TO DETERMINE GROWTH AND SURVIVAL OF *Litopenaeus vannamei* SUBSTITUTING GRAIN SORGHUM DDGS INGREDIENT FOR SOYBEAN AND FISH MEAL

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INTRODUCTION

Dry distillers grain with solubles from grain sorghum (DDGSgmS) is a by-product of fermentation process from ethanol producing industry. Due to the nature of its processing, the nutritional value of dry distillers grain sorghum with soluble (DDGSgmS) is potentially very high for shrimp. The low phytate concentration of DDGSgmS makes this feed grain ingredient a suitable candidate as plant protein source with the potential to replace high phytate soybean meal in diets. The levels of bacterial products in DDGSgmS also offer the potential for the replacement of and/or inclusion into a coca cola proprietary mixture for the replacement of fish meal. Fish meal is a limiting finite resource. There is a high priority to identify feed grade ingredients to replace the high levels of fish meal in shrimp feeds. DDGS ingredients have been used successfully as a feed ingredient for terrestrial animals, and fish. It is speculated that DDGS products can be a major source of growth factors such as prebiotics, polysaccharides, nucleotides, oligopeptides, oligosaccharides etc. Also. DDGS ingredients are a source of single cell protein due to its unique nature of processing. Thus, the objective of this trial was to evaluate the potential of DDGS from grain sorghum (DDGSgmS) as a feed grade ingredient for Pacific White shrimp *Litopenaeus vannamei*. This was done by determining the growth and survival of *Litopenaeus vannamei* when soybean and fish meals are replaced by different levels of dry distillers grain sorghum with solubles (DDGSgmS) on a protein bases.

METHOD

I. Grain Sorghum Ingredients: The following three grain sorghum ingredients were received in July, 2010: (1) dry distillers grain sorghum with solubles (DDGSgmS), (2) wet distillers grain sorghum with solubles (WDGSgmS) and (3) grain sorghum meal and were logged in as DDGSgmS, SMP log # 10-69, WDGSgmS, SMP log # 10-70, grain sorghum meal, SMP log # 10-71, respectively. The two dry ingredients were stored in an air conditioned room with air temperature and moisture at 23 to 27

C and 10 to 15% moisture saturated, respectively. The one wet ingredient (WDGSgmS) was placed into a frostless freezer at -2 to -5 C. Preliminary least cost computer program analyses indicated that the protein level for the grain sorghum meal was too low to be either a soybean or fish meal replacement in shrimp feeds. Preliminary production of shrimp feeds using the cold extrusion method indicated that the moisture level of the WDGSgmS ingredient limited maximum inclusion levels of only 9 to 10% on an "as fed" bases (2.91% to 3.24% on a dry weight bases). These inclusion levels of WDGSgmS on a dry weight bases would allow a maximum replacement level of defatted dehulled soybean meal of about 5% and fish meal of about 4%. For this reason the WDGSgmS was also not evaluated as a soybean meal or fish meal replacement. Table One gives analyzed (determined) values and "book values" for nutrient levels for DDGSgmS.

Table One: Determined (analyzed) and estimated (book) nutrient values for dry distillers grain sorghum with solubles (DDGSgmS)(SMP#10-30, LMCI#653)

Moisture	8.70		Leucine	4.57
Protein, Crude	36.50		Lysine	0.82
Carbohydrate	27.80		Methionine	0.57
Fiber, Crude	10.10		Methioni+Cystine	1.08
Ash, Total	3.61		Phenylalanine	1.74
Fat, Crude	8.25		Phenoalanine-Tyrosine	3.00
Cholesterol	0.04		Threonine	1.12
Calcium	0.06		Tryptophan	0.21
Phosphorus	0.40		Valine	1.81
Sodium	0.16		A Retinol**	490.00
Potassium	0.41		E Tocopherol**	10.00
Magnesium	0.20		C Ascorbic Acid*	30.00
Iron*	80.00		B_1 Thiamine*	4.20
Zinc*	31.00		B_2 Riboflavin*	1.20
Manganese*	26.00		B_6 Pyridoxine*	4.50
Copper*	9.00		Niacin*	39.00
Selenium*	0.80		Pantothenic Acid*	11.20
Arginine	1.18		Biotin*	0.38
Histidine	0.72		Inositol*	276.00
Isoleucine	1.50		Choline*	661.00

Values on an "as fed" bases ***Values are ppm**
****Values are IU/kg** **All other values are %**
Moisture, crude protein, crude fiber, total ash, crude fat, calcium, phosphorus, potassium, magnesium, arginine, histidine, isoleucine, leucine, lysine, methionine, methionine plus cysteine, phenylalanine, phenylalanine plus

tyrosine, threonine, tryptophan and valine are determined or analyzed values with all other values estimated or "book" values.

Analyzed or determined values were commercially done by Midwest Laboratories.

In terms of essential amino acids, methionine is usually most limiting essential amino acid for shrimp, arginine is usually the 2nd most limiting essential amino acid for shrimp), and lysine is usually 3rd most limiting essential amino acid for shrimp. The soluble carbohydrate level is an estimated value as calculated by subtracting the moisture, total ash, crude protein, crude fat and crude fiber values from 100%. These nutrient values in Table One were used in determine the ingredient values required to formulate the base and experimental diets listed in Table Three.

II. Diets: Twelve diets were formulated and extruded (10 experimental diets + 1 base diet + 1 reference diet). The diet number, treatment number, inclusion level (%) of dry distillers grain sorghum with solubles (DDGSgmS) and diet description for each treatment are presented in Table Two. There were 8 replicates per treatment. The DDGSgmS ingredient was evaluated at five inclusion levels (5%, 10%, 15%, 20%, and 25%) replacing equivalent amounts of isolated soy protein and fish meal on a protein bases and using wheat starch as the filler.

Table Two: Diet number, treatment number, inclusion level (%) of dry distillers grain sorghum with solubles (DDGSgmS) ingredient and diet description for each treatment.

Diet Number	Treatment Number	Inclusion Level (%)	Diet Description
11-0300	1	0	Base diet
11-0301	2	5	Soybean Meal replacement
11-0302	3	10	Soybean Meal replacement
11-0303	4	15	Soybean Meal replacement
11-0304	5	20	Soybean Meal replacement
11-0305	6	25	Soybean Meal replacement
11-0306	7	5	Fish Meal replacement
11-0307	8	10	Fish Meal replacement
11-0308	9	15	Fish Meal replacement
11-0309	10	20	Fish Meal replacement
11-0310	11	25	Fish Meal replacement
09-0011	12	0	Standard reference research

The base diet was a semi-purified diet containing three practical ingredients, squid meal, fish meal and poultry by-product, which were kept constant in all diets except when the

dry distiller grain sorghum with solubles (DDGSgmS) ingredient replaced fish meal on a protein bases. As the DDGSgmS ingredient was added to the base diet replacing isolated soy protein or fish meal appropriate levels of pure ingredients were adjusted to keep the crude protein, crude fat, total ash, crude fiber, Ca, P, K, Mg and marine oil (kept the HUFA levels constant) levels constant. Wheat starch was used as the filler. All other nutrients not kept constant and were in excess and thus not limiting to growth and survival.

Mash mixtures of diets (diet numbers11-0305 and 11-03010) with highest inclusion levels (25%) of the DDGSgmS and the base diet were prepared. Diets (diet numbers11-0305 and 11-03010) with highest DDGSgmS inclusion level and the based diet (diet # 11-0300) containing 0% DDGSgmS were mixed at appropriate proportions to get intermediate inclusion levels of DDGSgmS (5, 10, 15, 20%). The ingredient levels for all diets are given in Table Three.

Table Three: Ingredient levels for standard reference diet, base diet and experimental diets containing 5%, 10%, 15%, 20% and 25% dry distiller grain sorghum with solubles (DDGSgmS). Values are on "as fed" bases.

Diet = / Nutrient / Number	09-011	11-300	11-301	11-302	11-303	11-304	11-305	11-306	11-307	11-308	11-309	11-310
Alginate	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Ca Carbonate	2.50	2.60	2.60	2.60	2.60	2.60	2.60	2.62	2.64	2.66	2.68	2.70
Cellulose	3.20	3.20	2.68	2.16	1.64	1.12	0.60	2.60	2.00	1.40	0.80	0.20
Cholesterol	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
CuSO4*H2O	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Diatomaceous Earth	3.80	1.40	1.14	0.88	0.62	0.36	0.10	1.36	1.32	1.28	1.24	1.20
Fish, Menhaden	8.0	15.0	15.0	15.0	15.0	15.0	15.0	13.6	12.2	10.8	9.4	8.0
KCl	1.90	2.00	1.96	1.92	1.88	1.84	1.80	1.98	1.96	1.94	1.92	1.90
Methionine L-	0.00	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
MgO	1.60	1.50	1.48	1.46	1.44	1.42	1.40	1.48	1.46	1.44	1.42	1.40
NaCl	0.70	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Oil,Fish Menhaden	0.60	0.40	0.40	0.40	0.40	0.40	0.40	0.54	0.68	0.82	0.96	1.10
Oil, Soybean	0.60	2.70	2.30	1.90	1.50	1.10	0.70	2.48	2.26	2.04	1.82	1.60
Phospholipid,97%	4.00	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
PO4HCa, DiCalPhosphate	4.20	2.30	2.30	2.30	2.30	2.30	2.30	2.46	2.62	2.78	2.94	3.10
NaHexaMetaPO4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poultry By-Product	0.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
PM Min/Vit LMCI	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
PM Min/Vit LMCI	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Sorghum DDGS Dry	0.0	0.0	5.0	10.0	15.0	20.0	25.0	5.0	10.0	15.0	20.0	25.0
Soybean-90%	5.7	19.6	17.6	15.5	13.5	11.4	9.4	19.6	19.6	19.5	19.5	19.5
Squid, Muscle	30.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vit C,Staple35%	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

Wheat Starch	29.5	31.8	30.1	28.3	26.6	24.9	23.2	31.3	30.8	30.3	29.8	29.3

The reference diet was a standard semi-purified diet (09-0011) and was used to verify the quality of the test animals, methodology, and the experimental system in the trial. The nutrient levels and levels of squid meal, fish meal and poultry-by-product in the base diet (11-0300) are representative of 35% protein commercial shrimp feeds being produced in Central and South America. The calculated nutrient values for all diets are presented in Table Four. All diets were cold extruded using the standard cold extrusion (alginate, hexametaphosphate) method established by the Texas AgriLife Research Laboratory at Port Aransas.

Table Four: Calculated nutrient Levels for standard reference diet, base diet and experimental diets containing 5%, 10%, 15%, 20% and 25% dry grain sorghum DGGS

Nutrient Diet = Number	09-011	11-300	11-301	11-302	11-303	11-304	11-305	11-306	11-307	11-308	11-309	11-310
Moisture	8.10	8.76	8.82	8.88	8.93	8.99	9.05	8.75	8.74	8.73	8.72	8.71
Protein; Crude	35.3	35.0	35.1	35.2	35.2	35.3	35.4	35.1	35.3	35.4	35.6	35.7
Carbohydrate	27.2	30.5	30.5	30.6	30.7	30.8	30.9	30.6	30.7	30.8	30.9	31.0
Fiber Crude	3.28	2.54	2.55	2.56	2.56	2.57	2.58	2.50	2.46	2.42	2.38	2.34
Total Ash	18.1	15.3	15.1	14.8	14.6	14.3	14.1	15.1	14.9	14.7	14.5	14.3
Crude Fat	8.06	7.94	7.95	7.95	7.96	7.96	7.97	7.94	7.94	7.94	7.94	7.94
Marine Fat	3.10	2.04	2.04	2.04	2.04	2.04	2.04	2.06	2.08	2.10	2.12	2.14
Cholesterol	0.25	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Phospholipid	3.03	2.49	2.49	2.49	2.49	2.49	2.49	2.48	2.46	2.45	2.43	2.42
Calcium	2.70	2.76	2.76	2.76	2.77	2.77	2.77	2.75	2.73	2.72	2.70	2.69
Phosphorus	1.92	1.63	1.63	1.63	1.64	1.64	1.64	1.63	1.63	1.64	1.64	1.64
Sodium	0.93	0.80	0.76	0.72	0.69	0.65	0.61	0.78	0.76	0.75	0.73	0.71
Potassium	1.38	1.32	1.32	1.32	1.31	1.31	1.31	1.40	1.48	1.56	1.64	1.72
Magnesium	1.06	0.89	0.90	0.91	0.91	0.92	0.93	0.89	0.90	0.90	0.91	0.91
Iron*	112	158	162	166	170	174	178	155	153	150	148	145
Zinc*	161	163	165	166	168	169	171	162	161	160	159	158
Manganese*	38.0	36.9	38.1	39.3	40.5	41.7	42.9	37.6	38.2	38.9	39.5	40.2
Copper*	37.0	108	108	109	109	110	110	108	108	109	109	109
Selenium*	0.50	0.48	0.52	0.56	0.60	0.64	0.68	0.47	0.46	0.45	0.44	0.43
Arginine	2.68	2.75	2.64	2.53	2.43	2.32	2.21	2.73	2.70	2.68	2.65	2.63
Histidine	0.88	0.92	0.90	0.88	0.87	0.85	0.83	0.92	0.92	0.91	0.91	0.91
Isoleucine	1.56	1.71	1.69	1.67	1.65	1.63	1.61	1.71	1.70	1.70	1.69	1.69
Leucine	2.92	2.96	3.02	3.08	3.14	3.20	3.26	3.01	3.06	3.11	3.16	3.21
Lysine	2.31	2.41	2.32	2.23	2.14	2.05	1.96	2.36	2.31	2.27	2.22	2.17
Methionine	1.08	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.93	0.91	0.90	0.89
Methioni+Cystine	1.57	1.46	1.46	1.46	1.46	1.46	1.46	1.45	1.45	1.44	1.44	1.43
Phenylalanine	1.49	1.77	1.75	1.73	1.70	1.68	1.66	1.78	1.79	1.79	1.80	1.81

Phenylal+Tyrosine	2.72	3.14	3.09	3.05	3.00	2.96	2.91	3.15	3.16	3.17	3.18	3.19
Threonine	1.59	1.52	1.50	1.47	1.45	1.42	1.40	1.51	1.50	1.49	1.48	1.47
Tryptophan	0.33	0.39	0.38	0.37	0.35	0.34	0.33	0.39	0.38	0.38	0.37	0.37
Valine	1.41	1.78	1.78	1.77	1.77	1.76	1.76	1.78	1.78	1.78	1.78	1.78
Vitamin A**	1546	1546	1546	1546	1546	1546	1546	1546	1546	1546	1546	1546
Vitamin D**	1297	1297	1297	1297	1297	1297	1297	1297	1297	1297	1297	1297
Vitamin E**	218	217	217	217	217	217	217	217	217	217	217	217
Vitamin C*	140	140	140	140	140	140	140	140	140	140	140	140
Thiamine*	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8
Riboflavin*	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5
Pyridoxine*	81.1	81.1	81.1	81.1	81.1	81.1	81.1	81.1	81.1	81.1	81.1	81.1
Niacin*	83.0	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5
Pantothenic Acid*	30.0	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
Biotin*	0.73	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Inositol*	1390	1219	1219	1219	1219	1219	1219	1219	1219	1219	1219	1219
Choline*	3119	2870	2870	2870	2870	2870	2870	2870	2870	2870	2870	2870
Folic Acid*	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4
Cyanocoalimine*	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Values are on "as fed" bases and are calculated values ***Values in ppm** ****Values in IU/kg**

III. Shrimp: *Litopenaeus vannamei* were obtained from Shrimp Improvement Systems, Ismoraldas, Florida, SIS Ref# 23042010 , PL10-02)

A. PL's were cultured to 0.2 to 0.4 g in size in two to four weeks using methods of Texas AgriLife Mariculture Laboratory at Port Aransas.

B. Density: 6 shrimp/tank (Note: This density is equivalent to the semi-intensive commercial stocking density used in Texas, Sonora (Mexico), Central and South America of 6 shrimp / 0.1 m5 = 60 shrimp / m5).

C. Number needed: 6 shrimp/tank * 8 tanks/treatment * 12 treatments = 576

D. Initial weight: 0.315 g

III. Culture System: S-2

A. Culture tanks

1. Bottom area = 0.1 m5

2. Depth = 0.2 m

B. System parameters:

1. Sea water filtration: 1.0 micron

2. Cartridge Filter: 100 microns.
3. Salinity: 25-37 ppt
4. Temperature: 30 ± 1 C.
5. Light: 12 hr dark: 12 hr dim lighting from compact fluorescent bulbs
6. Recirculation: 12 GPH or 4193% per day
7. Exchange (Table Five): 100*1 GPM*1440 min/day / 1000 gal = 144%

Table Five: Calculation of water exchange in Gallons, Liters and, Percent per day.

Parameter	Gallons	Liters	Percent
Volume of 100 tank systems	820	3104	100
Exchange (1 gpm * 1440 min/day)	1440	5451	176

8. Aeration: none

IV. Acclimation: PLs reared at same salinity.

V. Growth Trial.

A. Length of experiment: 42 days

B. (I) Feeding

1. Frequency: 15 times daily
2. Each feed will be fed above satiation (Table Six)
3. Maximum amount of feed needed:
    a. Weight gain = 1.5 gm / week * 6 weeks = 9.0 g
    b. Feed/shrimp = FCR * weight gain = 2.5 * 6.0 g = 15 g
    c. Removal of uneaten feed: daily
4. The below feed curve (Table Six) represents the maximum amount of feed. When excess feed is observed the feed rate will be reduced as long as the feed rate is above satiation.

Table Six: Nutrition growth trial, GT 11-03 in System S-2, predicted growth curves and feed. Feed= 2.5 x Weight gain for 6 shrimp per tank and 8 tanks per feed

day		weight	wt gain	number	FCR	size	feed
0		0.32	0.04	6	2.5	Fry 2	0.61
1		0.36	0.05	6	2.5	Fry 2	0.69

2		0.41	0.05	6	2.5	Fry 2	0.71
3		0.45	0.05	6	2.5	Fry 2	0.79
4		0.51	0.06	6	2.5	Fry 3	0.88
5		0.57	0.07	6	2.5	Fry 3	0.99
6		0.63	0.07	6	2.5	Fry 3	1.10
7		0.71	0.08	6	2.5	Fry 3	1.23
8		0.79	0.09	6	2.5	Fry 3	1.37
9		0.88	0.09	6	2.5	Fry 3	1.39
10		0.97	0.1	6	2.5	Fry 3	1.53
11		1.07	0.11	6	2.5	Fry 3	1.65
12		1.18	0.11	6	2.5	Fry 3	1.65
13		1.29	0.12	6	2.5	Fry 3	1.80
14		1.41	0.12	6	2.5	Fry 3	1.80
15		1.53	0.13	6	2.5	Fry 3	1.95
16		1.66	0.13	6	2.5	Fry 3	1.95
17		1.79	0.14	6	2.5	Fry 3	2.10
18		1.93	0.14	6	2.5	Fry 3	2.10
19		2.07	0.15	6	2.5	Fry 3	2.25
20		2.22	0.15	6	2.5	Fry 3	2.25
21		2.37	0.16	6	2.5	Fry 3	2.40
22		2.53	0.17	6	2.5	Fry 3	2.55
23		2.7	0.17	6	2.5	Fry 3	2.55
24		2.87	0.18	6	2.5	Fry 3	2.70
25		3.05	0.19	6	2.5	3/32	2.85
26		3.24	0.19	6	2.5	3/32	2.85
27		3.43	0.2	6	2.5	3/32	3.00
28		3.63	0.2	6	2.5	3/32	3.00
29		3.83	0.2	6	2.5	3/32	3.00
30		4.03	0.2	6	2.5	3/32	3.00
31		4.23	0.2	6	2.5	3/32	3.00
32		4.43	0.2	6	2.5	3/32	3.00
33		4.63	0.2	6	2.5	3/32	3.00
34		4.83	0.2	6	2.5	3/32	3.00
35		5.03	0.2	6	2.5	3/32	3.00
36		5.23	0.2	6	2.5	3/32	3.00
37		5.43	0.2	6	2.5	3/32	3.00
38		5.63	0.2	6	2.5	3/32	3.00
39		5.83	0.2	6	2.5	3/32	3.00
40		6.03	0.2	6	2.5	3/32	3.00
41		6.23	0.2	6	2.5	3/32	3.00
42		6.43	0.2	6	2.5	3/32	3.00
					Total (g) for 42 d		94.69

VI. Tank assignment: Table Seven give the tank assignment for each of the treatments.

Table Seven: Treatment (T), SMP Diet #'s, Experiment System (S-2), tank row (back and front).

T#	SMP #	Back	Front	Replicate
1	09-0011	1-4	49-52	8
2	11-0300	5-8	53-56	8
3	11-0301	9-12	57-60	8
4	11-0302	13-16	61-64	8
5	11-0303	17-20	65-68	8
6	11-0304	21-24	69-72	8
7	11-0305	25-28	73-76	8
8	11-0306	29-32	77-80	8
9	11-0307	33-36	81-84	8
10	11-0308	37-40	85-88	8
11	11-0309	41-44	89-92	8
12	11-0310	45-48	93-96	8
13	10-32	36-38	86-88	6
14	10-33	39-41	89-91	6
15	10-34	42-44	92-94	6
16	10-35	45-47	95-97	6
17	10-36	48-50	98-100	6

VII. Water quality

A. Daily: Temperature, salinity, and DO in sump tank.

B. Weekly: measure ammonia, nitrite, nitrate, and pH in sump tank.

RESULTS AND DISCUSSION

The first experiment to evaluate the efficacy of dry distillers grain sorghum with soluble DDGSgmS as a potential replacement for soy bean and fish meals in commercial shrimp feeds was initiated on September 19, 2010. However, this experiment was prematurely terminated on September 29, 2010 due to loss of electrical power. The results reported in this paper are from the experiment initiated on June 28, 2011 and terminated on August 9, 2011.

Hydrological Parameters

Mean, minimum and maximum values for temperature and salinity are given in Table Eight. At the end of 42 days, the mean temperature was 30.1±0.2˚C. The experiment was conducted at ambient salinity (mean salinity: 30.4±2.3 ppt). Average dissolved oxygen of the seawater from

system was 5.8 ppm (range: 5.4 to 6.6 ppm). A mean DO level of 5.6 indicated that dissolved oxygen levels were not limiting.

Daily siphoning of excess feed, and feces along with water exchange helped maintained the desired oxygen levels in the tanks.

Table Eight: Mean STD minimum and maximum temperature, salinity and dissolved oxygen (DO) values.

	Temp	Salinity	DO
	(˚C)	(ppt)	(mg/L)
Mean	30.1	30.4	5.8
STD	0.2	2.3	0.2
Min	29.7	27.1	5.4
Max	31.0	33.7	6.6

Water quality

It is critical that water parameters such as ammonium and nitrite nitrogen are maintained below levels which reduced growth and survival. Observed levels of ammonium/ammonia, nitrite and nitrate nitrogen from the experiment are summarized in Table Nine. Ammonium/ammonia-N levels ranged between 0.049 ppm and 0.088 ppm, nitrite-N between 0.008 and 0.051 ppm and, nitrate-N between 0.151 and 0.509 ppm (Table Nine). Levels of ammonium/ammonia-N, nitrite –N and nitrate-N from this trial are within the acceptable limits for optimum shrimp growth and survival.

Minimum and maximum levels of pH (7.92 and 8.10) from this experiment are within desired limits for shrimp culture and did not limit growth and survival for the conditions of experiment. High rates of water exchange and recirculation together with daily tank bottom siphoning aided in maintenance of critical water quality indicators within acceptable range and thereby keeping the recirculation system from deterioration.

Table Nine. Mean, STD, minimum and maximum water quality parameters.

	Ammonia-N	Nitrite-N	Nitrate-N	pH
	(mg/L)			
Mean	0.070	0.032	0.381	
STD	0.012	0.014	0.135	
Min	0.049	0.008	0.151	7.920

Max	0.088	0.051	0.509	8.100

Experimental system validation

Shrimp survival ranged from 93.3% to 100.0 % with final weights ranging from 8.78 g to 12.91 g and mean weekly growth ranging from 1.46±0.17 to 2.15±0.09 g/wk. The survival of 100.0% with mean growth of 2.15±0.09 g/wk for shrimp fed the standard reference research diet (control) indicated desirable environmental conditions (water quality and hydrological parameters) and high health of test animals. In summary, the preceding indicates that the quality of the experimental system, shrimp, and feed nutrient levels, methodology, was not limiting growth and survival.

Table Ten: Survival, final weight, weight gain, growth, biomass, and FCR values from a 42 d trial with *L. vannamei* using POET corn DDGS as feed ingredient (same superscripts in a column are not significantly different)

Diet Number	Soybean or Fish Meal Replace-ment	DDGS Inclusion Level %)	Survival (%)	Final weight (g)	Weight gain (g)	Growth Rate (g/wk)
11-0300	Base	0	100.0 [a]	11.11 [c]	10.81 [c]	1.80 [c]
11-0301	Soybean	5	100.0 [a]	10.72 [c]	10.40 [c]	1.73 [c]
11-0302	Soybean	10	96.7 [a]	11.22 [c]	10.90 [c]	1.81 [c]
11-0303	Soybean	15	100.0 [a]	11.33 [c]	11.01 [c]	1.83 [c]
11-0304	Soybean	20	100.0 [a]	10.62 [c]	10.30 [c]	1.71 [c]
11-0305	Soybean	25	97.2 [a]	10.79 [c]	10.48 [c]	1.75 [c]
11-0306	Fish	5	97.2 [a]	10.63 [c]	10.31 [c]	1.72 [c]
11-0307	Fish	10	93.3 [a]	10.60 [c]	10.29 [c]	1.70 [c]
11-0308	Fish	15	100.0 [a]	10.02 [ab]	9.70 [ab]	1.62 [ab]
11-0309	Fish	20	96.7 [a]	9.38 [a]	9.07 [a]	1.51 [a]
11-0310	Fish	25	100.0 [a]	9.11 [a]	8.78 [a]	1.46 [a]
09-0011	SRD	0	100.0 [a]	13.21 [d]	12.91 [d]	2.15 [d]

Survival

Shrimp survival ranged from 93.3% to 100% at the end of 42 day trial (Table Ten). Results of one way ANOVA statistical analysis indicated that the differences in survival of shrimp between diets with and without DDGS are not significant ($P > 0.05$). The survival values for all DDGS diets from this trial are considered normal for a typical growth trial in experimental systems at Texas AgriLife Mariculture Laboratory at Port Aransas.

Growth Parameters (Final Weight, Weight Gain, Growth Rate, g/wk)

Mean shrimp final weights, weight gain and growth rate ranged from 9.11±1.04 g to 13.21±0.45 g, 8.78±0.97 to 12.91±0.45 g 1.46±0.11 to 2.12±0.15 g, respectively.. Results of one way ANOVA indicated that the differences in final weight, weight gain and growth rate for shrimp fed the standard reference diet were significantly different from the shrimp fed all the other diets. This was expected is an optimum diet with ingredient levels not based upon a least cost commercial shrimp feed.

The final weight, weight gain and growth of shrimp fed diets with 20% and 25% inclusion rates of dry distillers grain sorghum with soluble (DDGSgmS) replacing an equivalent amount of fish meal on a protein bases were significantly lower than those shrimp fed diets with 0%, 5%, and 10% inclusion rates of DDGSgmS. These data indicated that 20% or greater inclusion levels of DDGSmsS cannot replace the equivalent amounts of fish meal in shrimp feeds for a commercial shrimp feed similar similar in nutrient and ingredient levels of the base diet used in this experiment and the conditions of this experiment. For example, this experiment was conducted in a clean water system whereas it has been shown that in green water systems lower levels of fish meal are required. The final weight, weight gain and growth of shrimp fed diets with 5% and 10% levels of DDGSgmS replacing the equivalent levels of fish meal on a protein bases were not significantly different from the respective growth parameters for shrimp fed the base diet (i.e. a simulated commercial shrimp feed containing no DDGSgmS). These data suggest that up to 10% DDGSgmS can be added to commercial shrimp diets replacing fish meal on a protein bases as long as the diet was supplemented with appropriate levels of fish oil and minerals. These data also suggest that DDGSgmS can be used in an IP coca cola blend to replace fish meals.

The final weight, weight gain and growth of shrimp fed diets with 5%, 10%, 15%, 20% and 25% levels of DDGSgmS replacing the equivalent levels of isolated soy protein were not significantly from the respective growth parameters for shrimp fed the base diet (i.e. a simulated commercial shrimp feed containing no DDGSgmS). These data suggest that up to 25% DDGSgmS can be added to commercial shrimp diets replacing soybean meal on a protein bases.

Since the price of defatted, dehulled soybean meal (47-49% protein on “as fed” bases) is between $350 and $450 per ton and the price of fish meal is between $1,200 and $1,600 per ton the value of DDGSgmS for use in shrimp feeds using the feed formulations similar to the base diet and conditions of this research the value of DDGSgmS is between $300 and $1,200 per ton.

CONCLUSIONS (under the conditions of the trial)

1. The water quality and hydrological parameters were within acceptable range.
2. The high growth rate (2.15 g/wk) and survival (100%) for the shrimp fed the standard reference diet indicate that the culture conditions, methods, and the quality of shrimp were satisfactory.
3. For the conditions of this experiment, shrimp survival was not affected by any of the diet treatments.
4. The quality of the shrimp, non-DDGSgmS ingredients, conditions, and physical system used in this experiment was outstanding as documented by the high survival of 100% and growth rate of 2.15 g/wk for shrimp fed the reference diet.
5. Shrimp survival fed diets containing DDGSgmS did not differ from the non DDGSgmS diet (base) and the standard reference diet.
6. The data from this experiment indicated that 20% or greater inclusion levels of DDGSmsS cannot replace the equivalent amounts of fish meal on a protein bases in shrimp feeds for a diet similar to the base diet used in this experiment and the conditions of this experiment.
7. These data suggest that up to 10% DDGSgmS can be added to commercial shrimp diets replacing fish meal on a protein bases as long as the diet was supplemented with appropriate levels of fish oil and minerals.
8. These data suggest that up to 25% DDGSgmS can be added to commercial shrimp diets replacing soybean meal on a protein bases.
9. The results from this research suggest that the value of DDGSgmS with similar nutrient values as the DDGSgmS used in this research is between $300 and $1,200 per ton.