FATS AND PROTEINS RESEARCH FOUNDATION, INC.

Director's Digest

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NUTRITIONAL RESPONSE OF A WESTERN HEMISPHERE SHRIMP, PENAEUS VANNAMEI, TO MEAT AND BONE, FEATHER, AND POULTRY BY-PRODUCT MEALS

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SUMMARY

SEMI-PURIFIED DIETS WERE USED TO EVALUATE THE POTENTIAL OF INCLUDING MEAT AND BONE, FEATHER, AND POULTRY BY-PRODUCT MEALS AS FEEDSTUFFS IN COMMERCIAL SHRIMP FEEDS FOR PENAEUS VANNAMEI. SINCE LONG CHAIN UNSATURATED FATTY ACIDS (C20 AND C22) ARE ESSENTIAL, AND THESE FATTY ACIDS ARE NOT PRESENT IN NEUTRAL FAT FROM ANIMALS AND PLANTS FROM THE TERRESTRIAL AND FRESH-WATER ENVIRONMENTS, THE REQUIREMENT FOR THE C20 AND C22 UNSATURATED FATTY ACIDS WERE EVALUATED USING PURIFIED DIETS BY USING DIFFERENT LEVELS OF MARINE FISH OILS VERSUS LARD AND POULTRY OIL. MOST COMMERCIAL SHRIMP COMPANIES USE PENAEUS VANNAMEI AS THE SHRIMP SPECIES TO STOCK PONDS IN THE WESTERN HEMISPHERE.

IT IS IMPORTANT TO KEEP IN MIND THAT THE DATA IN THIS REPORT ARE NOT VALID ABSOLUTE FOR QUANTITATIVE NUTRITIONAL REQUIREMENTS. HOWEVER, THE DATA ARE COMPLETELY VALID AND RELIABLE ON A COMPARATIVE BASES UNDER THE CONDITIONS OF THE EXPERIMENT FOR ESTIMATING QUANTITATIVE REQUIREMENTS AND COMPARATIVE NUTRITIONAL QUALITY FOR THE FEEDSTUFFS TESTED.

THERE WERE NO DIFFERENCES IN SURVIVAL FOR ANY OF THE CONTROL AND EXPERIMENTAL FEEDS TESTED. GROWTH COEFFICIENTS OF SHRIMP FED FEEDS WITH FISH MEAL ARE GREATER THAN THOSE FED FEEDS WITH MEAT AND BONE, FEATHER AND POULTRY BY-PRODUCT MEALS. HOWEVER, THE MAGNITUDE OF THE DIFFERENCE IS SMALL (USUALLY MUCH LESS THAN 7%). THERE WERE NO DIFFERENCES BETWEEN THE GROWTH COEFFICIENTS OF SHRIMP FED FEEDS WITH MEAT AND BONE, FEATHER, AND POULTRY BY-PRODUCT MEALS.

GROWTH OF SHRIMP FED FEEDS WITH NO SUPPLEMENTAL MEALS ADDED IS LESS THAN THOSE WITH 2.5%, 5.0% AND 10.0% OF THE PROTEIN REPLACED WITH SUPPLEMENTAL MEALS. THERE IS NO DIFFERENCE BETWEEN THE DIFFERENT LEVELS FOR EACH SUPPLEMENTAL MEAL EVALUATED.

FOR THE PURIFIED DIETS CONTAINING DIFFERENT SOURCES OF NEUTRAL FAT AND LEVELS OF FISH OIL, THE DATA INDICATE THAT 3% LEVEL OF FISH OIL IS ADEQUATE FOR SUPPLYING THE C20 AND C22 UNSATURATED FATTY ACIDS. YET, WHEN A MIXED OIL OF LARD, POULTRY OIL AND FISH OIL WAS ADDED AT THE 7% LEVEL THERE WAS A DECREASE IN GROWTH. THIS INDICATES THAT THE RATIOS OF THE DIFFERENT FATTY ACIDS ARE IMPORTANT.

THE DATA INDICATE THAT UP TO 5% AND MAYBE 10% MEAT AND BONE, FEATHER, AND/OR POULTRY BY-PRODUCT CAN BE USED IN COMMERCIAL SHRIMP FEEDS FOR PENAEUS VANNAMEI. THE LEVEL OF USE OF MEAT AND BONE, FEATHER, AND POULTRY BY-PRODUCT MEAL WILL BE DETERMINED BY THE RELATIVE AVAILABILITY OF NUTRIENTS AND PRICES OF THESE MEALS VERSUS OTHER MEALS SUCH AS FISH, SOYBEAN, SQUID, ETC.

INTRODUCTION AND BACKGROUND INFORMATION

MEAT AND BONE, FEATHER AND POULTRY BY-PRODUCT MEALS HAVE BEEN USED EXTENSIVELY IN FEEDS BY MANY ANIMAL PRODUCTION INDUSTRIES. HOWEVER, THE USE OF MEAT AND BONE MEALS IN SHRIMP FEEDS ARE VERY LIMITED AND FEATHER AND POULTRY BY-PRODUCT MEALS ARE NOT BEING USED. THIS IS BECAUSE THERE IS NO SPECIFIC INFORMATION WHICH GIVES THE NUTRITIONAL RESPONSE OF MARINE SHRIMP TO MEAT AND BONE, FEATHER AND POULTRY BY-PRODUCT MEALS.

INTEREST IN THE FARMING OF PENAEID SHRIMP IN THE UNITED STATES AND THE WORLD IS VERY HIGH BECAUSE: (1) HIGH PRICE, (2) A LARGE GROSS INCOME OF $3000 TO $5000/ACRE/CROP, (3) LARGE MARKET AND HIGH DEMAND FOR SHRIMP AS CHARACTERIZED

BY THEIR HIGH PRICE, (4) INCREASING MARKET SIZE OF ABOUT 3%/YEAR, (5) LARGE NEGATIVE BALANCE OF PAYMENT DUE TO IMPORTATION OF ABOUT $1.2 BILLION/YEAR OF SHRIMP, (6) NATURAL SHRIMP FISHERIES ARE AT MAXIMUM SUSTAINABLE YIELD BUT CANNOT SUPPLY MARKET DEMAND; AND, (7) LARGE AMOUNT OF LAND AVAILABLE IN THE UNITED STATES (E.G. ALONG THE GULF COAST AND EVEN INLAND SUCH AS IN WEST TEXAS AND SOUTHERN ARIZONA AND CALIFORNIA) AND THE WORLD SUCH AS BRAZIL, ECUADOR, COLUMBIA, INDONESIA, AUSTRALIA, PHILIPPINES AND PEOPLE'S REPUBLIC OF CHINA.

THE FARMING OF MARINE SHRIMP HAS GROWN FROM NOTHING TO AN INDUSTRY HAVING A VALUE OF ABOUT 600 MILLION DOLLARS IN 15 YEARS OR ABOUT 7.5% OF THE TOTAL WORLD CONSUMPTION OF SHRIMP. THIS IS EXPECTED TO INCREASE TO ABOUT 30% IN ANOTHER TEN YEARS. PRODUCTION OF 1,000 POUNDS (SEMI-EXTENSIVE) TO 5,000 POUNDS (INTENSIVE) PER ACRE PER CROP IS PRESENTLY BEING OBTAINED WITH FOOD CONVERSION RATIOS OF 1.5 TO 2.0. THIS MEANS 1,500 TO 10,000 POUNDS OF FEED PER ACRE PER CROP USING THE 1.5 FOOD CONVERSION RATIO AND TWICE THESE VALUES FOR YEARLY CONSUMPTION VALUES ASSUMING A MINIMUM AVERAGE OF TWO CROPS PER YEAR. AN ESTIMATED 250,000 ACRES ARE IN SHRIMP PRODUCTION TODAY WITH OVER 1,000,000 ACRES IN TEN YEARS. ASSUMING THAT SHRIMP FEEDS CONTAINED AN AVERAGE OF ONLY 5% MEAT AND BONE, FEATHER, OR POULTRY BY-PRODUCT MEALS WITH 8,000 POUNDS OF FEED USED PER ACRE PER YEAR (4,000 POUNDS PER ACRE PER CROP AND TWO CROPS PER YEAR), THIS WOULD REPRESENT THE USAGE OF 240,000,000 POUNDS OF MEAT AND BONE, FEATHER, AND POULTRY MEALS PER YEAR BY THE SHRIMP INDUSTRY IN TEN YEARS. DATA FROM PREVIOUS RESEARCH HAS SHOWN THAT UP TO 5% MEAT AND BONE MEAL CAN BE USED IN FEED FORMULATIONS FOR PENAEUS VANNAME† WITH NO SIGNIFICANT REDUCTION IN GROWTH. HOWEVER, THERE WAS A LINEAR DECREASE IN GROWTH AS THE LEVEL OF MEAT AND BONE MEAL IN THE SHRIMP FEED INCREASED TO 20%. FURTHER RESEARCH INDICATED THAT THE DECREASE DUE TO INCREASING LEVELS OF MEAT AND BONE MEAL WAS NOT DUE TO THE CRUDE FAT COMPONENT OF MEAT AND BONE MEAL. HOWEVER, IT IS NOT KNOWN IF THE DECREASE IN GROWTH IS DUE TO THE QUALITY OF PROTEIN OR MINERAL COMPOSITION IN MEAT AND BONE MEAL. IF THE QUALITY OF PROTEIN IN MEAT AND BONE MEAL IS ADEQUATE, THEN IT WOULD BE POSSIBLE TO USE HIGHER LEVELS OF MEAT AND BONE MEAL IN SHRIMP FEEDS BY SUPPLEMENTING THE FEED WITH APPROPRIATE MINERAL PREMIX ADDITIONS.

NO INFORMATION IS PRESENTLY AVAILABLE CONCERNING THE NUTRITIONAL RESPONSE OF SHRIMP TO FEATHER OR POULTRY BY-PRODUCT MEALS.

Consequently, research with the objective to evaluate the protein quality of meat and bone, feather and poultry by-product meals in feeds to marine shrimp is proposed. This information would be very valuable for feed companies to consider utilizing these feedstuffs in shrimp feeds.

Penaeus vannamei is the major commercial species in the western hemisphere. Because of this and previous research conducted using this species, this species was used for this research effort.

OBJECTIVES

1. To evaluate the nutritional response of the juvenile shrimp, Penaeus vannamei to the protein quality of protein quality of meat and bone, feather, and poultry by-product meals in feeds.
2. To evaluate the nutritional repsonse of the juvenile shrimp, Penaeus vannamei to the fatty acid quality of lard and poultry oils versus fish oils in feeds.

EXPERIMENTAL DESIGN

Animals:

Juvenile shrimp, Penaeus vannamei, weighing 30 to 70 milligrams initial weight were used.

Experimental Feeds:

A series of experimental diets based upon a known standardized purified diet for Penaeus vannamei were used. The purified diet did not contain any meat and bone, feather, or poultry by-product meals. Three levels of meat and bone, feather, and poultry by-product meals representing a replacement of 2.5%, 5.0% and 10% of the protein of the purified diet containing a total protein level of 35% were used. These semi-purified diets were identical in terms of nutrient composition except for the level of protein originating from either meat and bone, feather, or poultry by-product meals.

A SECOND SERIES OF EXPERIMENTAL DIETS BASED UPON A KNOWN STANDARDIZED PURIFIED DIET FOR PENAEUS VANNAMEI WERE USED. THESE DIETS CONTAINED 3.0%, 5.0% AND 7.0% FISH OIL AND 7.0% OF MIX OIL (FISH OIL, LARD PLUS POULTRY OIL).

RESULTS

FORMULAS OF DIETS ARE AVAILABLE UPON REQUEST.

Table 25 summarizes the survival and growth (in terms of G, growth coefficient) for the different test feeds. Survival was excellent (82.91% to 98.75%) with no significant differences between any of the groups of shrimp fed the different experimental feeds. There were significant differences in growth.

ANOVA analyses (Table 26) for growth coefficients (G) presented in Table 25 indicate significant differences due to different feeds ($P < 0.0008$) but not to different tanks nor was there a feed*tank interaction.

The Student-Newman-Keuls test (Table 27) for growth coefficient (G) data given in Table 25, indicated that the shrimp fed the purified diet containing the mixed oil was significantly less than the purified diets containing the three levels of fish oils. This means that either an altered fatty acid profile or an inadequate amount of long chain unsaturated fatty acids caused the decreased growth since the mixed oil purified diet contained a lower level (1.7% fish oil) of the long chain unsaturated fatty acids as compared to the purified diet containing three percent fish oil. Further studies evaluating the effect of altered fatty acid profile by the addition of meat and bone, feather and poultry by-product meals need to be done.

EFFECTS OF MEAT AND BONE, FEATHER, POULTRY AND FISH MEALS ON THE GROWTH OF PENAEUS VANNAMEI. NUTRITION EXPERIMENT 89-02. VALUES REPRESENT MEANS AND STANDARD ERRORS FOR THE NUMBER OF REPLICATES IN PARENTHESES.

FEED	MEAL	LEVEL	OIL	LIPID	SURVIVAL	G
8905	BONE	2.5	MIXED	7	96.66 2.27	0.07835 0.00307
8906	BONE	5.0	MIXED	7	92.91 12.60	0.08189 0.00119
8907	BONE	10.0	MIXED	7	93.33 3.61	0.08082 0.00254
8908	FEATHER	2.5	MIXED	7	95.41 3.38	0.07865 0.00093
8909	FEATHER	5.0	MIXED	7	93.33 3.61	0.08232 0.00152
8910	FEATHER	10.0	MIXED	7	96.66 2.27	0.08053 0.00190
8911	FISH	2.5	MIXED	7	95.00 2.67	0.08252 0.00090
8912	FISH	5.0	MIXED	7	96.25 2.63	0.08411 0.00864
8913	FISH	10.0	MIXED	7	96.66 2.37	0.09590 0.00197
8914	POULTRY	2.5	MIXED	7	99.75 1.25	0.08091 0.00205
8915	POULTRY	5.0	MIXED	7	97.91 2.08	0.07907 0.00183
8916	POULTRY	10.0	MIXED	7	90.41 4.93	0.08130 0.00251
8917	NONE	0.0	MIXED	7	96.66 4.79	0.05594 0.00221
8918	NONE	0.0	FISH	7	96.66 4.79	0.07778 0.00215
8919	NONE	0.0	FISH	3	92.08 3.50	0.07533 0.00414
8920	NONE	0.0	FISH	5	92.08 3.50	0.07382 0.00290

TABLE 26 ANOVA TABLE FOR GROWTH COEFFICIENTS

SOURCE OF VARIATION	DF	SS	MS	F	P*
FEED	3	0.00239399	0.00079800	14.93	0.0008
TANK	3	0.00033626	0.00011209	1.61	0.2273
FEED*TANK	9	0.00048116	0.00005346	0.77	0.6486
ERROR	16	0.00111679	0.00006980		
TOTAL	31	0.00432821			

*SIGNIFICANCE LEVEL

TABLE 27 STUDENT-NEWMAN-KEULS TEST FOR GROWTH COEFFICIENT

ALPHA= 0.05 DF= 9 MSE= 0.000053

NUMBER OF MEANS	2	3	4
CRITICAL RANGE	0.0082706	0.0102071	0.011413

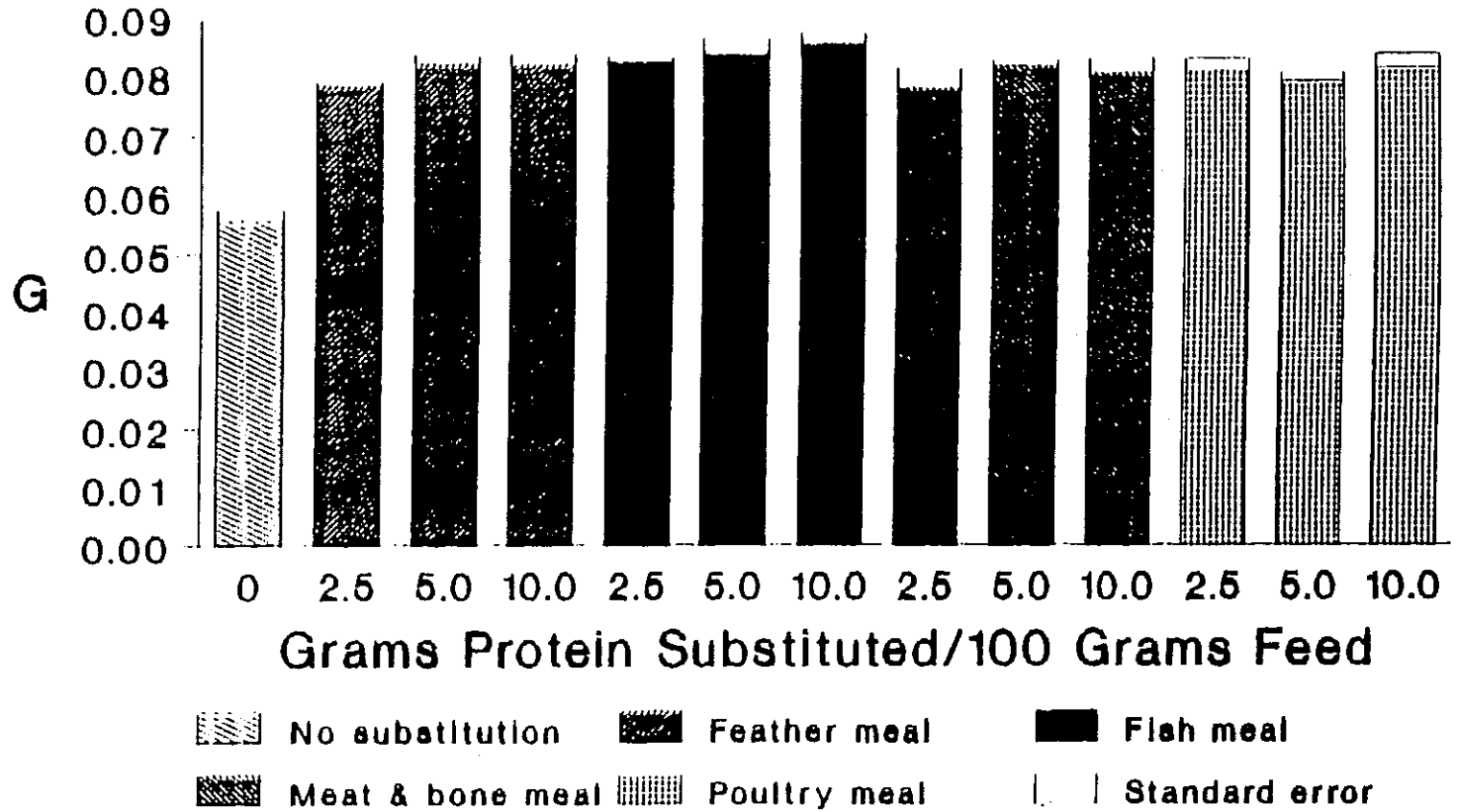
MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

SNK GROUPING	MEAN	N	FEED
A	0.07778	8	7% LIPID, FISH OIL ONLY
A A	0.07533	8	3% LIPID, FISH OIL ONLY
A	0.07382	8	5% LIPID, FISH OIL ONLY
B	0.05594	8	7% LIPID, MIXED OILS**

**FISH OIL, POULTRY OIL AND LARD

Figure 1

Effects of Feather, Fish, Meat and Bone, and Poultry Meals on the Growth Coefficients of *Penaeus vannamei*



The effects of different levels of feather, fish, meat and bone, and poultry by-product meals on growth (in terms of G) are also presented in Figure I. This figure shows the similarity of Penaeus vannamei shrimp growth fed diets containing three levels of the above four tested feedstuffs even though growth for shrimp fed the fish meals were significantly greater (Table 28). These data indicate that probably at least the amount of meat and bone, feather, or poultry by-product meals representing 5% protein and maybe even 10% protein replacement can be added to commercial shrimp feed contingent upon the essential fatty acid and mineral requirements being satisfied. In other words, the data indicate that the quality of protein in terms of essential amino acids from meat and bone, feather and poultry by-products are probably not limiting the inclusion of these feedstuffs in commercial shrimp feeds. There were no significant differences between the three levels of each of the four tested feedstuffs (Table 28).

Table 28 **ANOVA Table for Final Mean Weight**

Source of variation	df	SS	MS	F	P*
tank	3	0.26885392	0.08961797	4.3219	0.00[illegible]
feed	12	2.15677605	0.17973134	8.6676	0.0[illegible]
level	3	1.88181960	0.62727320	30.2505	0.0001
0 vs others**	1	1.82007808	1.82007808	87.7740	0.0001
among others**	2	0.06174152	0.03087076	1.4888	0.2313
meal	3	0.20457434	0.06819145	3.2886	0.0244
fish vs others***	1	0.20431267	0.20431267	9.8531	0.0023
among others***	2	0.00026167	0.00013084	0.0063	0.9937
level*meal	6	0.07038211	0.01173035	0.5657	0.7585
error	88	1.82476362	0.02073595		
total	103	4.25039359			

* significance level
** 2.5, 5, and 10%
*** feather, meat and bone, and poultry meals

Figure II graphically presents the data showing the effect of fish oil, poultry oil, lard and lipid level in terms of fish oil on growth (G). As also indicated in Tables 25 and 27, there is a significant decrease in growth for shrimp fed the purified feed containing mixed fish oil, poultry oil and lard as compared to purified feeds containing 3%, 5%, or 7% fish oil. Since the mixed oil contain 1.7% fish oil which was less than the lowest level of fish oil (3%) tested, it is possible that increased growth in feeds with meat and bone, feather, and poultry by-product meals can be obtained by adding more fish oil. Because these preliminary data indicate that deficiency of the long chain unsaturated fatty acids may have caused the decreased growth for shrimp fed feeds containing meat and bone, feather and poultry by-product meals as compared to fish meal, further studies involving the potential effect of the amount of fish oil on the amount of these three feedstuffs that can be added to commercial shrimp feeds is very justified.

CONCLUSIONS

1. Protein quality in terms of essential amino acids for meat and bone, feather and poultry by-product meals representing up to 10% protein in shrimp feeds is not limiting for growth of juvenile Penaeus vannamei.

2. The level of fish oil in terms of long-chain polyunsaturated fatty acids probably limit the amount of meat and bone, feather and poultry by-product in commercial shrimp feeds as these meals replace the more expensive marine animal meals such as fish meal.