Development of Dry Pelletised Barramundi Food from Catfish By-product

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FISHERIES RESEARCH & DEVELOPMENT CORPORATION

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OBJECTIVES

1. The production of a dried catfish by-product using a locally built solar dryer
2. Formulate feeds for barramundi using this dried by-product and other locally available agricultural products
3. Manufacture a formulated feed pellet, on site, which was acceptable to caged barramundi.
4. Conduct feeding trials on caged barramundi to determine the biological and economic performance of the locally produced pellet compared to a commercial product.

NON TECHNICAL SUMMARY:

The main reason for conducting this research was to investigate the possibility of producing feed for aquaculture enterprises in remote areas using locally available raw materials. In this case the major potential raw material was the waste from a local catfish wild capture fishery on Lake Argyle in the North East of Western Australia. This waste consists of the heads and frames of catfish after filleting. To make it a suitable ingredient for incorporation into fish feed pellets this by-product needs to be dried and ground.

This first stage of this project consisted of the development of a solar dryer, capable of being made on site, which would dry sufficient by-product for the project. This was intentionally a low technology approach to the problem and whilst a successful design was developed, the use of a self-contained, solar powered, extraction fan in the system increased the drying efficiency.

The dried by-product was chemically analysed and the results suggested that it could be a suitable aquaculture feed ingredient. Diets were formulated using this and other available ingredients and a 'per Tonne' cost comparison with available commercial feeds was made. This showed a large potential cost saving as long as the 'local' pellet performed satisfactorily in feeding trials.

It was also established that the formulations using the dried by-product could be pelletised using conventional methods. In this case a Lister Junior pellet press without steam conditioning. This machine is designed for on-farm use.

This concluded the first year of the investigation and it was considered that the objective to this time had been achieved. Also the method of feed production developed could be adapted to many remote sites in Australia and overseas where there is a potential for small to medium sized aquaculture operations and locally available by-products/waste products.

After a delay of 2 years for reasons given in the main report, 90-day feeding trials were conducted to compare the local pellet with a commercial product. Unfortunately these trials had to use very small barramundi fingerling (1.25 grams) and the results were disappointing. They did establish that it was feasible to use rear barramundi fingerlings on the local pellets but due, at least in part, to the lack of a facility to produce the feed in crumble form, these were not cost effective.

It was concluded that the approach taken in this project could prove to be of great benefit in remote areas but further work is required particularly with regard to producing feed of a size more suitable to the size of fish being reared. In this respect it is probable that the local pellets would prove to be of greater economic benefit when fed to larger fish.

KEYWORDS: Barramundi, aquaculture, fishery by-product, feed production, solar drying.

DEVELOPMENT OF DRY PELLETISED BARRAMUNDI FEED FROM CATFISH BY-PRODUCT.

FRDC PROJECT 94/061

FINAL REPORT

BACKGROUND

Lake Argyle is a body of fresh water in the North East of Western Australia approximately six times the size of Sydney Harbour and containing about six cubic kilometres of water. This water is exchanged at an average rate of 4 cu. Km. per annum making the lake entirely suitable for large-scale aquaculture.

Aquaculture of barramundi *(Lates calcarifer)* started in 1991 and augments a wild capture fishery for catfish. The catfish fishery produces 100 Tonnes per annum (whole weight) all of which is processed to fillets on board, plus approximately 60 Tonnes of by-catch. This produces 130 Tonnes per annum of by-product, some of which is fed directly to farmed barramundi. This project investigated the use of appropriate low technology to convert the by-product into a dry pelletised feed for barramundi.

Major constraints to the development of barramundi farming in Lake Argyle were removed in December 1993. Research by Keenan (FRDC 89/33) has shown that W.A. and N.T. socks of *Lates calcarifer* are not genetically diverse. Research by the W.A. Department of Agriculture Risk Pathology Laboratory has resulted in the removal of the requirement for farmers to use PICORNA virus free stock. This means that fingerlings (subject only to routine disease screening) can be bought from established farms in the Northern Territory, in large quantities, on a regular basis and at reasonable cost. This source replaces the current South Australian source which is restricted in production and, with freight costs, prohibitively expensive.

NEED

The major expense for barramundi farmers in Lake Argyle is the cost of feed. Currently (June 1995) feed bought from Queensland lands at Lake Argyle at $2.20 per Kg. of which $0.80 is freight. If production of barramundi improves as expected, there is a real possibility of a fall in its price, in which case the cost of feed could severely limit the expansion of the fishery. This project seeks to produce an endogenous feed that will have cost benefits over the commercial feed used.

It is no longer environmentally acceptable to dump fishery by-product, or by-catch, in an enclosed water body. This project seeks to convert an environmental problem into a useful product.

OBJECTIVES

a) The production of a dried catfish by-product using a solar drier.
b) Formulation of feeds for barramundi using the dried by-product and locally available agricultural products.
c) Manufacture of the formulated feeds to determine their acceptability to caged barramundi.
d) Feeding trials to assess the biological and economic performance of the locally produced feed.

Objective 1 – Solar Drying

i) Design and Construction.

The moisture content of the fresh catfish by-product is in the region of 65 to 70%. In order to incorporate this into a barramundi feed using conventional pelletising techniques this has to be reduced to 10 to 15%. A review of the literature suggested that solar drying could be used to produce fish products with a moisture content of no greater than 15% (Curran and Trim; Osel-Opare and Kakah). At this moisture content it was concluded that the product could be stored for 20 weeks or more without signs of deterioration (Osel-Opare and Kakah).

There are a number of suggested designs for solar dryers suitable for use with fish (Curran and Trim; Osel-Opare and Kukah; Doe et al.; Sachithanthan, Trim and Speirs). For this project it was decided to test a dryer consisting of a solar collector and drying tower following design principles suggested by both Curran and Trim and Osel-Opare and Kakah. One refinement not reported on in the literature was the possible incorporation into the dryer of a solar powered extraction fan. This equipment had been recently perfected by a Western Australian company.

The first model made consisted of a black polythene covered solar collector with a drying tower at one end again constructed of black polythene on a metal frame. The system was naturally vented, air entering at the end of the solar collector and exiting by convection from the top of the drying tower.

This design was only partially successful, as the air temperature within the drying tower never exceeded the ambient air temperature by more than 15 deg.C. A literature survey suggested that this limit was probably due to the single skin construction of the solar collector (Brenndorfer et al).

A second drier was then constructed, again with a black polythene covered collector but this time a double skin was used. The collector consisted of a metal frame over which the black polythene was stretched and secured with adhesive tape. The vertical ends of the collector were left open but covered with fly wire to allow air to enter freely. The drying chamber was tent shaped and positioned in the centre of the collector (see Fig.1). The drying chamber was constructed of sheet metal with a wooden access door on one side. Within the chamber was a frame to hold trays of wet by-product during the drying process. Provision was made to fit a solar powered extraction fan near the apex of the chamber. This design was much more successful with regard to achieving suitable drying temperatures and an evaluation report follows this section.

A major problem encountered after a short period of use related to the construction materials used. The polythene sheeting expanded with heat causing it to sag and partially block the flow of air through the collector. Also the adhesive tape used to join the polythene sheets rapidly lost its adhesion at the working temperatures encountered.

Later into the project a third drier was constructed; this time of galvanised sheet metal and painted black. The design was also slightly modified so that the drying chamber was at one end of the collector and not centrally positioned as in the second design. Tests have proved this to be a satisfactory drier although further potential improvements are planned. One major area of study concerns the possible recycling of the exhaust air. Later tests demonstrated that the relative humidity of this exhaust air never exceeded 50% and was usually between 25% and 32%. This is in line with the findings of other researchers (Osel-Opare and Kukah). As this was also the hottest air in the system, methods should be studied for feeding it back into the lower part of the drying chamber until such time as the relative humidity restricts the rate of drying. To optimise this a sophisticated control system would be required, however some progress could be made using a simple method of bleeding off a proportion of the saturated air.

This drier was capable of drying 60+ Kg. of wet by-product per 24 hours and three such driers would cope with the requirements of the second year of this project. Therefor development work on this aspect of the project was scaled down due to time and financial constraints.

ii) Evaluation

Wet by-product, consisting of the remains of the catfish after filleting, was processed through a commercial mincer to produce a coarsely ground wet product. This was placed on trays with mesh bases to a depth of about 25 mm. For evaluation purposes the dryer was loaded with 10 kg of wet product per run.

The attached data (Tables 1 and 2) show the results of measuring the elevation of temperature within the drying tower using the second design of solar drier as described above. In both runs the 'bottom' thermometer was placed at the bottom of the drying tower in line with the air inlet from the solar collectors. The 'top' thermometer was measuring the temperature approximately 30 cm. below the apex of the tower. The results obtained were in line with published data (Curran and Trim; Osel-Opare and Kukah; Sachithanthan, Trim and Speirs).

On both days there was a complete absence of cloud although on the 10th there was a significant wind during the late morning. When reading these data it must be remembered that solar noon at Lake Argyle is at approximately 11.15 am Western Australian Time.

In both runs the drying tower was loaded with 10 Kg of wet material and satisfactory drying was achieved within 24 hours. This rate of drying is faster than most reports in the literature but all published paper relate to the drying of whole or large pieces of fish for human consumption. In this work the fish was minced thus significantly increasing the surface area to weight ratio. Due to lack of any suitable measuring equipment at the time, no data on relative humidity levels were collected.

The difference between the two runs was that run 1 was conducted with an open vent at the apex of the drying tower whereas run 2 had the solar powered extraction fan* in place and operating during the whole of the recording period.

* The solar fan was 15 cm diameter with an extraction rate of 157 l/min. equivalent to 9.438 m^3/hr. The volume of the drier is approx. 4.95 m^3. Therefor a complete air change is achieved every 31 minutes.

iii) Conclusions

This design of solar drier appears to meet the requirements of the project in being able to produce dried material within an acceptable time span. The temperatures achieved were sufficiently high to prevent bacterial spoilage at the commencement of the drying cycle. Also flies would not usually enter the drying chamber and those that did we killed by the high temperature.

Whilst this design of drier was suitable for the project, other designs are shown in the literature which may be suitable for larger scale production (Sachithanthan, Trim and Speirs).

There was no difference in temperature elevation due to the use of the extraction fan even though the air exchange rates were much higher. This suggests that the efficiency of the drier with natural airflow was not maximised. Some preliminary tests with regard to relative humidity suggested that this was not the limiting factor in drying rate as reported but this was only a tentative conclusion due to lack of suitable measuring equipment. This conclusion is supported by the literature.

Objective 2 – Diet formulation

i) Analysis of dried by-product

Various samples of the wet by-product were analysed for dry matter content by heating to constant weight in a microwave oven on site. Whilst this is not a normally accepted method of carrying out dry matter determinations it appears to be sufficiently accurate for determination of the total quantity of dried by-product potentially available. The average dry matter content of the by-product was 34%.

A sample of the solar dried catfish waste material was sent to Dr Kevin Williams at the Bribie Island Aquaculture Research Centre for chemical analysis. The following results were received.

Dry Matter	84.7%
Ash	27.7%
Crude Protein	53.0%
Fat	18.0%
Calcium	9.13%
Phosphorus	4.49%
Gross Energy	22.1 MJ/Kg

This analysis is fairly typical of a fishmeal produced from waste fish although the Calcium and Phosphorus content are rather higher than with other species. At the commencement of the project it was planned that more comprehensive analysis work together with digestibility trials would be conducted at Bribie Island Aquaculture Research Centre. However, due to circumstances beyond the control of the project staff, this work was not carried out. For feed formulation purposes it was assumed that the amino acid profile of the protein in the dried by-product was similar to other fish proteins and that the digestibility of the protein was high. This latter assumption was based on the fact that the by-product was dried at a low temperature.

The fat content of the dried by-product is high and an analysis of the fatty acid composition carried out by the CSIRO Marine Laboratories shows an unusually low level of EPA (C20:5) and DHA (C22:6) for a fish oil. A copy of the analysis is attached (Table 3)

The moisture content of the solar dried material, about 15%, is consistent with that achieved by other researchers as mentioned in the original proposal and, whilst no chemical determinations have been made, storage for at least a few weeks does not appear to present any problems. It should be noted that the final pelletised feed would be produced as soon as possible after the by-product has been dried.

ii) Other locally available potential ingredients

Information obtained from the Kununurra branch of the Western Australian Department of Agriculture (now Agriculture WA) suggested that maize and grain sorghum should normally be available as a grain source, maize predominating. Also available as a vegetable protein was chickpeas. Whilst these are usually sold at a high price for human consumption, there was sufficient reject material in the form of 'splits' to be of interest to the project.

Due to the seasonality of the availability of both maize and chickpea splits it was necessary to conduct the initial product processing work with wheat and lupins. This approach was considered justified as the major objective was to determine whether the dried by-product could be incorporated into a pellet that would, of necessity contain both grain and other protein sources. Also, due to the continuing development of crop production in the Ord Irrigation area, it is probable that other potential ingredients will become available in the future.

iii) Diets formulated

Three diets were formulated containing either 30, 40 or 50% of the dried by-product. The diets had an increasing, calculated, energy density but a constant amino acid to energy ratio. The overall calculated analysis of the diets was in line with commercially available barramundi feeds. A copy of the three diets and their calculated analyses are attached (Table 4).

Objective 3 - Feed Manufacture

i) Initial trial diets

As the objective was to produce a pelletised feed using standard pelletising equipment, all ingredients have to be in the form of a fine meal with, ideally, a particle size of less than 2 mm. A small electric hammermill was installed which was suitable for grinding most dried products. Problems did arise with the grinding of the dried by-product due to both the pliable nature of the product as produced in the drier and its relatively high fat content. This problem was overcome by mixing the by-product with the unground grain component of the diet and grinding the two together. When handled in this way the dried waste was successfully ground through a 2 mm screen and the final meal proved to be quite suitable for pelletising.

Pellets of 4.5mm, 8mm and 11mm diameter were made using the Lister Junior pellet press on site. Pellets of a suitable hardness were produced at all levels of by-product inclusion and, although they sank rapidly when fed in the cages, were accepted by both barramundi and sooty grunter. These pellets were produced to test the suitability of the dried by-product for use in the manufacturing process and were not intended for controlled feeding trials.

An alternative method of pelletising, not in the original project, involved mixing the wet, minced waste with ground grain etc. to the same formulation, on a dry matter basis, as used in the pellets. This mixture was then passed through the mincer to give a coarse pasta type product which was then solar dried. The final dried pellet proved to be very stable both in air and in water. Also, by manipulating the moisture content, a floating or a slowly sinking feed was produced. It is felt that further work in this area could lead to the development of low cost alternatives to extruded feeds particularly where limited quantities of waste fish are available.

ii) Conclusions

From the work conducted to this point it could be concluded that diets potentially suitable for caged barramundi culture could be produced using solar dried catfish by-product with other, locally available, ingredients as long as a purchase programme was instigated to allow for the seasonal availability of such ingredients.

Based on the cost of suitable local ingredients, both maize and chickpea splits at $200 per Tonne (1995 prices) and a realistic production cost of the dried by-product of not more than $500 per Tonne. It was calculated that a product with a similar protein content to the commercial barramundi feed currently being used could be produced for $500 to $600 per Tonne. This compared with the landed price for the barramundi feed of $2,200 per Tonne (June 1995 price).

iii) Diet recommendations for feeding trials

As the objective of the project was to investigate the possibility of using dried catfish by-product in barramundi diets, it was decided to conduct the feeding trials using a diet containing the maximum inclusion level of by-product tested to date, ie. 50%. The suggested formula for this diet is attached (Table 5).

Objective 4 - Feeding Trials

Following the successful completion of the first part of the project a delay of approximately 2 years occurred prior to the commencement of the feeding trials, which were originally planned to be conducted in 1995/96. This delay was due to the unavailability of sufficient barramundi fingerlings from existing potential suppliers. This was a crucial factor not only from the perspective of this trial but also a potentially fatal weak link in the proposed development of a commercial barramundi farm on Lake Argyle.

A commercial decision was made to construct a hatchery to produce fingerlings from 'imported' eyed ova obtainable from the Darwin hatchery. This was constructed and successfully reared sufficient barramundi fingerlings to commence feeding trials in the last quarter of 1997.

At the same time as the hatchery was being built a series of floating cages were being constructed to a commercial design. This allowed an overall availability of 24 cages each 2 metres square for the feeding trials.

i) Details of feeding trial facility.

At the time of the feeding trial the facility consisted of 4 pontoons each 8 metres square and within each pontoon 6 sea cages were constructed each 2 metres square. The cages were arranged in 2 rows of 3 with walkways between each row of cages and around the perimeter of the pontoon. Thus each cage was accessible on at least two sides. The cages themselves were made from quarter inch mesh netting and had an overall depth of 2 metres.

The pontoons were each free-floating but tethered in a group together with a fifth pontoon with a feed store mounted on it. This formed a fully self-contained unit consisting of 24 individual cages each with a mechanical self-feeder. Commercially available feeders manufactured by Fischtech were mounted on each cage, which allowed the daily feed ration to be fed continuously over a 12-hour period.

The complete facility was positioned in a relatively narrow inlet at the northern end of Lake Argyle which was sheltered and close to Lake Argyle village. Due to the origins of the lake this inlet had a depth of water in excess of 30 meters with relatively little flow.

ii) Feeding trials

20,000 barramundi fingerlings, 55 days post hatch, with and average length of 48 mm and an average weight of 1.25 grams were assigned to one of four treatments. These fish had been reared at the Lake Argyle hatchery and fed a range of proprietary crumbles prior to the commencement of the trial. All fish were treated with a salt-water bath immediately prior to being place in the cages in the fresh water of the lake.

This salt treatment is essential to control protozoan pathogens, particularly Chilondanella, which is endemic in Lake Argyle. This pathogen is particularly destructive to fingerlings when the water temperature is around 26 degrees Celsius.

5,000 treated fingerlings were put in 2 cages in each of the 4 pontoons and the trial conducted so that each pontoon held all the fish for 1 treatment.

The four treatments were-

Treatment 1

A proprietary barramundi feed* in crumble form (no. 3 crumble) was fed from day 1 of the trial until day 60. From day 60 on, a barramundi starter pellet (no. 4 pellet) from the same manufacturer was fed. These products are manufactured by extrusion and both are floating feeds with good water stability.

Treatment 2

Argyle Pellet. A pellet produced on farm incorporating solar dried catfish waste and locally available maize (Table 6). This feed was made as 4.5 mm pellets using the Lister Junior pellet press without any steam conditioning. This is a sinking feed with poor water stability.

Treatment 3

Wet Minced Catfish Waste. This is the raw, minced by-product (heads and frames) from the catfish fishery. It was prepared daily and fed twice per day, morning and evening.

Treatment 4

Argyle Pellet (Water Stable). This product is to the same formulation, on a dry matter basis, as the Argyle Pellet used in Treatment 2 but the ground maize is mixed with the wet minced waste. The mix was passed through the mincer and formed a spaghetti type semi-moist pellet which was then solar dried and broken into short lengths. This feed was made as a 10 mm diameter pellet, the smallest die size available on site.

* This diet was a commercial Barramundi feed produced by the Ridley Corporation. The declared analyses at the time of the trial were:- Starter Crumbles – Protein 50%; Fat 10%; 1.6%; Ash 8% and Phosphorus 1.4%. No.4 Grower Pellets – Protein 40%; Fat 12%; Fibre 2.5%; Ash 10% and Phosphorus 1.2%

iii) Results

The trials commenced in the 1st October 1997 and were scheduled to continue for 90 days. Major management problems arose with Treatments 3 and 4 which caused these to be abandoned prior to the original completion date.

Treatment 3

From the commencement of offering the wet minced waste on day 1 the fish showed little interest in feeding. This was initially attributed to the fact that the fingerlings had been reared on a crumble diet. By day 16 the fish were still reluctant to eat and were becoming very weak. Attempts were made to freeze the mince to prevent it from rapidly dispersing in the water but this did not produce any improvement. By this time the cages were becoming badly fouled with decaying, uneaten mince with actual consumption limited to pieces of floating fat.

Attempts to grade these fish resulted in high mortality presumably due to additional stress. There was also a significant amount of fin-rot and problems with balance. It could be assumed that these were at least partly of nutritional origin.

By day 30 a large number of fish were dying from bacterial infection and the trial was abandoned. The number of fish remaining was 420. These survivors were size graded with the following results:-

Size of Fish (mm)	Number of fish
70 – 80	40
60 – 70	260
50 – 60	120

Treatment 4

From day 1 the fish showed no interest in consuming this feed. By day 6 a few fish were consuming small amounts but insufficient to support any real growth. This trial was abandoned on day 10 as the highly water stable pellets were accumulating at the bottom of the cage and not breaking up sufficiently to fall through. This caused a high degree of fouling of the nets. It was unclear whether the cause of the poor feed acceptance was due to flavour, texture or simply the size of the pellets which had a diameter of 10 mm.

Treatment 1

Following the placing of 2,500 fingerlings in each of the two cages, the fish were fed the Commercial No. 3 crumble via the automatic feeders for 16 days. On day 16 the fish were graded and split into two fractions according to size. Two cages were used for each fraction. Prior to grading, the size range was 56 to 90 mm and significant cannibalism was occurring. Feeding with the No. 3 crumble continued to day 30 when the fish were again grading due to cannibalism. At this time 3 separate groups could be identified. Fast growers measuring 90 to 110 mm with an average weight of 11.6 grams. Medium growers measuring 75 to 90 mm with an average weight of 7.5 grams. Slow growers measuring 65 to 75 grams with an average weight of 4.2 grams.

After grading the fish were placed in all six cages allocated to the treatment and the feed was changed to the Commercial No. 4 pellet. This feeding regime continued to day 90 which was the completion of the trial. All fish were then graded with the following results:-

Number for fish surviving – 3150.   Mortality - 37%
Fish 110 to 160 mm – 180
Fish 80 to 110 mm   - 2650
Fish 60 to 80mm   - 320

Total Weight of fish at 90 days - 47 kg
Average weight - 14.9 grams
Total feed offered - 140 kg
Based on the total biomass at day 1 (6.25 kg) and the recovered biomass at day 90 (47 kg), the Apparent Feed Conversion Ratio was 3.44:1

Treatment 2

The 5,000 fingerlings were again placed in 2 cages and fed the 'Argyle pellet' from day 1. This was made as a 4.5 mm pellet cut short. The fish were slow to accept the feed following the use of much smaller crumbles prior to the commencement of the trial. By day 16 the fish were still slow to feed and the rate at which the pellet sank compounded the problem. A further comment at this stage was that the pellet only had a shelf life of 4 days before mould formed. This was probably due to inadequate drying if the fish waste producing an excessively high moisture content in the pellet.

By day 30 a number of fish were dying due to fin-rot which was believed to be of nutritional origin and the pre-mix was increased by 50%. This produced no noticeable improvement and so non-nutritional factors were probably involved. The fish were graded into two sizes with 2 cages used for each size range. On day 60 the fish were graded for a second time because of cannibalism due to size variation, 2 cages being used for each of the three sizes as per treatment 1. At this time the length but not the diameter of the pellet was increased.

The trial continued to day 90 when all fish were graded with the following results:-

Number of fish surviving – 2260.   Mortality – 55%
Fish 110 to 150 mm   - 150
Fish 75 to 110 mm   - 1720
Fish 60 to 75 mm   - 390

Total weight of fish at 90 days – 16.25 kg
Average weight - 7.2 grams
Total feed offered - 140 kg
Based on total biomass at day 1 (6.25 kg) and the recovered biomass at day 90 (16.25 kg), the Apparent Feed Conversion Ratio was 14:1

iv) Discussion

The problems in conducting this feeding trial were those commonly encountered in the early stages of a commercial operation in a new area. These problems include type of feed to use, optimum feeding rates, disease control etc. In addition this trial demonstrates the need to match the feed, particularly the crumble/pellet size, to the size of the fish. Also it shows the problems of conducting such trials with very small fish (1.25 grams at start of trial) in commercial type conditions with relatively large numbers of fish.

The problems encountered with Treatments 3 and 4, which led to their termination, had some factors in common, mainly relating to the composition of the minced waste. There were also other unrelated factors involved.

There are two major possible reasons for the failure of Treatment 3. Firstly it is debatable whether small fish can utilise wet waste fish efficiently. Such a product needs to be very finely chopped or minced and so a significant amount of the product disperses in the water and drifts out of the cage or contaminates the netting. This contamination increases the disease risk within the cages as happened in this treatment. With larger fish the product could be coarsely chopped and may be more acceptable.

Secondly, there is some doubt concerning the palatability of catfish waste, either wet or dried. Of particular interest in this respect is the fatty acid composition of the catfish oil as reported earlier. This oil has very low levels of omega 3 fatty acids compared to 'typical' fish oils and also has a bland taste and little or no smell. It may be possible to increase the palatability of this product by adding a fish oil from a different species or some other attractant. This approach was not tested in the work that is the subject of this report.

If there is a problem with the palatability of the catfish waste this may have had an influence on Treatment 4. However, it is probable that the size of the pellets and the fact that, being water stable, they did not disintegrate in the water, was the major reason that feed consumption was virtually nil. As yet unpublished data by the author has shown that pellets manufactured by this process loose as little as 20% of their dry weight after immersion in fresh water for 14 days. During this time the pellets remain relatively hard and so small fish would not be able to consume any appreciable amount of feed from the surface of the pellets at the bottom of the cages. Also crumbles have been produced from pellets manufactured by this method and these have successfully been used in the rearing of marine fin-fish.

Results obtained from Treatments 1 and 2 demonstrate that barramundi can be grown from the fingerling stage in the cages used for the experiment although there are a number of critical management factors to be considered.

Treatment1, which was included as the 'commercial' control, produced a satisfactory growth rate for this size fish. Based on the average weight of surviving fish at day1 and day 90, the average daily liveweight gain was 2.75% of body weight. Using the calculated Apparent Feed Conversion Ratio data for this treatment (3.44:1) it would appear that these fish were consuming feed at the rate of 9.46% of their body weight per day. Even allowing for feed eaten by fish that did not survive to 90 days this is an unlikely feed intake level. It is more probable that a significant amount of feed offered was wasted although no attempt to measure this was made.

A indication of feed wastage can be calculated for the following assumptions:- probable actual feed intake for fish of this size is unlikely to be greater than 5% of body weight per day. If this were the case then the actual Feed Conversion Ratio was 1.8:1, not an unrealistic figure. This would mean that of the 9.46% body weight apparent intake, 4.46% was waste. Thus the overall wastage figure is 47% of feed offered.

As shown by the data, there was a high growth differential between individual fish in this treatment. The cause of this is unknown but could be genetic in origin. From a management point of view care is required to ensure that the fish are graded frequently to reduce the potential for cannibalism as occurred in this trial. From observations by the researchers rather than from data collected it would appear that this cannibalism was the major cause of mortality in this treatment, there being very little disease observed.

Treatment 2 demonstrated that a feed could be produced 'on farm' that would support growth of barramundi fingerlings although a great deal of further work is required before this can be recommended for a commercial operation. As with Treatment 1, the data produced suggests a high level of feed wastage and also, for this treatment, relatively poor feed utilisation.

The diet used in this treatment (see attachment) was significantly lower in protein than the commercial diet (30% v 50%) and also low in omega-3 fatty acids although no information was available on the level present in the commercial diet. This diet would restrict the growth potential of fish of the size used in the trial but this could probably be corrected by re-formulating the diet. The poor performance could also be attributed to the pellet size used. The 4.5 mm pellet is not suitable for fingerlings but no crumbling facility was available. The pellets formed were not water stable and breakdown was rapid. However, as the pellets sank quickly, the fish would not have access to the finer particles produced prior to the pellets falling through the bottom of the cage.
There is also a doubt as to the palatability of the pellet due to the use of the catfish waste containing none of the normal 'fish' attraction derived from the oil present. This would need to be investigated in feeds of the correct pellet size, preferably with much larger fish. If proved, then the addition of an attractant would be recommended.

Based on the same method of calculation as for Treatment 1, the average daily liveweight gain for the surviving fish in this treatment was 2.0% of body weight. The feed wastage was more extreme than in treatment 1 and may have been as high as 82% if the assumptions made for treatment 1 are followed. This hypothesis is supported to some extent in that a significant level of fouling of the cage nets occurred, suggesting an accumulation of uneaten feed, especially during the early stages of the trial.

Despite the lower average growth rate achieved by this treatment, there was still a noticeable variation in individual growth rates sufficient to require the fish to be graded to reduce cannibalism. At the conclusion of the trial the variation in size was similar to that occurring in treatment1. Whilst no actual figures are available, it is probable that the higher mortality in this treatment was due disease factors associated with the net fouling in addition to the cannibalism.

An economic analysis of this trial is only possible for treatments 1 and 2. Based on feed prices for the last quarter of 1997, the analysis is as follows:-

Treatment 1	Average feed cost del. Lake Argyle	- $1.65 per kg*
	Apparent Feed Conversion Ratio	- 3.44:1
	Feed cost per kg. liveweight gain	- $5.68.
Treatment 2	Estimated cost of feed to produce	- $0.50 per kg
	Apparent Feed Conversion Ratio	- 14:1
	Feed cost per kg. liveweight gain	- $7.00

* This was lower than the price in 1995 due to a reduction in both the ex Mill price and freight costs.

This table shows that the 'Argyle Pellet', as would be expected, performed relatively better in economic terms than in biological terms. Improvements in both the manufacture and presentation of this pellet are quite feasible at minimal cost. It is also probable that these pellets would perform relatively better with larger fish.

v) Conclusions from feeding trials

Due to time constraints originally caused by lack of suitable fingerlings, this feeding trial was conducted using fish of 1.25 grams liveweight instead of 50+ grams as originally intended. This caused a number of management problems and significantly reduced the amount of useful information obtained. There were, however, a number of valid conclusions that could be drawn from this work.

1) Barramundi Fingerlings of 1.25 grams liveweight can be reared in 'commercial' type cages on Lake Argyle provided sufficient attention is paid to such management factors as adjusting feed size to fish size.
2) Current fish stocks available have an inherent variability with regard to potential growth rate. This makes frequent grading of small fish essential to reduce cannibalism. It also provides a pool for the breeding of fast growing lines assuming that this variability is of genetic origin.
3) Whilst a 'local' feed can be produced it needs to be correctly formulated and manufactured in the required sizes if it is to compete with commercial diets. Further work is required in this area particularly with larger fish where this approach is likely to show more commercial benefit.
4) Whilst not successful in this trial probably due to feed size problems, it was shown that a water stable feed can be produced using low technology, relatively inexpensive equipment in remote areas if there are suitable, local, ingredients available.
5) The feeding of wet, minced, trash fish or by-product is not successful with small fish. It may be more practical with larger fish but the potential for causing a high level of pollution will always be present.

BENEFITS

In a number of areas both within Australia and overseas potential sites for aquaculture fail to be developed due to the lack of a suitable, cost effective feed supply. The Kimberly region of Western Australia where this project was conducted is one such area. Many of these areas have supplies of by-products both from fishing and agriculture which, with suitable processing can be used as feed ingredients. The extension of the results from this project demonstrate that many of these by-products can be processed as low cost. The cost effectiveness of these processes are not dependant upon a high throughput and so are beneficial to isolated communities where aquaculture may be conducted at the subsistance level.

At the same time as producing low cost feeds, the process described has the potential to convert environmentally damaging waste products into valuable by-products.

FURTHER DEVELOPMENT

The project, as eventually conducted, failed to demonstrate that the 'Argyle' pellet was suitable for intensive barramundi culture. It is believed that this, at least in part, was due to the way the feeding trials were conducted, specifically with regard to the size of fish used and the size of feed that could be manufactured on site.

It is recommended that further feeding trials are conducted with fish in the grow-out phase with an initial weight of at least 50 grams each. These trials should be conducted using both the standard pelletised feed and the dried, low pressure extruded feed. Care will be required to match pellet size to size of fish.

This project was specifically designed to use the waste from the Lake Argyle catfish fishery. In other parts of Australia different fish wastes are available. There is a need to formulate feeds and conduct feeding trials in these areas where there are plans to commercialize this waste.

PROJECT CONCLUSIONS

In areas with a suitable climate where a supply of fresh fish by-product is available, solar dryers can be used to convert this into a dry material for use as an aquaculture feed ingredient. This can be achieved with a zero external energy input.

When mixed with other suitable aquaculture feed ingredients, such a product can be included at a high level in the production of a pellet with acceptable physical characteristics. These pellets can be formed either on conventional pelletising equipment or by using a mincer as a low pressure extruder. In this latter method a moist pellet is formed which can then be solar dried.

It is probable that the approach taken in this project will result in the production of a feed at a much lower cost that that commercially available. This is particularly true in remote areas where transport cost are high.

The project failed to establish that the cheap, locally produced feed was more cost effective than commercially available feeds. As commented upon in the text, this was possibly due to the size of the fish used in the feed trials. It is generally felt that fish in a grow-out situation, ie. from 50 grams upwards, will perform comparatively better, both from a biological and economic standpoint. It will require further work to prove or disprove this hypothesis.

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Sachithananthan K and Trim D S and Speirs C I – A Solar Dome Dryer for Drying Fish, FAO Expert Consultation on Fish Technology in Africa, Lusaka, Zambia. 21-25 January 1985

Diagram of Solar Dryer

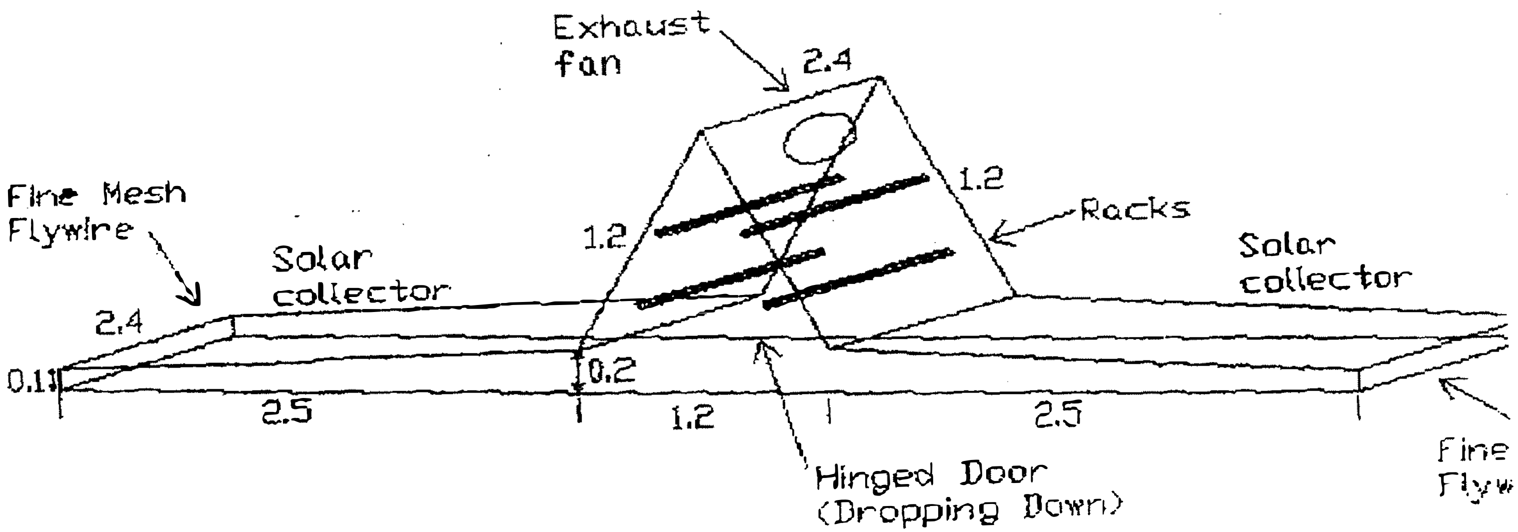


Fig 1

Table 1

SOLAR DRYER EVALUATION

Run 1. 10th September 1994
Fan off.

Time	Shade Temperature	Sun Temperature	Bottom Thermometer	Top Thermometer	Temperature Difference	
	A	B	C	D	C-A	D-A
8.30 am	27	32	40	43	13	16
9.30 am	30	37	45	52	15	22
10.30 am	31	39	45	50	14	19
11.30 am	31	41	46	54	15	23
12.30 pm	33	41	47	57	14	24
1.30 pm	35	39	45	55	10	20
2.30 pm	35	38	45	51	10	16
3.30 pm	34	35	40	45	6	11
4.30 pm	30	30	29	30	-1	0

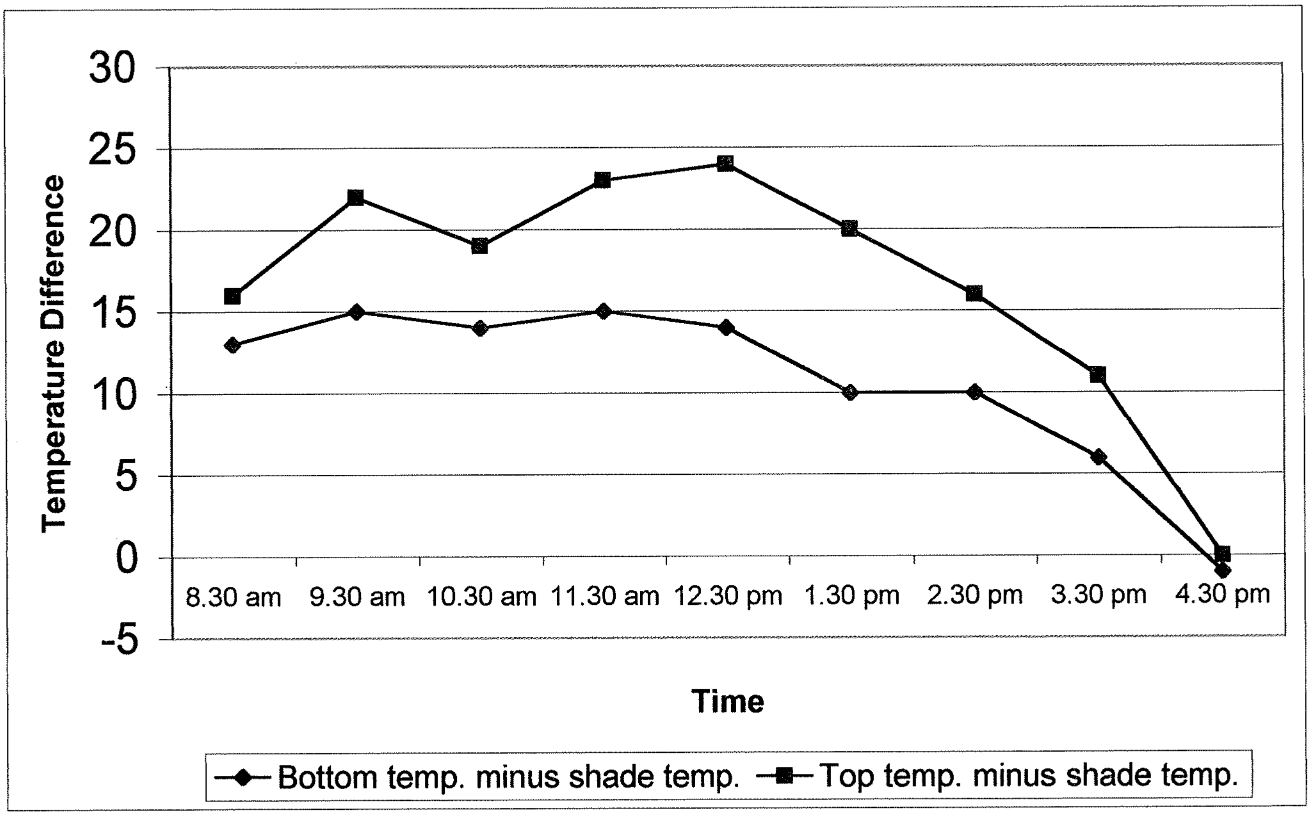


Table 2

SOLAR DRYER EVALUATION

Run 2. 11th September 1994
Fan on.

Time	Shade Temperature	Sun Temperature	Bottom Thermometer	Top Thermometer	Temperature Difference	
	A	B	C	D	C-A	D-A
6.30 am	24	24	26	28	2	4
7.30 am	26	30	35	40	9	14
8.30 am	28	36	42	48	14	20
9.30 am	30	40	43	53	13	23
10.30 am	34	44	48	58	14	24
11.30 am	33	42	48	58	15	25
12.30 pm	34	44	49	58	15	24
1.30 pm	33	42	46	55	13	22
2.30 pm	35	40	42	50	7	15
3.30 pm	33	36	38	45	5	12
4.30 pm	30	30	27	28	-3	-2

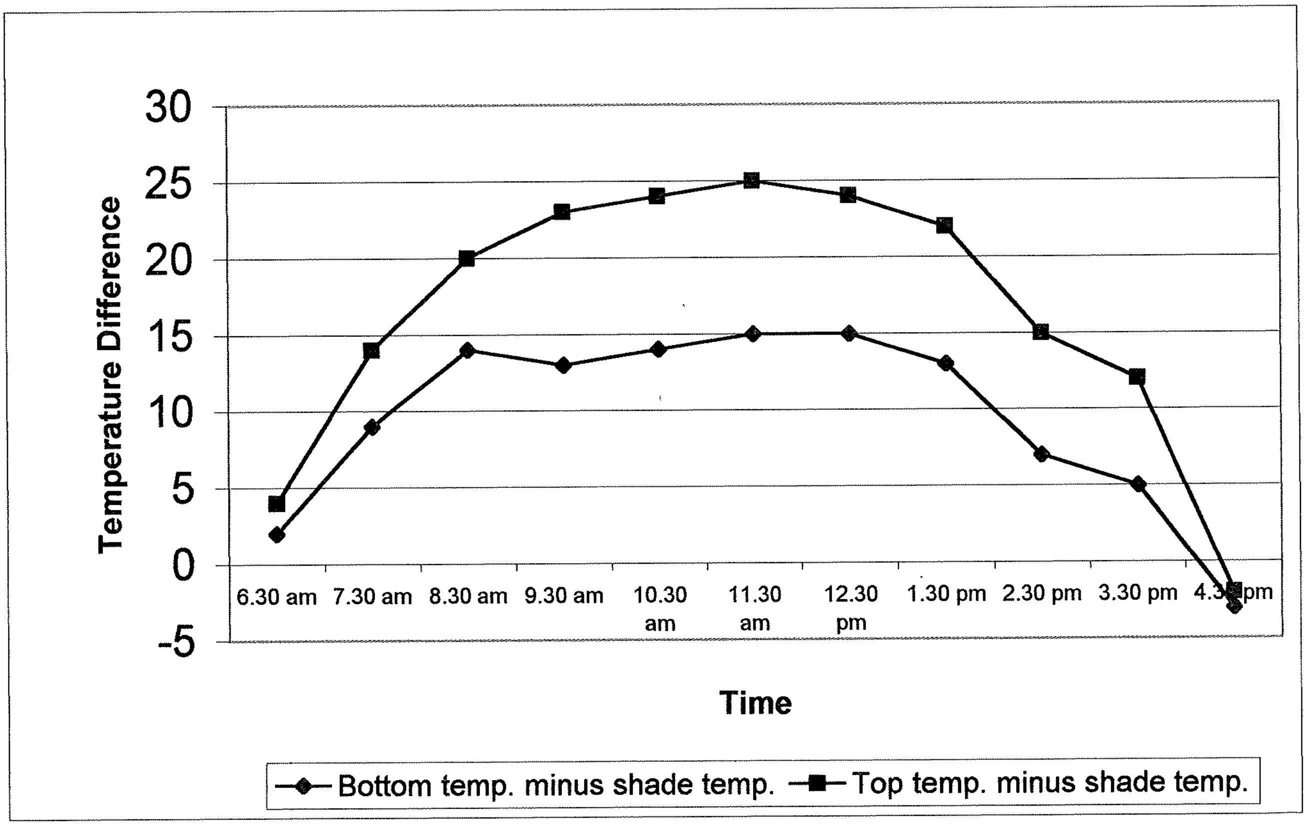


Table 3
FATTY ACID COMPOSITION OF OIL FROM FRESHWATER CATFISH EX LAKE ARGYLE

Fatty Acid	Percentage Composition
12:0	0.2
13:0	0.2
14:0	4.3
15:0	1.5
16:0	22.1
17:0	1.5
18:0	6.1
20:0	0.4
22:0	0.3
24:0	0.1
Sum Saturates	**36.7**
i 14:0	0.2
br 15:1	0.1
i 15:0	1.3
a 15:0	0.5
i 16:0	0.5
i 17:0	1.2
a 17:0/17:1	1.3
Sum Branched	**5.1**
14:1	0.1
15:1	0.1
16:1(n-9)	0.6
16:1(n-7)	12.3
16:1	0.7
18:1(n-9)	12.7
18:1(n-7)	4.6
18:1(n-5)	0.2
20:1	1.0
20:1	0.3
20:1	0.6
22:1	0.1
24:1	0.1
Sum Monounsaturates	**33.5**
C16 PUFA	0.5
18:2(n-6)	4.3
18:3(n-3)	1.3
18:4(n-3)	0.6
18:3(n-6)	0.6
20:2	0.6
20:3(n-6)	0.7
20:4(n-3)	0.7
20:4(n-6)	2.9
20:5(n-3)	2.3
22:4(n-3)	0.4
22:4(n-6)	1.2
22:5(n-3)	3.5
22:5(n-6)	0.9
22:6(n-3)	1.3
Sum PUFA	**21.8**
Other	2.9
Total	**100**

Analyses carried out by CSIRO Marine Laboratories, Hobart, Tasmania.

Table 4

DETAILS OF INITIAL DIETS FORMULATED

Ingredient	%	%	%
'Argyle' Fish Meal	30.0	40.0	50.0
Lupinseed Meal	25.0	20.0	15.0
Soya Bean Meal	15.0	10.0	5.0
Millmix	10.0	10.0	10.0
Wheat	19.7	19.7	19.7
Fish Premix*	0.3	0.3	0.3

Calculated Analysis	%	%	%
Protein	33.5	35.1	36.7
Fat	7.7	9.1	10.5
Fibre	6.8	5.8	4.9
Calcium	2.81	3.68	4.56
Phosphorus	1.59	2.00	2.41
Salt	0.37	0.46	0.55
Met. Energy	11.2 MJ/kg	11.6 MJ/kg	12.1 MJ/kg
Lysine	2.14	2.32	2.50
Methionine	0.68	0.78	0.88
Cystine	0.42	0.41	0.40
Threonine	1.28	1.35	1.42
Tryptophane	0.37	0.38	0.40
Leucine	2.35	2.51	2.68
Isoleucine	1.34	1.37	1.04
Arginine	2.39	2.36	2.34
Histidine	0.80	0.82	0.85
Tyrosine	1.13	1.20	1.27
Phenylalanine	1.75	1.74	1.72
Valine	1.58	1.74	1.89
Sodium	0.14	0.18	0.22
Omega 6 Fatty Acids	1.51	1.54	1.58
Omega 3 Fatty Acids	0.23	0.29	0.35

* A commercial Trout vitamin and trace mineral premix was used for these diets.

Table 5

DETAILS OF PROPOSED FORMULATION FOR THE FEEDING TRIALS

Ingredient	%
'Argyle' Fish Meal	50.0
Maize	20.5
Chickpea Splits	25.0
Soyabean Meal	2.5
Fish Premix	2.0

Calculated Analysis	%
Protein	34.9
Fat	11.1
Fibre	1.9
Calcium	4.5
Phosphorus	2.39
Salt	0.59
Met. Energy	13.4
Lysine	2.45
Methionine	0.89
Cystine	0.38
Threonine	1.36
Tryptophane	0.35
Leucine	2.43
Isoleucine	1.37
Arginine	2.21
Histidine	0.82
Tyrosine	1.18
Phenylalanine	1.59
Valine	1.88
Sodium	0.24
Omega 6 Fatty Acids	2.96
Omega 3 Fatty Acids	0.34

Table 6

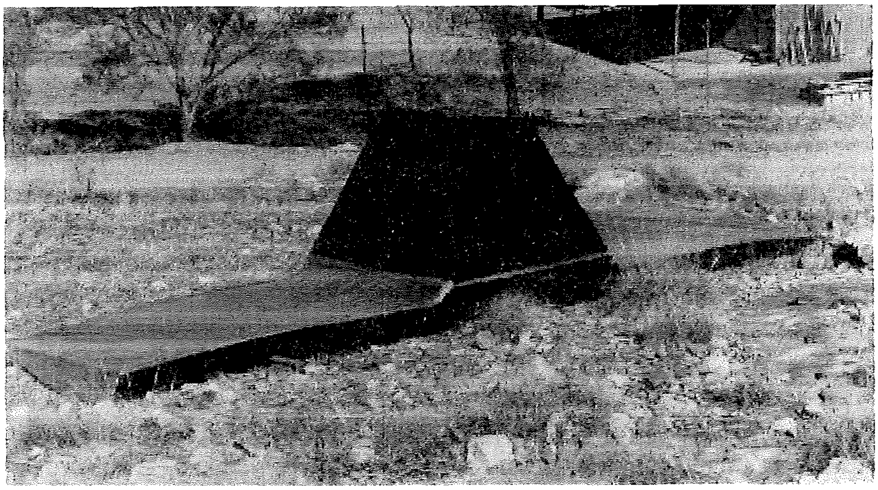
DETAILS OF THE 'ARGLYE' PELLET

Ingredient	**%**
'Argyle' Fish Meal	49
Maize	49
Fish Premix *	2

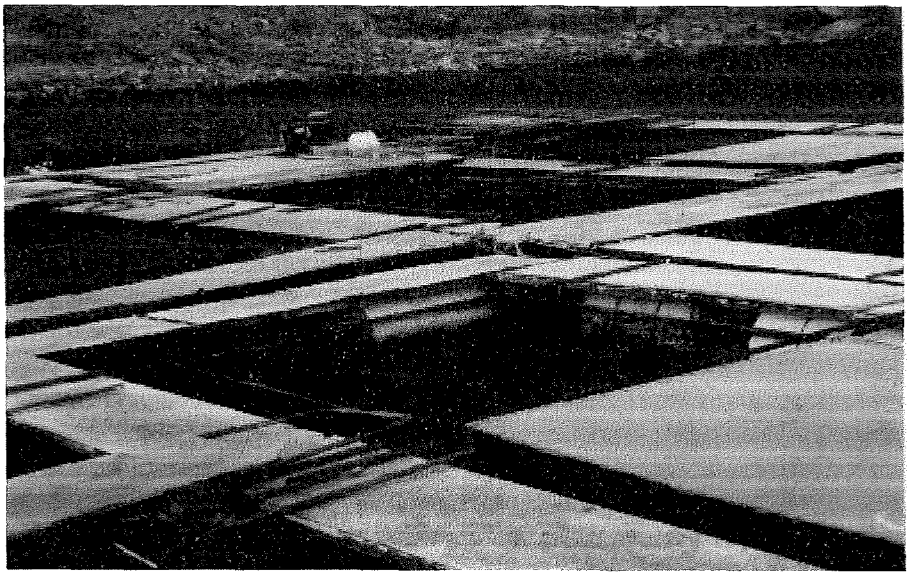
Calculated Analysis	**%**
Protein	30.0
Fat	10.7
Fibre	1.8
Calcium	4.42
Phosphorus	2.70
Salt	0.53
Met. Energy	13.7 MJ/kg
Lysine	2.07
Methionine	0.82
Cystine	0.31
Threonine	1.19
Tryptophane	0.30
Leucine	2.45
Isoleucine	1.16
Arginine	1.72
Histidine	0.68
Tyrosine	1.06
Phenylalanine	1.29
Valine	1.67
Sodium	0.17
Omega 6 Fatty Acids	2.96
Omega 3 Fatty Acids	0.34

* This premix was manufactured by the Ridley Corporation Ltd and supplied per kg of diet:- Phosphorus 4 g; Mg 0.4g; Zn 150 mg; Se 0.1 mg; Mn 100 mg; Cu 5 mg; Fe 60 mg; I 2.4 mg; Co 0.05 mg; Vit A 8000 IU; Vit D 1000 IU; Vit E 200 IU; Vit K 10 mg; Choline 1000 mg; Niacin 100 mg; Riboflavin 20 mg; Pyridoxine 10 mg; Thiamine 10 mg; Pantothenic Acid 50 mg; Folate 5 mg; Vitamin C 500 mg; Biotin 1 mg; Vit B12 0.02 mg; Inositol 600 mg.

Fig. 2



Solar Dryer on which evaluation tests were performed.



Layout of cages for feeding trials.

Fig. 3

Mincer being use to make semi-moist pellets

Lister Junior Pellet Press in operation

Appendix 1 – Intellectual Property

There is no intellectual property claimed from this work.

Appendix 2 – Staff.

Staff for first year:-

Michael Hoxey – Principal Investigator.

Neville Stewart – Manager of Lake Argyle Fisheries.

Staff for feeding trials:-

Neville Stewart

Steve Grandison – Farm Manager

Benjamin Stewart – Farm Assistant