Final Report

Sorghum as source of ingredient to replace cassava for feeding *Pangasius* in Vietnam

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Abstract

Sorghum is one potential ingredient to substitute for cassava as a source of starch for feeding Pangasius in Vietnam. Sorghum contains a reasonable amount of protein (10%), higher than cassava. Sorghum contains higher amino acids, similar to corn but relatively higher in tryptophan and threonine. The U.S. Grains Council (USGC) conducted a sorghum feeding trial to Pangasius catfish at research farm of a private company in Vietnam. The sorghum diet was compared to a cassava-based diet and corn-based diet. Grain sorghum was obtained from the United States and was analyzed for chemical composition and amino acids content. Researchers allotted 2,160 Pangasius fingerling at 25 g body weight randomly in 12 floating cages made of nylon net placed in 0.5-hectare pond with 3 meters deep. The cages were divided into three groups of dietary treatments and replicated 4 times. Three dietary treatments were used containing cassava 15%, sorghum 20% and corn 10% in the diets respectively. The diets were formulated to have the same nutrient content using soybean meal, rice bran, cassava, fish meal, wheat and wheat bran. The Pangasius fish were fed starter diets containing 29% protein and have similar amino acids profile in floating form. The feeding trial was performed for 120 days and total measurement was conducted after feeding 75 and 120 days. The Pangasius readily consumed the diets containing sorghum. Results showed no difference on growth performance of Pangasius fed different sources of starch from cassava, sorghum and corn. Body weight of the fish after 120 days of feeding were 149.6, 140.4 and 142.8 grams, respectively, while feed/gain ratio were 1.35, 1.41 and 1.40, respectively. There was no different in fish mortality due to dietary treatments with average mortality 3.3 to 5.8%. Observations at the end of trial indicated that fish fillet color was not different among the dietary treatments. Density and floatability of diets were also similar among the diets, which indicate sorghum can be used to produce aqua feed easily. In conclusion, U.S. sorghum, can be successfully fed up to 20% in the diet of Pangasius to replace cassava and similar to a corn diet at 10% inclusion rate.

(**Key words:** Pangasius, Sorghum, Cassava, Corn, growth performance and fillet color)

1. Introduction

In 2014, Vietnam catfish production was estimated at 1.2 million tons, requiring around 2.4 million compound feed, assuming the feed conversion ratio at 2.0. Most of growing and finishing catfish feed contains 26-28% protein and is comprised of soybean meal, fish meal, cassava, rice bran, wheat bran and supplemental oil. The majority of catfish feed is manufactured in a factory equipped by extruder to produce floating feed. In order to produce floating feed, minimum starch level in the diet should be formulated and majority of starch was obtained from cassava through readily available local supplies. Most of feed companies do not want to use corn as a feed, because the xanthophyll in corn may be transferred to the fish fillet. Vietnam has been exporting catfish fillets to many countries in the world and consumers are demanding white color of catfish fillet.

Cassava production in Vietnam is estimated around 7 million tons and has not increased in the last five years. The demand of cassava for feed, especially for catfish and swine feed, continues to increase following the increase in feed production. Cassava is also used, in some extent, for fuel ethanol production and has been exported to China. Therefore, the demand for cassava continues to increase and cassava price is becoming a major concern for feeding cassava to livestock, including catfish.

Vietnam may start to look for alternatives to replace cassava in feeding catfish, with sorghum as a viable alternative. U.S. sorghum may be a good alternative ingredient as a source of starch and does not contain xanthophyll, similar to cassava. U.S. sorghum is also low in tannins, desirable for feeding as tannins would interfere with fish performance. Sorghum's other advantage is higher protein content (>10%) compared to cassava that has only 2.5% protein.

Information of feeding sorghum to aquaculture is limited. There are reports of fish feed pellet produced from sorghum processing residue in Australia and low tannin sorghum can be successfully fed to tilapia in Nigeria. Feeding value of sorghum for catfish is not known, therefore there is a need for information about U.S. sorghum that contains low tannin, high protein and valuable starch that can be fed to Vietnam's catfish as a substitute of cassava.

2. Materials and Methods

Trial on growth performance was carried out at experimental farm of Hung Vuong Co., Mekong Delta Sadec, Vietnam while feed production for the trial was performed at Hung Vuong feedmill. Fish culture was performed in 12 floating cages at size 2x3x2m placed in a pond at size 5000m^2 with 3 m deep. Fresh water for the pond was obtained from Mekong River. Cages were placed in such way that provides sufficient water movement and exchange. Daily water quality measurement was performed and indicated that pH of water is stable at 8 and Dissolved Oxygen is 4, while daily temperature ranged from 28 to 32 ^oC.

1.1.1. Diets

Feeding trial comprises three dietary treatments:

T-1. Control diet with cassava at inclusion rate 15% in the diet
T-2. Diet contains 10% corn to replace cassava
T-3. Diet contains 20% U.S. sorghum to replace all cassava in the diet.

The experimental diets were formulated to contain same nutrient content as presented in Table 1.

Table 1. Dietary composition of Catfish feed containing different level of DDGS

	Starter Diet (29% protein)		
Ingredients	**Cassava**	**Sorghum**	**Corn**
Soybean meal, Arg.1	53.70	51.20	54.00
Rice Bran, full fat	15.30	17.65	15.00
Wheat bran	5.00	5.00	-
Defatted rice bran	5.00	-	-
Cassava	15.00	-	10.00
Wheat	-	-	5.00
Fish meal, 62	2.00	2.00	2.00
Fish meal, 55	1.90	1.80	1.80
Sorghum	-	20.00	-
Corn	-	-	10.00

Premix2	0.90	0.90	0.90
Salt	0.70	0.70	0.70
Mono Calcium Phosphate	0.50	0.75	0.60
Total	100.00	100.00	100.00

1: Arg. :Argentine, 2: Premix contain vitamin and trace element provided per kg of diet: iron, 50 mg; copper, 30 mg; manganese, 20 mg; zinc, 30 mg; cobalt, 0.1 mg; selenium, 0.1 mg. vitamin A (retinyl acetate), 7,000 IU; vitamin D3 (cholecalciferol), 1,000 IU; vitamin E (DL-α-tocopheryl acetate), 50 IU; vitamin K activity, 3 mg; thiamine, 6 mg; riboflavin, 7 mg; pantothenic acid, 15 mg; niacin, 40 mg; pyridoxine, 6 mg; folic acid, 2 mg; biotin, 0.1 mg.

The size of pellet for starter feed would be 3-4 mm and each dietary treatment was fed to Pangasius fish at size 25 g. The fish were grown in a floating cage made of nylon net (mesh 1) at size 2x3x2 m (effective volume for water 12 m3) containing 180 fish per cage. Each treatment was replicated four times and the trial was performed for 120 days.

1.2. Feeding system

At least 2,160 fingerling of Catfish Basa at size 25 g (12 cages x 180 fish= 2160) were purchased from supplier and adapted in the cages before the trial started. Feed initially was offered at 5% biomass and fed four times per day at 7:30 a.m., 10:30 a.m., 13:30 p.m. and 15:00 p.m. Amount of feed given was based on 95% satiation. Initial of feed was given at amount that can be consumed by fish within 10 minutes multiplied by 90% and given in that amount for five days. The following five days were fed at full amount, therefore the average would be 95% satiation. This calculation was repeated for every 10-day period.

2.3 Measurement of performance

At end of each feeding period (75 and 120 days), total fish were weighed from each cage and residual feed was measured. Daily mortality and feed consumption were also recorded. Feed conversion ratio was calculated and corrected for the mortality weight. Sorghum and corn samples were analyzed for proximate composition at Hung Vuong laboratory. Moisture, protein, crude fiber, ether extract and ash were analyzed according to Method EC 152/2009, TCVN 4328-1:2007, AOCS Ba-6a-05, ISO 6492:1999 and EC 152/2009, respectively. Amino acids level in sorghum and corn were analyzed by Evonik laboratory in Singapore.

Experimental grower diets were analyzed for Amino acids contents at Evonik SEA Laboratory in Singapore. Samples (diets) for Amino acids analyses were hydrolyzed in 6 *N* HCl for 24 h at 110◦C under N atmosphere. Performic acid oxidation was carried out before acid hydrolysis for methionine and cysteine analysis (AOAC International, 2000; 982.30 E [a, b, c]). The Amino acids in the hydrolysate was subsequently determined by HPLC after postcolumn derivatization. Amino acid concentrations were not corrected for incomplete recovery resulting from hydrolysis.

2.4. Statistical analyses

Randomized Completely Design with three treatments and four replications containing 300 fishes per replicate cage was used in this trial for each species of fish. Data was analyzed using computer program Proc Mix (SAS ver. 9.12) and any significant different due to the treatment was further analyzed using Least Square Difference.

2. Results

2.1. Sorghum, corn and diet composition

Composition of sorghum and corn used in this experiment is presented in Table 2. Protein content in sorghum is 10.03%; protein in corn is 8.43%. In contrast, fat content in sorghum is 2.72% compared to corn containing 4.20%. Sorghum also contains slightly lower starch levels (1.2%), compared to corn. A lower fat and starch level may indicate that sorghum contains less energy for monogastric animals compare to corn. Sorghum, however, contains higher protein than corn and may be important for feeding fish that demand higher protein than feeding poultry (NRC, 2011 and NRC, 1994). Both ingredients should have much more protein than cassava (2.5%) although cassava may have slightly higher amount of starch (70%).

Table 2. Proximate composition and essential amino acids level of sorghum and corn

Nutrient	**Sorghum**	**Corn**
Proximate composition (%)		
Moisture	12.68	13.44
Protein	10.01	8.43
Crude Fiber	2.81	3.29
Fat	2.73	4.2
Ash	1.37	1.06
Starch	66.3	67.61
Amino acids (%)		
Methionine	0.167	0.167
Cystine	0.182	0.178
Methionine + Cystine	0.349	0.345
Lysine	0.198	0.231
Threonine	0.314	0.270
Tryptophan	0.122	0.059
Arginine	0.355	0.353
Isoleucine	0.398	0.257
Leucine	1.316	0.906
Valine	0.497	0.366
Histidine	0.224	0.221
Phenylalanine	0.502	0.354

Amino acids content in sorghum and corn is presented in Table 2. Sorghum contain lower lysine than corn (0.198 vs 0.231%) but has a higher amount threonine (0.314 vs 0.270) and tryptophan (0.122 vs 0.059%). The later amino acid is true for corn as tryptophan is one of the limiting amino acids in corn. Both sulfur amino acids (methionine and cysteine) are similar in the two grains. As for protein, amino acids content in cassava would be less compared to the grains and cassava would be considered as source of starch only rather than protein and amino acids.

Three types of feed were formulated to contain similar nutrient content when cassava, sorghum and corn were included in dietary treatment. The composition of test diets is presented in Table 3. All diets contain similar protein both analyzed by Hung Vuong or Evonik Laboratory. However, Evonik results contain slightly higher level than Hung Vuong results, 30.3-30.9% versus 28.5-29.3% respectively, probably related to differences in method of analysis. Analyzed starch levels in all diets are >30%, which seems to be necessary for production of floating feed. Diets containing sorghum tend to have higher starch levels compared to diets on cassava base, which indicate that sorghum can be used to replace cassava as source of starch.

Table 3. Analyzed proximate composition, starch and amino acids level of diets containing cassava, sorghum and corn (%) fed to Pangasius

Nutrient	**Control - cassava diet**	**Sorghum diet**	**Corn diet**
Proximate composition (%)			
Moisture	10.03	9.70	10.53
Protein	29.27	28.52	29.20
Crude Fiber	3.89	3.45	4.60
Fat	6.32	6.78	7.72
Ash	9.09	8.21	9.05
Starch	34.74	36.29	31.75
Amino acids (%)			
Methionine	0.670	0.669	0.739
Cystine	0.432	0.417	0.434
Methionine + Cystine	1.102	1.086	1.173
Lysine	1.742	1.725	1.749
Threonine	1.147	1.117	1.168
Tryptophan	0.371	0.368	0.383
Arginine	2.170	2.155	2.144
Isoleucine	1.326	1.334	1.344
Leucine	2.200	2.384	2.275
Valine	1.458	1.472	1.467
Histidine	0.733	0.765	0.756
Phenylalanine	1.451	1.494	1.489
Protein analyzed by Evonik	30.27	30.86	30.67

The amino acids composition of grower feeds is presented in Table 3. There is a little variation in amino acids content among dietary treatments. Lysine content is maintained at around 1.73-1.74% while methionine at 0.67-0.74%. Those amino acids content are presented as total amino acids derived from feed ingredients. Total protein analyzed by Evonik laboratory in Singapore in all dietary treatments are 30.3-30.9% and this figure would be 1% higher analyzed at Hung Vuong Laboratory.

Density and floatability of dietary treatments is presented in Table 4. Density ranges from 0.40 to 0.44 kg per liter, with sorghum based diet showing a slightly higher density compare to corn or cassava diets. However, floatability of cassava based diet is more than 34 minutes while sorghum based diet is 29 minutes and corn based diet is 30 minutes. Longer time of floatability indicates that the diet would take longer time to float on the water until it sinks. All diets would have sufficient floatability time until the diets are consumed by Pangasius. The difference in floatability time may be related to different quality of starch in relation to gelatinization during extrusion process, but the difference is relative small.

Table 4. Density and floatability of diets containing cassava, sorghum and corn for Pangasius

Parameter	Cassava Diet	Sorghum Diet	Corn Diet
Density (g/liter)	419	435	402
Floatability (time till sinking)	34 minutes and 22 second	29 minutes and 12 second	30 minutes and 23 second

2.2. Growth performance

Performance of Pangasius fed different diets containing cassava, sorghum and corn for 0-75 days, 76-120 days and 0-120 days is presented in Table 5, 6 and 7 respectively. The diets were consumed readily by Pangasius with little adaptation. Performance of Pangasius after initial stage of feeding for 75 days show the fish grew from 25 g to around 70 g. Growth rate is relatively slow at beginning of the trial and this is related with weather condition in Mekong Delta during that time. High rainfall and lower temperature resulted in limited feeding and slower the growth rate. Efficiency of feed utilization is still good as shown in FCR (feed conversion ratio) at around 1.2.

The second stage of trial was monitored from 76 to 120 days or 45 days of feeding. Performance data in Table 6 indicated fish growth is improving, and body weight of fish reach around 150 g with body weight gain at 70-78 g in 45 days of feeding. FCR during this period would be higher as expected when the fish grows at higher body weight. There is no statistical difference among the treatments during this period with average FCR around 1.5. Since there is no difference on performance of Pangasius during initial stage and second stage of growth, the final performance from 0 to 120 days of trial would also be the same among the dietary treatments. There is no statistical difference among the dietary treatments to feed intake, body weight gain, feed/gain ratio and mortality. The final measurements at 120 days shows that Pangasius reached 150 g of body weight with FCR around 1.35-1.42. Mortality of fish is relatively low in this trial with number range from 3.3 - 5.6% and there is no significant effect due to the dietary treatment.

Table 5. Growth performance of fish fed diets with cassava, sorghum, or corn as the main ingredient for 75 d period[1]

Item	75 d weight (g/fish)	Weight gain (g/fish)	Feed intake (g/fish)	FCR true (g/g)	FCR corrected (g/g)[3]	Mortality (%)[4]
Dietary Treatment[2]						
1) Cassava	71.26	48.95	59.00	1.21	1.20	1.42
2) Corn	72.47	50.36	57.95	1.16	1.15	1.70
3) Sorghum	66.93	44.71	56.60	1.28	1.27	2.05
SEM[5]	3.56	3.57	1.82	0.08	0.07	1.31
P-value	0.33	0.33	0.47	0.37	0.33	0.96

[1]Values are least-square means of 4 replicate cages with each cage having 180 fishes at placements.
[2]Diet 1 was the control formulated primarily with cassava. Diet 2 was formulated with 10% of corn. Diet 3 was formulated with 20% of sorghum.
[3]Feed conversion ratio was corrected for mortality.
[4]Mortality probability values were arcsine transformed.
[5]Pooled standard error

Table 6. Growth performance of fish fed diets with cassava, sorghum, or corn as the main ingredient from 75 to 120 d period[1]

Item	120 d weight (g/fish)	Weight gain (g/fish)	Feed intake (g/fish)	FCR true (g/g)	FCR corrected (g/g)[3]	Mortality (%)[4]
Dietary Treatment[2]						
1) Cassava	149.66	78.40	113.56	1.49	1.46	3.06
2) Corn	142.84	70.37	110.60	1.62	1.59	1.70
3) Sorghum	140.40	73.48	110.19	1.56	1.51	4.48
SEM[5]	9.15	6.62	6.45	0.10	0.10	1.23
P-value	0.60	0.51	0.85	0.45	0.45	0.16

[1]Values are least-square means of 4 replicate cages with each cage having 180 fishes at placements.
[2]Diet 1 was the control formulated primarily with cassava. Diet 2 was formulated with 10% of corn. Diet 3 was formulated with 20% of sorghum.
[3]Feed conversion ratio was corrected for mortality.
[4]Mortality probability values were arcsine transformed.
[5]Pooled standard error

Table 7. Growth performance of fish fed diets with cassava, sorghum, or corn as the main ingredient for 120 d period[1]

Item	120 d weight (g/fish)	Weight gain (g/fish)	Feed intake (g/fish)	FCR true (g/g)	FCR corrected (g/g)[3]	Mortality (%)[4]
Dietary Treatment[2]						
1) Cassava	149.66	127.36	172.02	1.37	1.35	4.03
2) Corn	142.84	120.73	167.77	1.42	1.40	3.33
3) Sorghum	140.40	118.18	165.98	1.45	1.41	5.83
SEM[5]	9.15	9.15	7.22	0.08	0.08	0.91
P-value	0.60	0.61	0.71	0.64	0.75	0.09

[1]Values are least-square means of 4 replicate cages with each cage having 180 fishes at placements.
[2]Diet 1 was the control formulated primarily with cassava. Diet 2 was formulated with 10% of corn. Diet 3 was formulated with 20% of sorghum.
[3]Feed conversion ratio was corrected for mortality.
[4]Mortality probability values were arcsine transformed.
[5]Pooled standard error

Picture of fillet of Pangasius after feeding diets containing corn (Co), cassava (DC) and sorghum (SR) for 120 days is presented in Picture below. The fillet was collected at end of trial in expectation to evaluate if feeding different starch sources would affect the color of fillet, especially a yellow color due to yellow corn. Fillet color can be sensitive to the consumers when Vietnam exporting Pangasius fillet to different countries.

The picture shows there is no indication that Pangasius fed corn at 10% (Co) in this experiment cause yellow color on fillet after 120 days of feeding. Previous study on feeding 15% DDGS to Pangasius also did not affect the color of fish despite the xanthophyll level (the pigment that cause yellow color in yellow corn) of DDGS is almost three times higher than that found in original corn grain (DDGS Handbook, 2011). The pigment content in 10% corn diet in this experiment would certainly be lower level compare to the diet with 15% inclusion rate of DDGS, therefore 10% inclusion rate of corn would not affect fillet color as expected.

Picture 1. Fillet color of Pangasius fed corn (Co), cassava (DC) and sorghum (SR) based diets

3. Conclusion

Sorghum can be used as a source of starch to replace cassava for feeding Pangasius. At a 20% inclusion rate in Pangasius diets, Sorghum was not proven to affect growth performance, fillet color and the physical properties of the feed pellets (density and floatability). Similar to that of sorghum, feeding 10% corn in the diet of Pangasius resulted in the same performance as feeding cassava and sorghum. Both grains, sorghum and corn, can be used for feeding catfish. The use of sorghum would be affected by the cost of the grain, as this should determine its use in the feed formulation.

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