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Linear Programming Analysis of Fish Feed Costs for Intensive Culture Systems in Saudi Arabia

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Abstract. Feed costs represent about 50% to 60% of production costs in intensive tilapia culture systems in Saudi Arabia. Feed costs therefore has a major role in the economics of such enterprises. A linear programming model was developed to formulate least cost feeds for tilapia with protein levels of 30% to 40%. Feeds were formulated subject to limits imposed on their content of protein, fiber, fat, carbohydrates, metabolizable energy to protein ratio, lysine and sulfur amino acids, fish meal, and cottonseed meal. Data regardirg feed ingredient composition and prices, nutrient requirements of tilapia and limits on the use of certain feed ingredients were obtained from secondary sources. Ingredients considered include: corn, cottonseed meal, soybean meal, herring fishmeal, oats, meat and bone meal, poultry by-product meal, sorghum, wheat, wheat bran, soybean seeds, and rice. Results indicated the importance of fishmeal, cottonseed meal, corn, poultry by-products, and soybean seeds and meal in feed formulation. Metabolizable energy to protein ratio proved to be the most binding constraint for diets with protein level higher than 39%. The cost of feed ingredients was 867.18 SR/ton for the 30% protein feed and increased with increasing dietary protein to reach 1,494.40 SR/ton for the 39 % protein feed. Market prices for the formulated feeds were estimated and compared with actual fish feed prices. Comparison results indicate the possibility for reducing fish feeding costs. Feeding costs for producing one Kg of fish could be reduced by 0.45 SR.

Introduction

Aquaculture in Saudi Arabia has expanded significantly during the last few years. Aquaculture production was 1,401 tons in 1991 and almost doubled by 1997 to reach 2,700 tons with tilapia being the main cultured species [1].

Feed is the most important cost item for semi-intensive and intensive culture systems. Sadek, Kallafalah, and Adel [2] evaluated the performance of an intensive tank culture system for tilapia in Egypt. They found that feed costs represented about 58% of total variable costs.

Materials and Methods

Data needed for the application of linear programming method to least cost feed formulation include: (1) nutrient requirements of the animal, (2) limits placed on the level of certain feed ingredients, (3) cost of feed ingredients, and (4) nutrient and energy content of feed ingredients.

Nutrient requirements of tilapia

Protein is essential in fish diets as a source of essential amino acids. Tilapias require the same ten essential amino acids reported to be indispensable for other species. Quantitative essential amino acid requirements for tilapia have been identified [6; 7, pp.125-138; 8; pp.170-171]. Studies with channel catfish have shown that if lysine and sulfur amino acids (methionine and cystine) requirements are met, the requirements for other essential amino acids will also be met [9, pp.109-110]. The optimum dietary protein level for tilapia in intensive culture systems has been reported to range from 30% to 35% [8, p.170]. Optimum dietary protein is higher for small size fish than for large size. For example, in the absence of natural food, dietary protein for tilapia fry may reach 50% [9, p.167].

Energy is essential in that it contributes to the metabolic utilization of all nutrients in a diet. Protein, lipids, and carbohydrates can all be used by fish as a source of energy. However, carbohydrate is used more efficiently by warmwater than by coldwater and marine fish [10, p.15]. Energy and protein should be kept in balance. The optimum digestible energy to protein ratio for tilapia is approximately 8 to 9.7 Kcal/g protein in the diet [9, pp.173-174;10, p.5].

The amount of carbohydrates in the diet varies with fish species depending on their ability to use it as an energy source. The percentage of available carbohydrates for tilapia diets varied from 30% to 40% of the diet and may reach 50% of the diet [6; 8, p.172;11]. Also, tilapias do not tolerate high levels of dietary fats. A dietary fat level greater than 12% depress growth of tilapia [9, p.174].

Phosphorus and calcium are the minerals that are required in largest amounts by fish. Unlike calcium, fish do not obtain a significant amount of phosphorus from the water [10, pp.16-17;12]. Fish required vitamins in trace amounts for normal growth and reproduction. Vitamins and mineral requirements are mostly supplied from a supplemental premix. Finally, although the inclusion of fiber in research diets increased growth and efficiency of protein utilization [10, p.33], high levels of dietary fiber over 8-12% can depress fish growth [13, p.482].

In fish feed formulation, restrictions can be placed on the levels of certain feed ingredients. For example, fishmeal have been found to be beneficial in fish diets, therefore, minimum levels of fishmeal are usually assigned in the diets [9, p.112; 10, p.50]. A minimum dietary fishmeal of 7.5% has been recommended for catfish diets [14]. The use of cottonseed meal in fish diets is limited due to its gossypol content. Dietary cottonseed meal levels of 20% to 30% have been found to be safe and useful for tilapia diets [8, p.172].

Prices, nutrient and energy content of feed ingredients

The selection of feed ingredients was constrained by data availability on the nutritional composition and on market prices of feed ingredients. Ingredients considered include: corn, cottonseed meal, soybean meal, herring fishmeal, oats, meat and bone meal, poultry by-product meal, sorghum, wheat, wheat bran, soybean seeds, and rice. Ingredient market prices were obtained from Grain Silos and Flour Mills Organization and published Foreign Trade Statistics [15]. Nutrient compositions of feed ingredient were obtained from published feed ingredient composition tables [10, pp.65-71;16, pp.74-93]. Gross energy content of ingredients were estimated based on 5.65 Kcal/g protein, 9.45 Kcal/g lipid, and 4.1 Kcal/g carbohydrate. Metabolizable energy content of ingredients were estimated based on 5 Kcal/g protein, 9 Kcal/g lipid, and 2 Kcal/g carbohydrate [17].

The linear programming model

The model was based on the general form that may be expressed as follows:

$$\text{Minimize } R = \sum_{i=1}^{n} P_i X_i \qquad \text{subject to}$$

$$\sum_{i=1}^{n} A_{ij} X_i \leq G_j$$

$$\sum_{i=1}^{n} A_{ij} X_i \geq B_j$$

$$X_i \geq 0$$

$$i=1, 2, 3, \ldots, n$$
$$j=1, 2, 3, \ldots, m$$

Where R is the objective function, P_i is the price of ingredient i, X_i is the quantity used of ingredient i, A_{ij} is unit content of nutrient j in ingredient i , B_j is minimum level of feed ingredients or nutrient j, and G_j is maximum level of feed ingredient or nutrient j.

The model was developed with the objective of minimizing the cost of ingredient combination per unit of tilapia feed subject to the following constraints: (1) crude protein percentage was initially limited to 30% then increased to 40% by increments of

1%, (2) a maximum level of 12% is placed on fiber, (3) fat percentage was limited to a maximum of 12%, (4) available carbohydrate was limited to a maximum of 50%, (5) metabolizable energy was restricted to 9.7 Kcal/g protein in the feed, (6) cottonseed meal was restricted to a maximum level of 20%, and (7) fishmeal was limited to a minimum level of 7.5%. (8) Lysine and sulfur amino acids (methionine and cystine) were constrained to minimum level of 4.10% and 3.21% of dietary protein, respectively, and (9) a constraint to assure that exactly 0.944 Kg is produced, to make allowance for the addition of vitamin and mineral premix, was incorporated in the model. Several situations were programmed to examine the effects of changes in constraint limits and in ingredient prices.

Results and Discussion

The optimal feeds produced by the model are given in Table 1. The optimal ingredient combinations include fishmeal, cottonseed meal, corn, wheat bran, soybean meal, soybean seeds, and wheat. As dietary protein increased, the amount used of corn, poultry by-products, and soybean seeds increased. Also, diet contents of crude lipids, metabolizable energy, and lysine increased as protein percentage increased. However, the metabolizable energy to protein ratio was constant. Constraint dual prices yielded by the model indicated that fiber and fat were not binding for all feeds. In contrast, dietary use(LCOT) and on fishmeal (LFM) constraints were binding. Dual prices of protein and MEPR increased as dietary protein increase, while that of SAAPR decreased as dietary protein increased up to 35% then increased. Dual price of LFM increased then start to decrease to reach zero at dietary protein level of 38%. Ingredient costs of the feeds including the costs of vitamin and mineral premix are shown in Table 1. Lowest cost per unit of feed was for producing the 30% protein feed and increased with increasing protein percentage in the feed.

Market prices for the formulated feeds were estimated assuming that ingredient costs represent 86.5% of total production costs and allowing for a 20% profit margin [4]. Moreover, production cost components except ingredient cost and its opportunity cost would not change as dietary protein increases. The resultant estimated market prices per ton of feed are shown in Table 1. Actual fish feed market prices are 1,589; 1,649; 1,687; 1,756; and 1,927 SR/ton for the 24%; 28%; 32%; 36%; and 40% protein level feed, respectively. It can be seen that the estimated market prices of the feeds produced by the model are low compared to the actual market prices. Comparing the prices for the 36% protein feed, the most commonly used one, indicates a saving of 179.22 SR/ton. Utilizing a feed conversion ratio (F.C.R.) of 2.5:1 implies that production costs can be reduced by 0.45 SR/Kg of fish. The marginal cost for an additional one percent in dietary protein starting with the 30% feed were estimated and they are shown in Table 1. These figures represent the marginal costs facing the fish producer for changing the type of feed being used. Marginal benefits from increasing protein percentage in the diet would be reflected in lower F.C.R. values. A fish producer can maximize his profits by equating the marginal cost and the value of marginal benefits.

Table 1. Initial optimum solution of the model

	Dietary protein percentage									
	30%	**31%**	**32%**	**33%**	**34%**	**35%**	**36%**	**37%**	**38%**	**39%**
Ingredient[1]										
Fish meat	10.74	7.5	7.5	7.5	7.5	7.5	7.5	7.5	13.02	26.32
Cot. meal	20	20	20	20	20	20	17.95	7.5		
Corn		3.74	7.97	14.42	20.87	27.32	32.8	34.24	33.36	19.32
Wheat bran	60.79	54.52	45.55	33.58	21.6	9.63				
Polt.by prd	2.08	12.25	14.89	16.35	17.81	19.27	22.01	30.02	26.18	
Soybean seeds			3.57	7.63	11.69	15.75	19.22	20.22	26.64	45.63
Soybean meat	5.87	1.74								
Wheat										8.2
Calculated nutrient content[1]										
Crude fiber	8.7	8.21	7.6	6.8	6	5.2	4.36	3.36	2.73	3.08
Crude lipids	4.59	5.53	6.32	7.01	7.69	8.37	9.09	9.93	10.66	11.26
Gross energy[2]	4178	4239	4321	4413	4504	4595	4684	4761	4848	4947
ME	2913	3007	3104	3201	3298	3395	3492	3589	3686	3783
ME/P[3]	9.71	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
Lysine[4]	5.05	4.81	4.86	4.79	5.06	5.15	5.25	5.39	5.81	6.58
Sulfar A.A.[4]	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21
Cost/ton[5]	867.18	907.2	960.1	1013.4	1066.7	1120.1	1178.6	1258.9	1349.8	1494.4
Price/ton	1203.0	1251.1	1314.5	1378.5	1442.5	1506.5	1576.8	1673.1	1782.2	1955.7
Margi. cost		48.04	63.47	63.98	63.98	64	70.29	96.33	109.11	173.49

(1) Kg /100 Kg, (2) Kcal/Kg, (3) Kcal ME/g protein, (4) % of dietary protein, (5) ingredient cost including 100.46 SR for vitamin and mineral premix.

Range analysis

Range analysis refers to estimating upper and lower bounds for the maximum amount that ingredient prices and constraint coefficients can be changed, one value at a time, without changing the optimal solution. Table (2) shows the maximum level that ingredient prices can take without changing feed optimal ingredient mixes. It can be seen from the table that soybean seeds, corn, cottonseed meal, wheat bran, and poultry by-products prices can be increased by as much as 228.7%, 68%, 59.7%, 28.2%, and 27.2%, respectively, without changing optimal ingredient mixes. However, as dietary protein increased the maximum percentage increase for all ingredients decreased, except for corn and soybean seeds. For example, wheat bran and poultry by-products upper bounds price levels represented 103.5% and 102.5% of original prices. It is not unlikely that wheat bran and poultry by-product prices be increased by 3.5% and 2.1%. Therefore, in the sensitivity analysis wheat bran and poultry by-product prices were increased by 4% and 6%, respectively.

Table 2. Upper bound prices of feed ingredients for different diet (SR/Kg)

		Dietary Protein Percentage					
Ingredient	**Price**	**30%**	**31%**	**32-35%**	**36-37%**	**38%**	**39%**
Fish meal	2.698	2.98				3.125	3.15
Cot.seed meal	0.708	1.130	0.991	0.965	0.965		
Corn	0.56		0.626	0.94	0.917	0.873	0.873
Soybean meal	0.964	1.19	1.05				
Wheat bran	0.40	0.51	0.41	0.41			
Poult. by-prod.	1.701	2.16	1.737	1.737	1.790	1.790	
Soybean seeds	0.991			1.872	1.872	3.257	3.257
Wheat	1.50						

Sensitivity analysis

Sensitivity analysis was undertaken to demonstrate the effect of the changes in the coefficients of some key variables of the model. Accordingly, wheat bran and poultry by-products prices were increased and restriction on the use of soybean seeds in feed formulation was applied. Results of the indicated changes in terms of feed composition, costs, estimated market prices, and marginal cost for increasing protein percentage are shown in Appendix, Tables 3 through 5. Increasing wheat bran price to 0.416 SR/Kg or poultry by-product price to 1.804 SR/Kg led to the reduction in the quantity used of either and increasing the use of soybean meal, soybean seeds, and corn for feeds with protein levels of 31% to 35%. Composition of feeds with 36% protein or higher were not affected by the increase of wheat bran price. While the increase in poultry by-product price led to the substitution of fish meal, soybean seeds, and cottonseed meal for poultry by-products and corn . Ingredient combinations for the 30% and the 31% protein feeds were not altered when soybean seeds were constrained to zero level. Moreover, there was no feasible solution for feeds with protein levels greater than 35%, mainly due to metabolizable energy to protein ratio constraint. For the remaining feeds, wheat bran and poultry by-products substituted for cottonseed meal and corn, except for the 35% protein feed where the amount of poultry by-products and corn increased and that of cottonseed and wheat bran decreased.

The percentage change in estimated market price and marginal costs associate the changes in ingredient prices and constraints as compared to the initial solution are shown in Figs. 1 and 2. It can be seen from the figures that constraining the use of soybean seeds to zero had the greatest effect on the estimated prices and marginal costs followed by increasing poultry by-product and wheat bran prices. The increase in feed prices and marginal costs as a result of increasing poultry by-product price or excluding soybean seeds is positively related to dietary protein percentage. While the opposite was observed when wheat bran price increase. The increase in feed estimated market price as a result of restricting the use of soybean seeds, ranged from zero for the 30-31% protein feeds to 12.1% for the 35% protein feed, as compared to the initial optimum solution. While the percentage increase in marginal cost ranged from zero for the 30% protein feed to 77.14 for the 35% protein feed as a result of restricting the use of soybean seed. Increasing poultry by-product price to 1.804 SR/Kg had no effect on the cost of the 39% protein feed. For the remaining diets, the percentage increase in estimated prices ranged from 0.21% to 1.93%. While the percentage increase in marginal costs ranged from 0.58% to 17.61% and the marginal costs of the 38% and 39% feeds were reduced by 3.8% and 16.27%, respectively. Increasing wheat bran price to 0.416 SR/Kg had no effect on the estimated prices of the 36-39% protein diets. For the remaining feeds, the percentage increase in feed price decreased as dietary protein increased. It ranged from 0.11%, for the 35% protein diet to 0.97%, for the 30% protein feed.

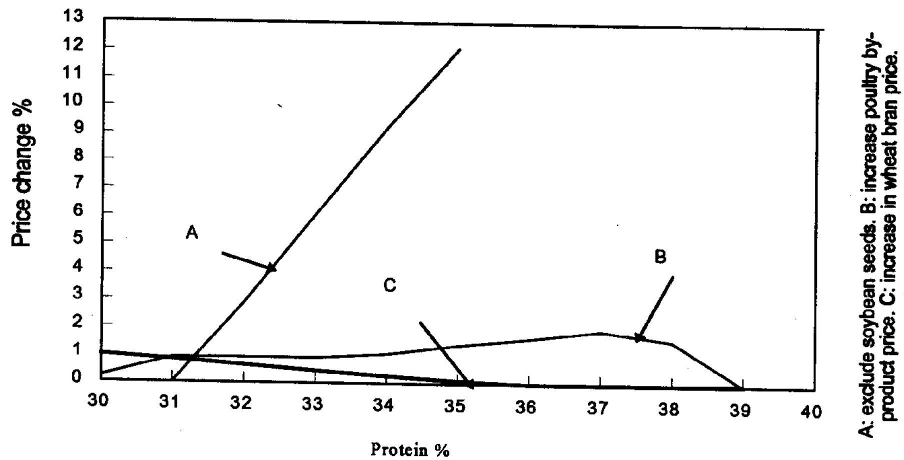

Fig. 1. The estimated effect of changing ingredient prices and constraints on feed prices.

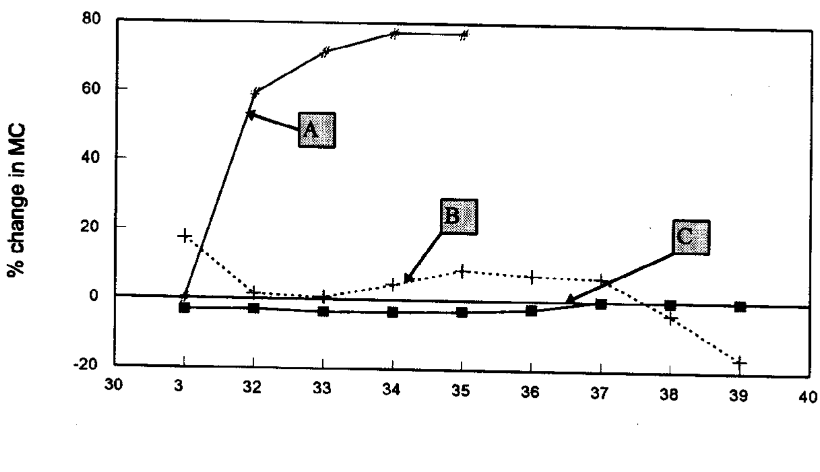

Fig. 2. The estimated effect of changing ingredient prices and constraints on dietary protein marginal cost.

Summary and Conclusions

The purpose of this study was to investigate the possibility of reducing fish feeding costs through the formulation of least cost feeds for tilapia intensive culture using linear programming method, and to investigate the effects of price and ingredient limits changes on feed ingredient mixes and costs. The results indicated the importance of fish meal, cottonseed meal, corn, poultry by-products, soybean seeds and meal in feed formulation. However, as dietary protein percentage increased, the relative importance of corn, poultry by-products and soybean seeds increased, while that of wheat bran and soybean meal decreased. Market prices for the formulated least cost feeds were estimated and compared with actual market prices for compatible feeds. Comparison results were in favor of the formulated feeds. A saving of 179.22 SR/ton was realized for the 36% protein feed, the most commonly used one. This indicates that feeding cost could be reduced by 0.45 SR/Kg of fish. The incremental costs for increasing dietary protein by one percent were estimated. These costs may be used to select the type of feed (i.e. selecting protein percentage) that maximize producer's profits. Feed costs were more sensitive to the restriction imposed on the use of soybean seeds than to increasing poultry by-products or wheat bran prices.

References

[1] Ministry of Agriculture and Water , Aquaculture and Fishery Resources Department. Unpublished data.

[2] Sadek, S.; Kallafalah, H. and Adell, F. "Tilapia (*Oreochromis niloticus*) Biomass Yield in a Commercial Farm using Circular Tanks." *J. Appl. Icthyol.*, 8 (1992), 93-102.

[3] Hebicha, H. A. and Bartholomew W. Green. " Economic Analysis of Different Tilapia Pond Culture Systems." *J. Agr Res. Rev.*, (1994), (accepted for publication).

[4] AL Qunaibet, Mohammad H.; Essam, A. Abo Elwafa and Mostafa Mansour. "Improving the Competitive Status of the Saudi Broiler Industry." *J. King Saud Univ. Agri. Sci.*, 4, No.2 (1992), 139-164.

[5] Hebicha, H. A. "Applying Linear Programming in the Formulation of Least Cost Diets for Tilapia (Oreochromis niloticus)." *J.Agr.Res.Rev.*, 1995, (accepted for publication).

[6] Jauncey, K. "A Short Guide to Aquaculture Feeds and Feeding in Egypt." *Paper presented at the Fish Feeds Seminar*, November, 14-15 (1988), Abbassa, Egypt.

[7] Wilson, R. P. "Amino Acids and Proteins." In: *Fish Nutrition*, 2nd ed. Halver, J.E. (Ed). California, Academic Press, Inc. 1989.

[8] Luquet, P. "Tilapia, Oreochromis Spp." In: *Handbook of Nutrient Requirements of Finfish*: Wilson, R. P. (ed) CRC Press, Inc., 1991.

[9] Lovell, T. *Nutrition and Feeding of Fish*. New York: Van Nostrand Reinhold, 1989.

[10] National Research Council (NRC). *Nutrient Requirement of Fish*. National Academy of Sciences. Washington, D.C.: National Academy Press, 1993.

[11] Halver, J. E. "Fish Nutrition and Fish Feed Technology. "*Lectures presented at the Central Laboratory for Agriculture Research*, Abbassa, Sharkia, 1 - 13 August, 1994.

[12] Lovell, R.T. "Phosphorus in Fish Feeds." *Comm. Fish Farmer and Aqua. News*. 5, No. 5 (1979).

[13] Hardy, R. W. "Diet Preparation." In: *Fish Nutrition*, 2nd ed. California, Academic Press, Inc. Halver, J. E. (Ed), 1989.

[14] Lovell, R. T. "Practical Fish Diets." In: *UNDP/FAO Fish Feed Technology*. Lectures presented at the FAO/UNDP Training Course in Fish Feed Technology, held at the College of Fisheries, University of Washington, Seattle, USA, 1980.

[15] Ministry of Finance and National Economy. *Foreign Trade Statistics*. Riyadh Central Department of Statistics, 1993.

[16] National Research Council (NRC). *Nutrient Requirements of Warmwater Fishes and Shellfishes*. National Academy of Sciences. Washington, D.C., National Academy Press, 1983.

[17] Wee, K.L. and Tuan, N.A. "Effects of Dietary Protein on Growth and Reproduction in Nile Tilapia (*Oreochromis niloticus*)." In: R.S.V. Pullin, T.Bhukaswan, K.Tonguthai and J.L.Maclean (Eds.). *The Second International ymp os ium n Tilapia in Aquaculture. ICLARM Conference Proceedings* 15, 623 P. Department of Fisheries, Bangkok, Thailand, and International Center for Living Aquatic Resources Management, Manila, Philippines, 1988..

Appendix

Table 3. Diet composition and costs associated with increasing wheat bran price to 0.416 SR/Kg

	Dietary protein percentage									
	30%	**31%**	**32%**	**33%**	**34%**	**35%**	**36%**	**37%**	**38%**	**39%**
Ingredient (%)										
Fish meal	10.74	7.5	7.5	7.5	7.5	7.5	7.5	7.5	13.02	26.32
Cot. Meal	20	20	20	20	20	20	17.95	7.5		
Corn		11.81	21.18	30.54	34.88	33.57	32.8	34.24	33.63	19.32
Wheat bran	60.79	41.65	25.18	8.71						
Polt. by-prd	2.08	7.41	6.82	6.50	9.25	15.45	22.01	30.02	26.18	
Soybean seeds		2.11	6.91	11.71	15.24	17.33	19.22	20.22	26.64	45.63
Soybean meal	5.87	9.26	11.88	14.51	12.61	5.62				
Wheat										8.2
Cost (SR/ton)	876.91	915.71	967.04	1018.4	1069.8	1121.4	1178.6	1258.9	1349.8	1494.4
Est. price/ton	1214.7	1261.3	1322.9	1384.4	1446.2	1508.1	1576.8	1673.1	1782.2	1955.7
Marginal cost		46.56	61.60	61.60	61.75	61.94	68.64	96.33	109.11	173.49

Table 4. Diet composition and costs associated with increasing poultry by-product price to 1.804 SR/Kg

	Dietary protein percentatge									
	30%	**31%**	**32%**	**33%**	**34%**	**35%**	**36%**	**37%**	**38%**	**39%**
Ingredients (%)										
Fish meal	10.74	7.5	7.5	7.50	7.5	7.5	11.31	21.5	25.23	26.32
Cot. meal	20	20	20	20	20	20	20	14.99	6.53	
Corn		11.81	21.18	30.54	34.88	33.57	31.38	29.05	29.1	19.32
Wheat bran	60.79	41.65	25.18	8.71						
Polt. by-prd	2.08	7.14	6.82	6.50	9.25	15.45	13.83			
Soybean seeds		2.11	6.91	11.71	15.24	17.33	22.95	33.95	38.61	45.63
Soybean meal	5.87	9.26	11.88	14.51	12.61	5.62				
Wheat										8.2
Cost (SR/ton)	869.33	916.41	970.04	1023.7	1079.4	1137.4	1200.2	1285.9	1373.4	1494.4
Est. price/ton	1205.6	1262.1	1326.5	1390.8	1457.6	1527.2	1602.7	1705.5	1810.4	1955.7
Marginal cost		56.5	64.36	64.35	66.83	69.60	75.46	102.78	104.96	145.26

Table 5. Diet composition and cost associated with excluding soybean seeds

	Dietary protein percentage						
	30%	31%	32%	33%	34%	35%	36-39%
Ingredient (Kg/100 diet							
Fish meal	10.74	7.5	7.5	5.50	7.5	7.5	No feasible solution
Cot. Meal	20	20	7.78				
Corn		3.47	2.12	9.14	25.35	41.56	
Wheat bran	60.79	54.52	59.53	52.29	30.81	9.33	
Plot. by-prd	2.08	12.25	22.55	30.56	35.83	41.09	
Soybean meal	5.87	1.74					
Cost/ton	867.18	907.21	991.58	1083.1	1177.5	1272.0	
Est. price/ton	1203.0	1251.1	1352.3	1462.1	1575.5	1688.8	
Marginal cost		48.04	101.24	109.79	113.37	113.37	

تحليل تكاليف علائق الاستزراع المكثف للأسماك في المملكة العربية السعودية باستخدام البرمجة الخطية

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(قدم للنشر فى ١٤١٧/٥/١٩ هـــ، قبل للنشر فى ٢٠/ ١ / ١٤١٨ هـــ)

ملخص البحث : تهدف الدراسة الي تحديد التوليفة المثلى من مواد العلف اللازمة لتصنيع علائق كاملة ومتوازنـــة للاستزراع المكثف لأسماك البلطي وبحث امكانية تخفيض تكلفة التغذية بالإضافة لبيان تأثير التغير في كل من أسعار ونسب مواد العلف المستخدمة على مكونات ومواصفات وتكلفة العلائق. تم الاعتماد على أسلوب البرمجة الخطيـــة والبيانات الثانوية المنشورة لتحقيق أهداف الدراسة. اشتملت مكونات العلف التي تم أخذها في الاعتبار على الذرة، فول الصويا، كسب فول الصويا، كسب القطن، مسحوق السمك، الشوفان، مسحوق اللحم والعظـــم، القمـــح، النخالة، حبوب السورجوم، الأرز، مسحوق مخلفات الدواجن.

أوضحت النتائج أهمية مسحوق السمك، كسب القطن، الذرة، فول الصويا، ومخلفات الدواجن في تكويـــن العلائق. كذلك بينت الدراسة أن القيد الخاص بنسبة الطاقة الممثلة إلى البروتين يعتبر من أهم القيود المؤثـــرة علـــى تكوين وتكاليف العليقة، وأوضحت العلاقة الطردية بين تكلفة مكونات العليقة ونسبة البروتين في العليقـــة. فقـــد بلغت تكليفة مكونات العليقة (٣٠٪ بروتين) ٨٦٧,١٨ ريال/طن وارتفعت إلى حوالي ١٤٩٤,٤ ريال/طن للعليقة (٣٩٪ بروتين). كذلك أوضحت النتائج أن التكلفة الحدية لزيادة نسبة البروتين في العليقة تتزايد بمعـــدل مـــتزايد. وبمقارنة الأسعار التقديرية لبيع العلائق المثلى مع نظيرتها بالسوق المحلي تبين ان هناك إمكانية لخفض أسعار العلائق . الأمر الذي ينجم عنه إمكانية خفض تكلفة التغذية لإنتاج الكيلوجرام من الأسماك بحوالي ٠,٤٥ ريال.