Buenos Aires - should be listed on page 18.

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International Fishmeal and Oil Manufacturers Association

EFFECT OF RAW MATERIAL FRESHNESS AND PROCESSING TEMPERATURE EXPOSURE ON THE QUALITY OF FISH MEALS

PART 2

(SOUTH AMERICAN FISH MEAL)

RESEARCH REPORT NUMBER: 1993-3

EFFECT OF RAW MATERIAL FRESHNESS AND PROCESSING TEMPERATURE ON THE QUALITY OF FISH MEALS

PART II

(SOUTH AMERICAN FISH MEAL)

EXTENDED SUMMARY AND CONCLUSIONS

In the second part of the special products project the effect of freshness of South American fish (anchovy) on the quality of meal measured by the growth of Atlantic salmon smolts, Penaed shrimps and early weaned pigs was investigated.

In the original protocol it had been planned to investigate also the effect of processing temperature exposure on the quality of the fish meal prepared from fresh South American fish. Two meals were produced at different processing temperatures, but, unfortunately, they were found to have mink digestibility values which were similar, differing by only 2% units. This arose because of the high digestibility value for the fish meal produced on a regular dryer. A similar problem arose in the first part of the trial with European fish. It appeared that when a regular (indirect steam rotadisc) dryer was operated to give gentle drying, the resultant meal achieved a mink digestibility approaching that expected for a low temperature meal - almost 90%.

Due to difficulties in finding another factory in South America able to operate regular and low temperature dryers at the same site, this part of the project was abandoned.

Comparing meals made from anchovy of different freshness fed to salmon smolts, growth and feed conversion were adversely affected with stale fish, though differences were not significant. This result was surprising in the light of the biogenic amine content of the moderately fresh and stale fish meals - they were much higher than in the similar trial with meals made from European fish of different freshness. The sum of the amines histamine, cadaverine, putrescine and tyramine for the moderately fresh and stale anchovy meals were 3,384 and 7,873 ppm respectively compared with 2070 and 3860 ppm respectively for the European meals. It is suggested that the differences reflect variability in fish growth or differences in relative toxicity/anti-nutritional effect of biogenic amines or some other protein degradation product not determined. As the growth of the fish was regarded as good, the former explanation is considered less likely.

Although the effect on feed intake was small, salmon had a lower feeding response (frequency of taking feed) with the stale fish meal, suggesting it was less palatable. It is recommended that the effect of individual biogenic amines on palatability of fish meal to salmon should be investigated.

In four trials with shrimp at three different centres using three species of Penaeds (monodon at two centres, vannemi at one centre and stylirostris at one centre) growth

was adversely (significantly) affected with fish meal made from fish that was not fresh, and particularly with the stale fish meal. The growth depression comparing stale with fresh fish treatments was around 20% in trials at two of the centres. At one centre (Bangor, UK), the extent of the growth depression was not clear.

This work clarifies the Bangor work in that the additional centres (Mexico and Tahiti) had statistically satisfactory designs. On the basis of this work, and the earlier shrimp work with herring fish meal reported in the first part of the project (Research Report 1991-2), it is recommended that for Penaed shrimps, fish meal used in the diet should be from fresh fish.

Testing the anchovy fish meals fed to early weaned pigs, both growth and feed conversion were significantly depressed with the stale fish meal. This result contrasts with the herring meal trial in which growth and feed conversion were not affected by freshness. It is suggested that the higher biogenic amine content of the stale anchovy meal than the stale herring meal may have caused the growth depression.

It is regarded as prudent to recommend that fish meal for early weaned pigs should be made from fresh fish.

1. INTRODUCTION

The objectives of the special product fish meals project are to investigate the effects of freshness of raw material and processing temperature exposure on the feeding value of fish meal intended for special purposes, e.g. salmon diets (see Figure 1). Part I of this work with European (herring) fish meal has been reported already (Research Report 1991-2; August 1991). In this second part of the project part of the earlier work was repeated using South American fish meals (anchovy).

From the results of the first part of this work it was clear that some target species showed greater responses than others. For example, salmon smolts responded to fish meal quality more than either salmon fry or trout, possibly because faster growth was achieved with the former. Though a target species, mink are not regarded as a major outlet for special product fish meals. Consequently for the second part of this work, growth trials were undertaken only with salmon smolts, shrimp and early weaned pigs, though meals were first assessed for digestibility of nitrogen using mink.

The main design of the trials and the results with conclusions are given in the text. More details of the trials will be found in the Appendices.

2. FRESHNESS OF RAW MATERIAL - SOUTH AMERICAN FISH

2.1 Fish Meal Production

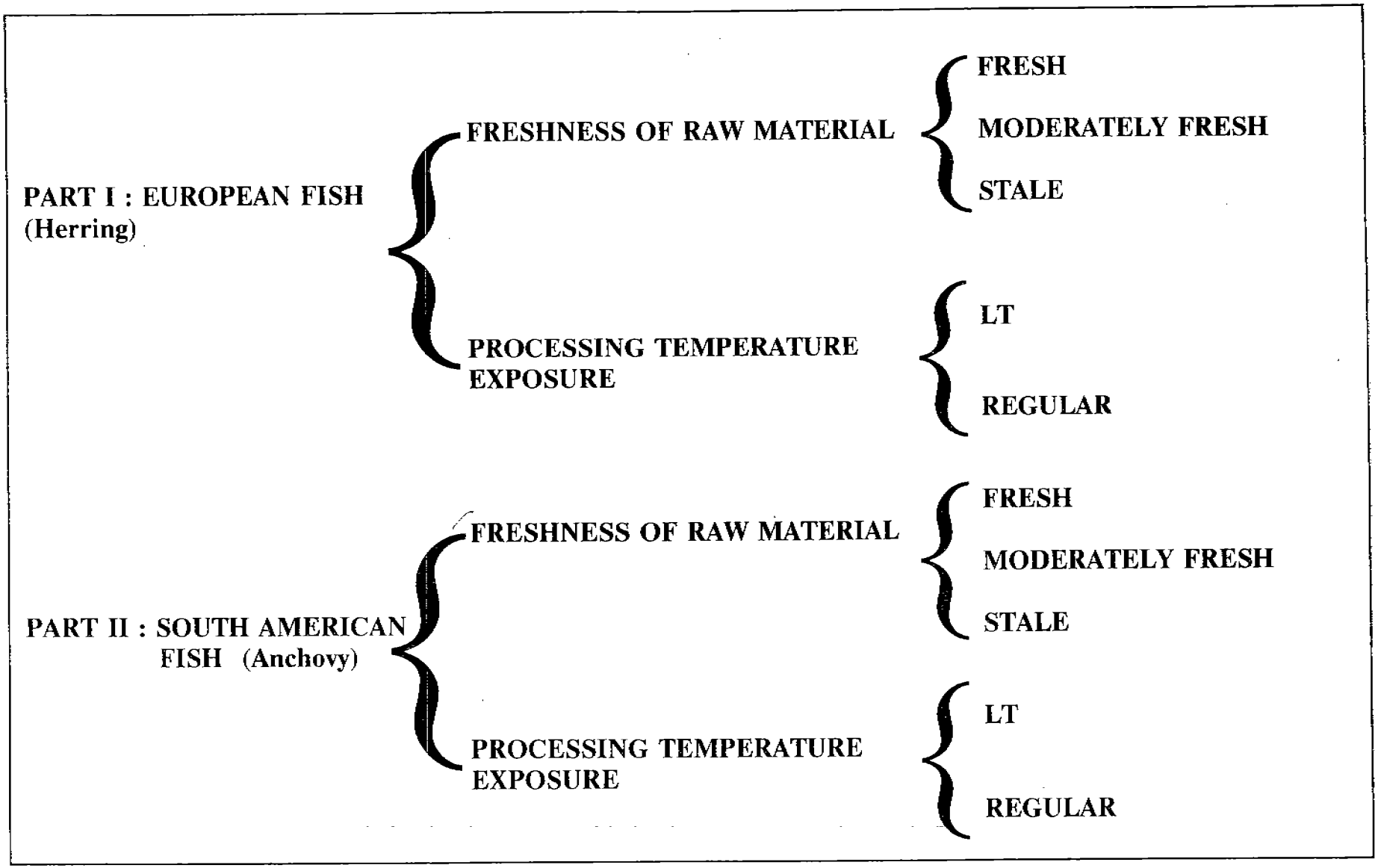
The raw material used was anchovy caught in a similar location within a 12 hour period, off the coast of Chile. The fish was landed within a few hours of being caught. The TVN of the fresh, moderately fresh and stale raw materials were 14, 30 and 50 mg per 100g fish respectively. The fish was processed through two dryers in sequence, the first an indirect steam dryer, followed by an indirect hot air dryer. Details of the processing conditions are given in Appendix Table 1. The fish meal for trial purposes was selected when the production line had been running the particular batch of raw material for at least 30 minutes. The analysis of the fish meals is given in Appendix Table 2. Each of the three fish meals was found to have a true protein digestibility in mink of around 90%.

2.2 Trial with Salmon Smolts at Otter Ferry, Scotland Experimental

The facilities and procedure used were as in the previous trial except that the number of tanks used was increased to 12, four per treatment. The average weight of the fish at the start was 129-140g. During the 12 week period of the trial the average sea water temperature was 13°C growth and feed conversion and feeding responses were measured. The latter was an assessment of the frequency with which the fish took feed. As well as the trial fish, an assessment of the performance of their contemporaries which were reared in 6m. diameter tanks on proprietary feeds was obtained.

FIGURE 1

SPECIAL PRODUCTS PROJECT - OVERALL PLAN



Results

As in the previous trial, growth was rapid. There were numerical differences in growth and feed conversion with the fastest growth and best feed conversion being obtained with meal made from the freshest fish with that from the stalest fish being worst, but the differences were small. However, over the trial period the specific growth rate was significantly worse with the stale fish meal (see Figure 2 and Table 1). Differences in feeding response tended to be greater. The meal from the fresh fish was significantly more palatable than the other two meals. Growth and feed conversion of the trial fish were better than those of similar fish on proprietary diets. At the end of the trial, the trial fish were about 25% heavier and feed conversion 20% better, despite the fact that the farm fish were in larger tanks which should have given them an advantage.
Compared with the first trial at Otter Ferry with fish meals made from herring of different freshness, differences in this trial were small. This is surprising in view of the higher amine levels in the moderately fresh and stale meals. Although variation from one batch of fish to another in terms of response may be the reason for the smaller difference in this trial; it may also be due to factors in addition to the four amines monitored (see analysis of fish meals in Appendix Table 1).

2.3 Trials with Shrimps

2.3.1 Trials with P.monodon at the University of Bangor, Wales

Experimental

The trial was undertaken with P.monodon. From the same Malaysian parent stock prawns were reared in systems of recirculated sea water at 28°C±2°C. During the trial animals were held in individual baskets 28cm x 19cm x 13.5cm held in raceways of 2500 l. capacity with a flow rate of 50 l. per minute. During the first week shrimp received live mussels. The trial period consisted of two periods each of four weeks, separated by a week during which live mussel flesh was fed. During the two treatment periods different treatments were imposed. This way, each animal acted as its own control. Animals were weighed every two days during the last three weeks of each period. Statistical analysis of the results consisted of linear regression of growth rate and comparison (paired to test) of the slope factor of the line obtained. This was obtained for each group of prawns on the same dietary regime. Details of the diets used are given in Appendix Table 2.

Results

An example of the growth achieved in two periods where the same control diet (live mussel) was fed is shown in Figure 3. The initial weight of the prawns was 1g to 3g. On this control diet (live mussel) growth was similar in both periods with gains of around 1½g to 2g in 25 day periods. The slopes of the regression lines were almost identical. An example of shrimp fed different fish meals (fresh and moderately fresh) in the two periods is also shown, with a significant difference. A summary of the treatment comparisons is given in Table 2.

FIGURE 2

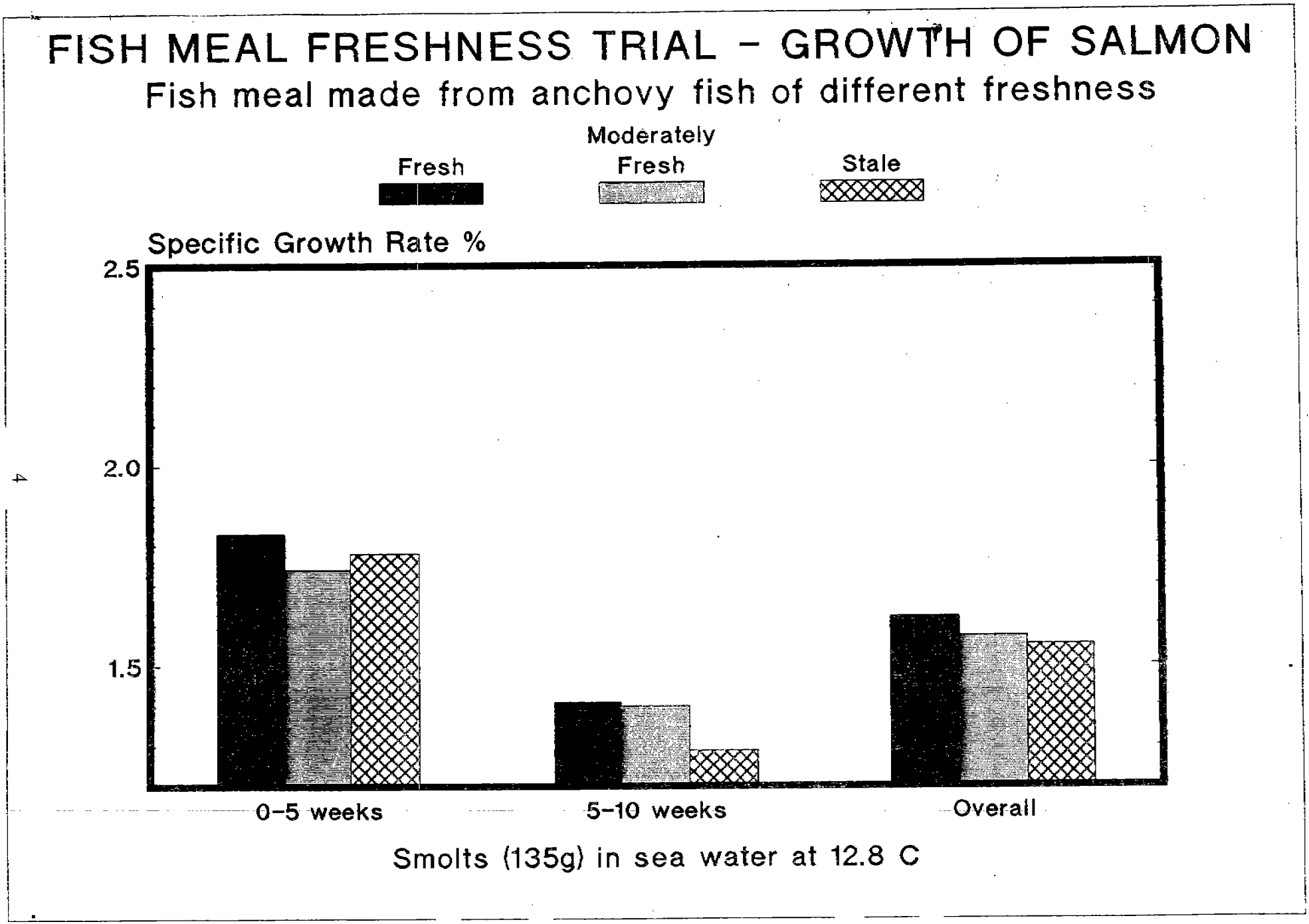

FISH MEAL FRESHNESS TRIAL - GROWTH OF SALMON
Fish meal made from anchovy fish of different freshness
Fresh
Moderately Fresh
Stale
Specific Growth Rate %
2.5
2.0
1.5
0-5 weeks
5-10 weeks
Overall
Smolts (135g) in sea water at 12.8 C

TABLE 1

OTTER FERRY TRIAL : GROWTH AND FEED CONVERSION OF SALMON SMOLTS

	Dietary treatment: 1 (F)	2 (MF)	3 (S)	SED	P	Significance
No. tanks per treatment	4	4	4			
Initial weight (g) (week 1)	132	139	135			
Final weight (g) (week 10)	424	431	408			
Specific growth rate (%):						
1 to 5 weeks	1.83	1.74	1.78	0.039	0.152	NS
6 to 10 weeks	1.41	1.40	1.29	0.049	0.064	NS
1 to 10 weeks	1.62	1.57	1.55	0.019	0.009	Sig^{n}
Feed consumed[1] g/fish	263	264	252			
Feed conversion (wt. gain wt. feed) 1 to 10 weeks	0.91	0.91	0.94	0.020	0.30	NS
Feeding response[2]	369	327	321	10.5	0.003	Sig^{n}
Water temperature ^{0}C	—— 13.1 ——					

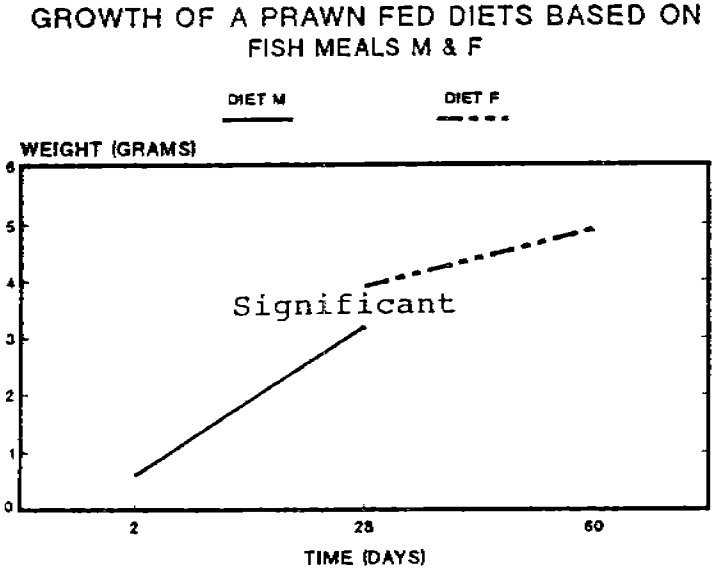
[1]estimated based on fish surviving

[2]out of 465

NS non-significant

FIGURE 3

FRESHNESS OF FISH FOR FISH MEAL - EFFECT ON PRAWN GROWTH



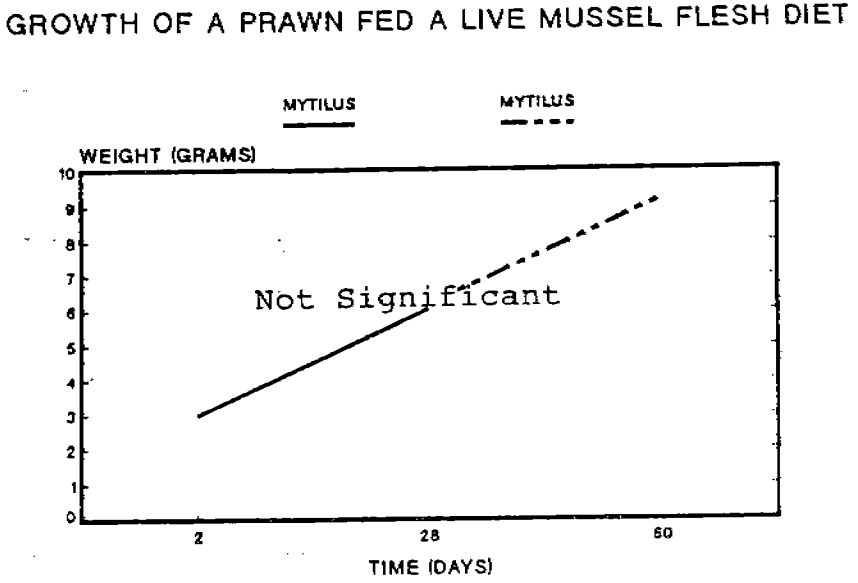


TABLE 2

FRESHNESS OF FISH FOR FISH MEAL - EFFECT ON PRAWN GROWTH

No. of animals

MF v F

1	died
4	MF better than F (2 c.v. sig^{n})

MF v S

2	died
1	no growth
2	MF Better than S (1 c.v. sig^{n})

S v F

0	no deaths
3	no growth
2	F better than S (1 c.v. sig^{n})

F - meal from fresh fish

MF - meal from moderately fresh fish

S - meal from stale fish

The medium fresh meal was better than the stale meal with the fresh meal being intermediate as far as shrimp growth was concerned. The difference approached significance.

2.3.2 Trials with P.vannemi at the University of Nuevo Leon, Mexico

Experimental

The University of Nuevo Leon was provided with the same fish meals as used in the trials above. They worked with P.vannemi held in tanks each of 60 l. capacity (60 x 30 x 35cm) supplied by simulated sea-water in a closed recirculatory system. The mean temperature was 25°C. Two trials were carried out, the first with 15 shrimps per tank and the second with 8 per tank.

The first trial ran for 15 days using shrimp weighing approximately 1g at the start; the second trial ran for 28 days with shrimp weighing 1g to 4g. Each treatment in each trial was replicated eight times (four tanks per treatment). Growth rate was determined at the end of the trial and the results were statistically analysed using an ANOVA technique.

Results

The results are shown below:-

Table 3: Growth of Shrimp Fed Meals from Fish of Different Freshness: Results of Trials in Nuevo Leon

	Freshness of Anchovy used in Fish Meal:			
	Fresh (F)	Moderately Fresh (MF)	Stale (S)	Significance
	Weight gain (g)			
Trial 1	0.59	0.50	0.47	F>MF&S*
Trial 2	1.92	1.64	1.63	F>MF&S*

* = Significant P = 0.05

The feed conversion did not appear to be affected by treatment and in all cases was in the range 3.0 to 3.5.

The growth achieved in the first trial was disappointing - probably because of the relatively high stocking density. It was repeated and better growth was achieved. There

was a treatment response in both trials, the meal from fresh fish giving better results than the other two. The difference tended to be greater in the first trial despite the lower growth rates.

It would appear that P.vannemi are sensitive to freshness of fish used in fish meal production and that best growth is obtained from meal made from very fresh raw material (TVN only 14 mg N per 100g fish in the case of these trials).

2.3.3 Trials with P.monodon and P.stylirostris at IFREMER, Tahiti

Experimental

The facilities used by IFREMER were similar to those used in Nuevo Leon - shrimps were held in groups in 225 l. capacity tanks. However, the facility is unusual in that each tank receives sea-water direct - it is not a recirculating system. Five tanks were used for each treatment, 10 animals per tank. The water temperature was 27°C.

Two trials were carried out, one with P.monodon, the other with P.stylirostris. Initial weights were 2.5g and 8.4g respectively. The trials lasted 30 and 31 days respectively.

Results

The growth rates achieved were as follows:-

Table 4: Growth of Shrimp Fed Meals from Fish of Different Freshness: Results of Trials in Tahiti

	Freshness of Anchovy used in Fish Meal:			
	Fresh (F)	Moderately Fresh (MF)	Stale (S)	Significance
	Weight gain (g)			
Trial 1 (P.monodon)	3.3	3.1	2.8	F>MF&S*
Trial 2 (P.stylirostris)	6.7	6.0	5.6	F>MF&S*

* = Significant P = 0.05

Growth with the fresh fish meal was better than that with the other two in both trials; though the moderately fresh meal gave a better result than the stale meal the difference was smaller. These results are similar to those obtained in Nuevo Leon. It appeared that P.monodon and P.stylirostris are also sensitive to freshness of fish meal, giving the best growth with meal from very fresh raw material.

In the previous research report a shrimp trial, whilst indicating shrimp growth was depressed with meals made from herring which was not fresh. This latest series of results with anchovy confirm the importance of freshness.

In conclusion, four trials with shrimp at three different centres gave results with three species of Penaeds (monodon, vannemi and stylirostris) which in each case showed that growth was affected by the freshness of the fish used in producing fish meal. On the basis of this result it can be recommended that for Penaed shrimps fish meal used in the diet should be from fresh fish.

2.4 Trials with Early Weaned Pigs

2.4.1 Trial at North of Scotland College, Aberdeen

A trial was carried out at the North of Scotland College, Aberdeen with early weaned pigs, similar in design to previous trials reported earlier (see Research Report 1991-2).

Experimental

The cheaper weaning diets used before were used, details of which are given in Appendix Table 3. As before the soyabean meal used was a high protein (49% dehulled) soyabean meal and part of the cereals were cooked (micronised). The three diets with fish meals F, MF and S were adjusted based on the fish meal analysis to equate protein and oil as far as possible. A block of pigs consisted of 18 Large White x Landrace selected from litters at three to four weeks of age and matched for genotype, sex ratio and weight. They were randomly allocated to three treatment groups.

Originally seven replicates (blocks) were to have been used. However, there was a mild incidence of disease in the first two replicates resulting in lower than normal growth. In view of this, three more replicates were included giving a total of 10, 180 pigs in total. Other aspects of the trial including recording and duration, etc., were as reported previously.

Results

Because there were some larger differences than expected in the initial weight of the pigs, the results were analysed by analysis of variance (Table 5) and also by analysis of covariance (Table 6). In the latter analysis the initial weight was used as covariate to try to reduce effects of initial weight difference.

The results showed that both growth and feed conversion in weeks 1 and 2, and over the whole four weeks of the trial, were better with the meals from fresh and moderately fresh fish than the meal for stale fish. Differences for both growth and feed conversion for the whole trial were statistically significant ($P<0.05$) following covariance analysis (see Table 6). They did not reach significance with analysis of variance (see Table 5). Although the differences in growth and feed conversion were apparent after two weeks at this stage they did not reach significance. Although the fresh fish meal gave better results than that from moderately fresh fish, differences were small. Feed intake was

Table 5

The Effects of Freshness of Fish Meal on Voluntary Feed Intake and Performance of Early Weaned Piglets (over 4 weeks)

	Diet 1	Diet 2	Diet 3	SED	P
Fish meal	F	MF	S		
Live weight (kg):					
initial wt	7.58	7.50	7.34	0.088	<0.05
middle wt	11.32	11.26	10.76	0.254	<0.10
final wt after 4 weeks	19.61	19.61	18.81	0.326	<0.05
Weight gain g/day					
0-2w	273	263	244	19.5	NS
0-4w	433	429	410	12.9	NS
Feed intake g/day					
0-2w	340	328	318	26.3	NS
0-4w	563	555	539	15.4	NS
Feed conversion					
0-2w	1.25	1.29	1.34	0.117	NS
0-4w	1.31	1.31	1.34	0.058	NS

Table 6

The Effects of Freshness of Fish Meal on Voluntary Feed Intake and Performance of Early Weaned Piglets (over 4 weeks)
(Analysis of covariance using initial weight as covariate)

	Diet 1	Diet 2	Diet 3	SED	P
Fish meal	F	MF	S		
Live weight (kg): initial wt middle wt final wt	 7.58 11.32 19.64	 7.50 11.28 19.72	 7.34 10.74 18.67	 0.088 0.261 0.322	 <0.05 NS <0.05
Feed intake g/day 0-2w 0-4w	 355 559	 315 543	 355 554	 24.5 12.3	 NS NS
Growth rate g/day 0-2w 0-4w	 275 435	 272 437	 233 400	 18.6 11.5	 NS <0.05
Feed conversion ratio 0-2w 0-4w	 1.23 1.29	 1.21 1.26	 1.44 1.41	 0.098 0.047	 NS <0.05

similar on all treatments.

In contrast to the earlier pig trials with fish meals made from herring at different freshness, this trial with anchovy meal showed freshness did affect growth or feed conversion. Because intake was unaffected, the results suggest poorer utilisation of the meal from staler fish. This may result from the higher levels of biogenic amines in this fish meal than in the meal from stale herring.

In conclusion, it appears that whilst the early weaned pig can tolerate some spoilage of fish used in fish meal, more extensive spoilage does affect the pig's performance. It is, therefore, prudent to recommend that for all fish used to produce fish meal for early weaned pigs the fish should be fresh.

3. Processing Temperature Exposure - South American Fish Meal

The same catch of fresh anchovy fish was processed at the same time through either an indirect steam rotadisc dryer (regular drying) or through a combination of preliminary indirect rotadisc steam dryer followed by final drying in an indirect hot air dryer (low temperature drying). Samples of the meals produced were then tested for true protein digestibility in mink.

Though the meal produced in the low temperature facility had a mink digestibility of over 90%, the regular dried meal was only slightly lower (around two units). Consequently it was concluded that because the digestibility difference was so small, there was no point in continuing to evaluate these meals through animal testing.

As with the herring fish trial, low temperature v regular drying failed to produce the expected digestibility difference (around 5 units or more lower for the latter). This would seem to suggest that careful use of regular dryers can give good results.

In view of the failure to find another factory in South America with the facility to dry fish in low temperature and regular dryers, this part of the project was abandoned.

This failure to produce meals through regular and low temperature dryers from the same fresh fish prevents work to assess the effect of drying temperature on the feeding value of fish meals. However, trials with commercial products carried out by members have shown that superior growth in salmonids and early weaned pigs with LT meals were part of the difference is likely to have resulted from the gentler drying and higher digestibility.

APPENDIX TABLE 1 - PREPARATION OF FISH MEALS

SAMPLE CARASTERISTICS

SAMPLE IAFMM1:
- ANCHOVY FISH MEAL
- TVN = 14 mg/100gr (raw material)
- TVN = 106 mg/100gr (concentrate)
- DATE OF PRODUCTION APRIL 01, 1991
- TIME OF PRODUCTION FROM 21:00 TO 22:00 Hr
- TIME FROM CAPTURE 14 HOURS

SAMPLE IAFMM2:
- ANCHOVY FISH MEAL
- TVN = 30 mg/100gr (raw material)
- TVN = 190 mg/100gr (concentrate)
- DATE OF PRODUCTION APRIL 02, 1991
- TIME OF PRODUCTION FROM 09:00 TO 10:00 Hr
- TIME FROM CAPTURE 25 HOURS

SAMPLE IAFMM3:
- ANCHOVY FISH MEAL
- TVN = 50 mg/100gr (raw material)
- TVN = 239 mg/100gr (concentrate)
- DATE OF PRODUCTION APRIL 02, 1991
- TIME OF PRODUCTION FROM 16:00 TO 17:00 Hr
- TIME FROM CAPTURE 34 HOURS

Parameters description

TMP P C : Temperature of the coocked fish.

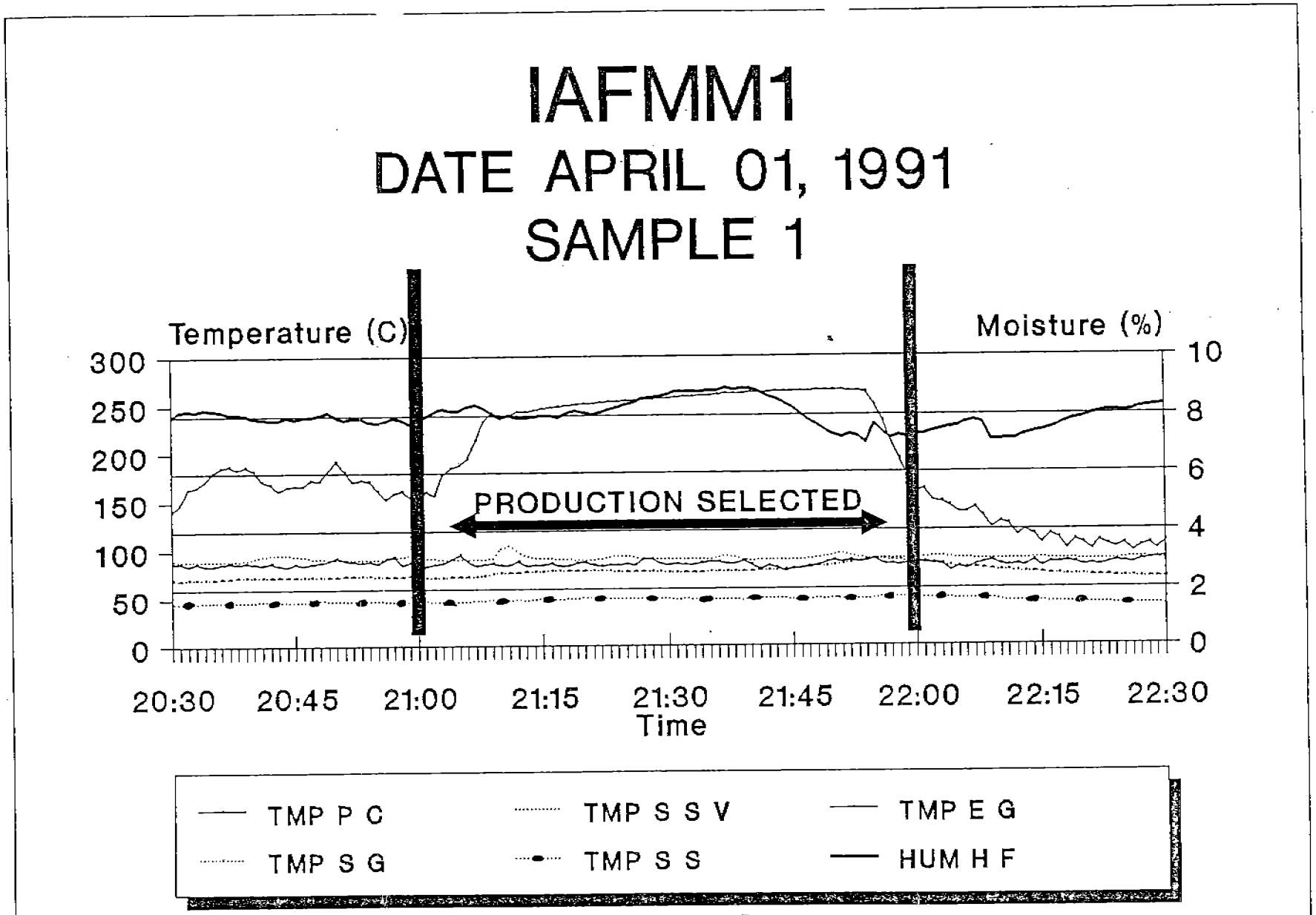
TMP S S V : Temperature of moist scrap at the outlet of the steam drier.

TMP E G : Temperature of inlet gases to the hot air drier.

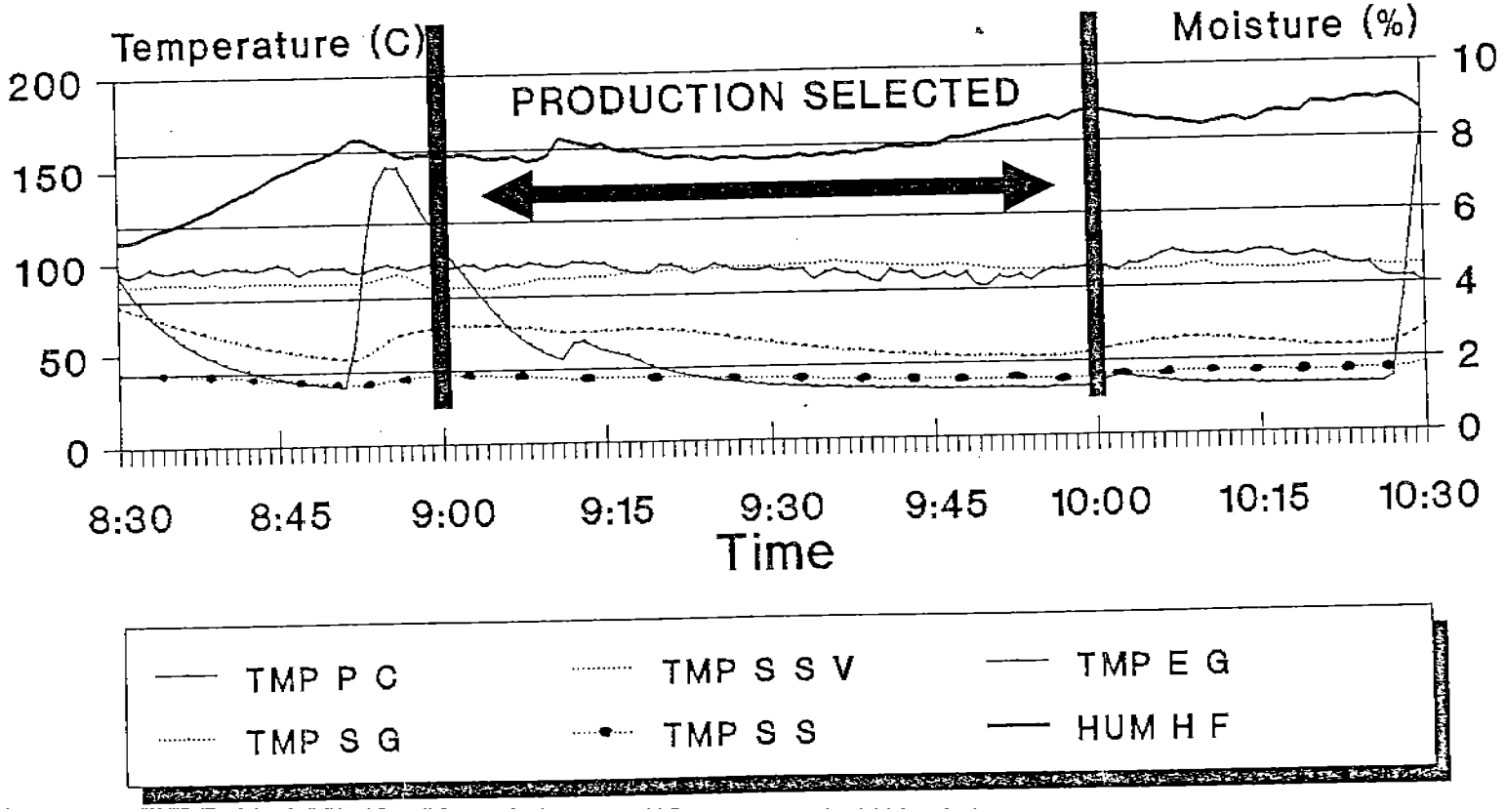
TMP S G : Temperature of outlet gases from the hot air drier.

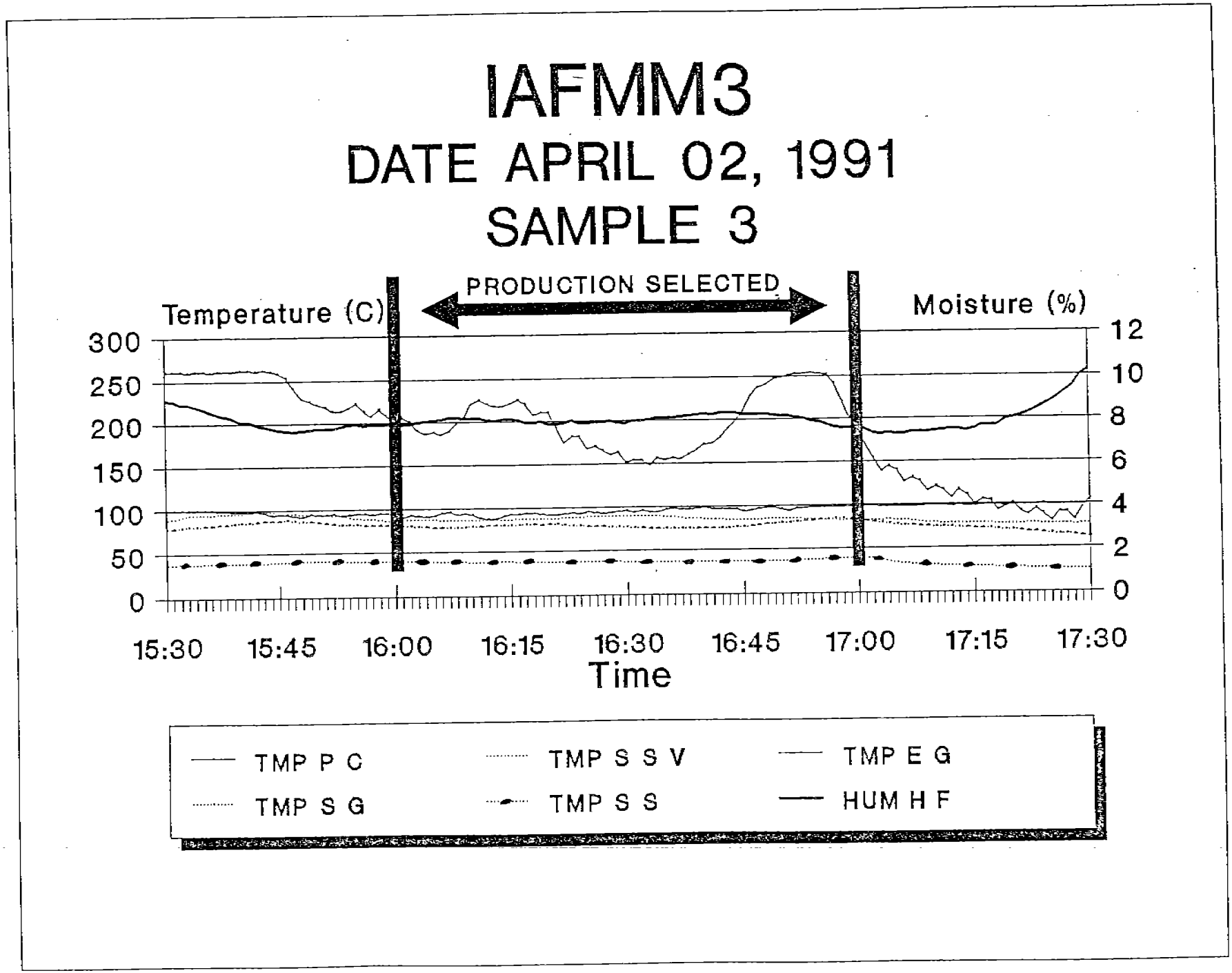
TMP S S : Temperature of scrap at the outlet of the hot air drier.

HUM H F : Moisture of the final product.


IAFMM1
DATE APRIL 01, 1991
SAMPLE 1
Temperature (C)
Moisture (%)
300
250
200
150
100
50
0
10
8
6
4
2
0
PRODUCTION SELECTED
20:30
20:45
21:00
21:15
21:30
21:45
22:00
22:15
22:30
Time
TMP P C
TMP S S V
TMP E G
TMP S G
TMP S S
HUM H F

IAFMM2
DATE APRIL 02, 1991
SAMPLE 2




IAFMM3
DATE APRIL 02, 1991
SAMPLE 3
PRODUCTION SELECTED
Temperature (C)
Moisture (%)
300
250
200
150
100
50
0
12
10
8
6
4
2
0
15:30
15:45
16:00
16:15
16:30
16:45
17:00
17:15
17:30
Time
TMP P C
TMP S S V
TMP E G
TMP S G
TMP S S
HUM H F

APPENDIX TABLE 2
(See Circular Letter 1993/37)

CHEMICAL COMPOSITION OF THE FISH MEALS

	Fresh	Moderately Fresh	Stale
	(% as received)		
Protein	69.6	67.5	65.8
Oil (ether extract)	7.7	7.4	9.4
Ash	14.5	15.3	15.4
Moisture	9.6	10.9	11.1
Chlorides expressed as salt	2.41	2.98	2.98
Available lysine	5.56	5.67	5.25
True digestibility of protein in mink	91.4	89.7	89.8
Biogenic Amines	mg amine free base/100g sample		x10 = ppm
Histamine	2.8	185.0	470.1
Cadaverine	5.1	80.3	159.9
Putrescine	3.5	44.6	91.6
Tyramine	-	28.5	65.7
TOTAL (ppm)	114	3384	7873

COMPOSITION AND ANALYSIS OF WEANING DIETS			
Ingredients (g/kg)	Diet F	Diet MF	Diet S
Barley	477.0	474.0	473.5
Micronised wheat	150.0	150.0	150.0
Anchovy	120.0	122.0	125.0
Soya bean meal HP	50	50	50
Dried whey	50	50	50
Fullfat soya extruded	100	100	100
Vegetable oil	4.7	5.3	3.0
Dicalcium phosphate	12.5	12.5	12.6
Limestone	2.5	2.5	2.5
Lysine HCl	0.5	0.5	0.5
Methionine	0.5	0.5	0.5
Molasses	30.0	30.0	30.2
Minerals/vitamins*	2.5	2.5	2.5

* Composition of supplement was Ca 130g/kg; Vit A 8,000,000 iu/kg; Vit D 800,000 iu/kg; Vit E 20,000 iu/kg; Vit K 1,200 mg/kg; Vit B_2 2,400 mg/kg; Vit B_6 2,000 mg/kg; Vit B_{12} 24 mg/kg; Pantothenic acid 8,000 mg/kg; Nicotinic acid 8,000 mg/kg; Folic acid 480 mg/kg; Biotin 40 mg/kg; Iron 24,000 mg/kg; Zinc 40,000 mg/kg; Manganese 1,200 mg/kg; Copper 70,000 mg/kg; Iodine 800 mg/kg; Cobalt 400 mg/kg; Selenium 60 mg/kg and Ethoxyquin + BHA 40 g/kg.

PROXIMATE ANALYSIS OF EXPERIMENTAL DIETS			
	Diet F	Diet MF	Diet S
Dry matter (g/kg)	912.0	908.7	910.7
Crude protein (g/kg)	231.0	217.9	226.4
Fat (AEE) (g/kg)	70.3	74.1	69.1
Fat (CME) (g/kg)	63.2	65.1	64.7
Neutral detergent fibre (g/kg)	125.2	149.0	138.5
Ash (g/kg)	60.2	58.4	60.8
*Digestible energy (MJ/kg)	14.8	14.4	14.5

* Estimated by regression equation.