *et al.* (1997) observed that the scale carp (*Cyprinus carpio communis*), Bhakur (*Catla catla*) and Nain (*Cirrhinus mrigala*) were stocked (5000 ton ha^{-1}) in two earthen ponds at the depast mental fish farm located in the highly sodic soil conditions having organic carbon as low as 0.21% and pH as high as 9.4. Testoviron Depot drug (Testosterone - enanthate and Propionate combination) was fed to experimental fishes (1 mg kg^{-1} body weight) mixed in artificial fish feed consisting of rice bran + mustard oil cake 2-3% of body weight once a day during morning hrs. control fishes were given absolute alcohol in fish feed daily as above. Computer analysis suggests that 1 mg/kg. body weight dose has stimulatory effect in scale carp and Bhakur but proved ineffective in the Nain. Both control and treated individuals of all the 3 species follow the "cube low".