Evaluation of Sunflower Meal as a Soybean Meal Replacement in Rainbow Trout Diets

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Abstract: Rainbow trout (*Salmo gairdneri*) were fed 38% protein experimental diets which contained either sunflower or soybean meal. Fish were reared in 2 sets of tanks under controlled and ambient water temperatures during January–April 1982. With controlled water temperature, fish fed the sunflower meal diet had a significantly higher final weight, average gains and food conversion ratio. Under ambient water temperature conditions, trout fed sunflower meal diet also had significantly higher final weight and average gain than trout fed soybean meal diets. A 35% protein sunflower meal adequately replaced a 49% protein soybean meal as a protein source in rainbow trout diets.

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Fish meal is the preferred protein source for fish rations, but low supply, high costs and contamination with heavy metals and pesticides have encouraged research using oilseeds as alternate protein sources (Ketola 1975, Smith 1977, National Research Council 1981). Soybeans have been studied as an alternate protein source, but raw and underheated soybeans contain a globulin protein that inactivates the pancreatic and intestinal proteases, trypsin and chymotrypsin (Smith 1977, National Research Council 1981). Heat treatment to 175-195 C will inactivate the globulin protein in soybeans (Smith 1977, Reinitz et al. 1978, Brandt 1979, Fordiani and Ketola 1980, Ketola 1980). Heat-treated soybean meal (SBM) has been used as a major protein source in diets for rainbow trout and channel catfish *(Ictalurus punctatus)* with good results (Smith 1977, Reinitz et al. 1978, Brandt 1979).

Smith (1977) reported that commercially processed SBM is normally only heated to 100 C for 1-3 minutes. This process does not destroy the globulin proteins. Trout fed diets containing greater than 20% non-heat treated commercial SBM have demonstrated poor growth and high mortality (Smith 1977). The use of commercial SBM in trout is limited by the level of heat treatment currently used in processing.

Nutritional characteristics of sunflower meal (SFM) are similar to other oilseed meals. However, SFM does not contain growth-depressing or toxic substances which may limit the amount of meal used (Cobia and Zimmer 1978). SFM has given results similar to commercial SBM when substituted on an equal-protein basis in feeding trials with cattle and sheep (Cobia and Zimmer 1978, Kinard 1980, Kaufman and Pratt 1981). Studies have shown SFM to be equivalent to cottonseed meal as a protein supplement in cattle rations and to soybean meal protein for lactating dairy cattle (Cobia and Zimmer 1978). Feed manufacturers use SFM as a supplemental protein for ruminants, primarily in dairy and beef rations (Cobia and Zimmer 1978).

Nationwide, sunflower plantings have increased from 1 to 5 million acres from 1977-1979 (Kinard 1980). This growth in sunflower production has made the United States the second largest producer and the largest exporter of sunflower products in the world (Cobia and Zimmer 1979, Kinard 1980). New processing facilities constructed in the northern United States are expected to double the volume of seeds processed (Kinard 1980). Declining cotton acreage in the South has resulted in excess processing capacity at cotton oil mills, and there is potential to produce 750,000 tons of SFM if the seeds were available for processing (Kinard 1980). If U. S. processing capacity reaches its projected potential, an additional 700,000 tons of SFM could be produced by the mid-1980's (Kinard 1980). This will have a noticeable impact upon the protein supply available for use in livestock, poultry and fish rations.

Studies in Alabama, Arkansas, Georgia and Mississippi have shown that rainbow trout can be grown as a winter crop in channel catfish production facilities (Reagan and Robinette 1975, Kilambi et al. 1977, Newton et al. 1977, Robinson and Newton 1981). Thus, the potential for increased production of both sunflowers and trout in the South prompted this study. The objective of this study was to evaluate sunflower meal as an alternative to commercial, solvent-extracted SBM as a protein source in diets for rainbow trout.

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Methods

Three types of SFM have been developed: 42% protein meal from dehulled seeds; 35% protein meal from partially dehulled seeds; and 28% protein meal from seeds with hulls. All SFM is prepress-solvent extracted and contains less than 2% residual oil (Kinard 1980, Kaufman and Pratt 1981). Currently, the 42% protein SFM is not commercially available, therefore, a 35% protein SFM was used for study diets.

In order to evaluate SFM as a dietary component for fish, rainbow trout were reared in tanks under controlled and ambient water temperatures. Trout were fed experimental diets containing SBM and SFM. Three diets, containing 38% protein by weight, were formulated based upon the following combinations: Diet SBM49 (soybean)—10% fish meal, 49% SBM;

Table 1. Composition of Experimental Diets Fed to Fingerling Rainbow Trout during January–April, 1982

Constituent[a]	Percent of Diet		
	SBM49 (soybean)	SBM20 (control)	SFM33 (sunflower)
Menhaden fish meal (61% protein)	10	30	30
Soybean meal (49% protein)	49	20	0
Sunflower meal (35% protein)	0	0	33
Meat and bone meal	15	15	15
Corn (yellow)	12	12	11
Wheat middlings	5	8	5
Ricebran	0	8	0
Trace mineral mix No. 1[b]	0.10	0.10	0.10
Vitamin mix No. 30[c]	0.40	0.40	0.40
Choline chloride (50%)	0.20	0.20	0.20
Ascorbic acid	0.10	0.10	0.10
MHA	0.38	0.30	0.25
Fish oil[d]	7	5	5

[a] Vitamin and trace mineral premix formulas were obtained from the January 1978 USFWS Trout Feed Formulation Specifications.

[b] Trace mineral mixture No. 1 (Guaranteed analysis of element $g.kg^{-1}$ mineral mix) Zinc, 75 ($ZnSO_4$-185 $g.kg^{-1}$); Manganese, 75 ($MnSO_4$-207 $g.kg^{-1}$); Iron 10 ($FeSO_4 \cdot 7H_2O$) - 50 $g.kg^{-1}$) Copper, 1.54 ($CuSO_4$ - 3.85 $g.kg^{-1}$); and Iodine, 0.51 (KIO_3-0.84 $g.kg^{-1}$).

[c] Vitamin mix No. 30 (Guaranteed potency per pound of premix in grams unless otherwise listed): D-calcium pantothenate, 12; pyridoxine (pyridoxine HCl), 3.5; Riboflavin, 6; Niacinamide, 25; Folic acid, 1; Thiamine (thiamine mononitrate), 4; Biotin, 40 mg; Vitamin B_{12}, 2.5 mg; Mendione Sodium Bisulfite Complex, 1.25; Vitamin E (d or dl alpha tocopherol acetate), 40,000 i.u.; Vitamin D_3, stabilized, 750,000 USP.

[d] Menhaden fish oil produced by wet rendering process. Stabilized with 0.01% ethoxyquin. Free fatty acids as 3.0% oleic. Iodine value, WIJS 150-170.

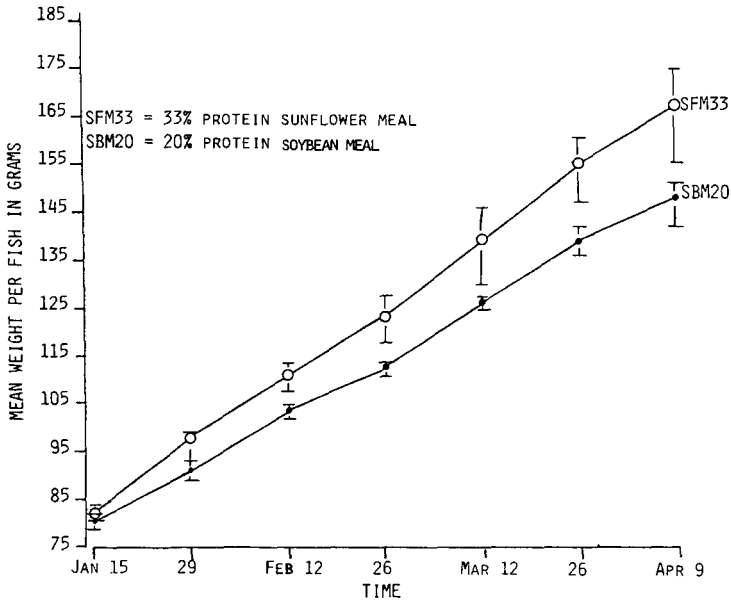

Figure 1. Growth of rainbow trout fed sunflower and soybean meal diets under controlled temperature, 1982.

Diet SBM20 (control)—30% fish meal, 20% SBM; and Diet SFM33 (sunflower)—30% fish meal, 33% SFM (Table 1). Diets were formulated to meet or exceed amino acid, mineral and vitamin levels recommended by the NRC for coldwater fishes (National Research Council 1981). Diets were manufactured into 0.32 x 0.64 cm sinking pellets, and were fed twice daily according to the New York State Fish Hatchery Feeding Chart (Klontz 1979) for 85 days, during January-April 1982.

All fish were individually weighed at 2-week intervals throughout the test period in order to adjust feeding rates. Mortalities were recorded and replaced with fish of equal size. Growth data were analyzed using ANOVA and means were separated using Duncan's new multiple-range test ($P \leq 0.05$). Samples of each of the 3 diets, and of SBM, and SFM were certified by Woodson-Tenent Laboratories, Inc. for proximate analysis composition (Table 2) and the SBM was analyzed for trypsin inhibitors.

Controlled Temperature

Trout were grown in 6 513 l fiberglass raceways supplied with 1.2 l/min of dechlorinated water maintained at 15 ± 1 C. Each raceway was stocked with 15 trout, average weight 82 g. Diets SFM33 and SBM20 were fed to trout in 3 randomly selected raceways.

Ambient Temperature

Trout were grown in 9 133 l circular plastic tanks supplied with water from a 0.1 ha pond at approximately 7.6 l/min. Water temperatures ranged from 2 to 24 C with an average of 10.5 C and varied < 4 C on any given day. Each tank contained 15 trout with an average weight of 39 g. Each of the 3 diets was fed to trout in replicates of 3 randomly selected tanks.

Results and Discussion

Trout readily accepted the pellets and fed well under both temperature regimes. Mortalities, which ranged from 0 to 11%, were sustained as a result of injuries incurred during weighing or when fish became trapped in cooling units of the fiberglass raceways.

There was no significant difference in weight between trout fed each

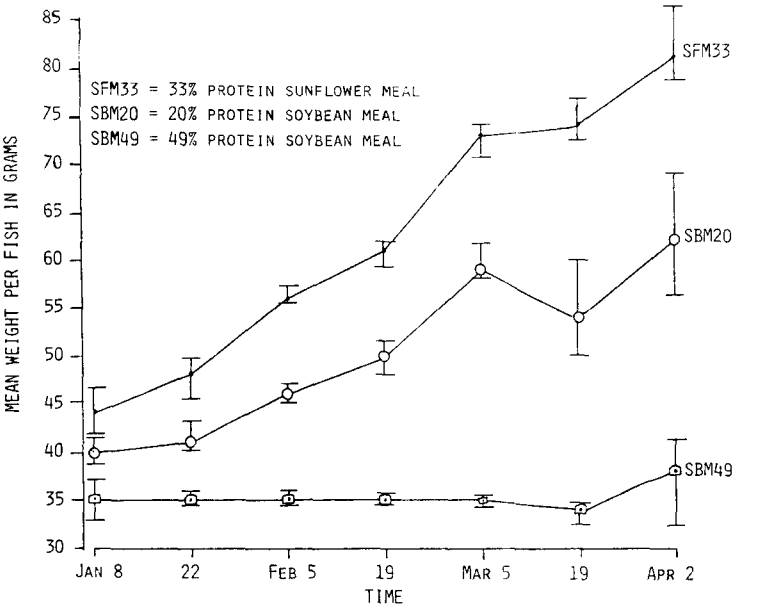

Figure 2. Growth of rainbow trout fed sunflower and soybean meal diets under ambient temperature, 1982.

Table 2. Proximate Analysis of Experimental Diets, Soybean Meal, and Sunflower Meal Fed to Fingerling Rainbow Trout during January–April, 1982 (Woodson-Tenent Laboratory)

Meal or Diet	Moisture Content (% H_2O)	Dry Matter Composition (%)					Nitrogen Free Extract[a]	Gross Energy[a] Calories
		Ash	Protein	Fiber	Carbohydrates[a]	Lipid		kg
Soybean meal[b]	10.96	5.89	49.00	3.16	33.31	0.84	30.15	3,238
Sunflower meal[c]	9.80	7.03	35.88	17.45	45.95	1.34	28.50	2,692
Diet SBM49	9.54	9.83	38.03	3.44	32.50	10.10	29.06	3,588
Diet SBM20	9.42	12.84	38.03	3.70	29.11	10.60	25.41	3,487
Diet SFM33	9.34	12.34	38.03	7.85	30.09	10.20	22.24	3,324

[a] Calculated values.
[b] Processed solvent-extraction.
[c] Processed by prepress-solvent extraction.

Table 3. Performance of Rainbow Trout Fed Experimental Diets of Sunflower and Soybean Meals

	Controlled Temperature Experiment		
	SFM33	SBM20	CV (%)
Average initial weight (g)	82A	81A[a]	23.4
Average final weight (g)	167A	148B	24.7
Average gain/sampling period (g)	13.9A	11.8B	7.4
Average FCR/sampling period	1.79A	2.19B	20.9
Percent mortality	0	8.9	

[a] Means in the same line followed by different letters are significantly different ($P \leq 0.05$).

diet under controlled water temperatures at the beginning of the experiment. Final weights, average gain per sampling period and FCR were significantly different between these 2 diets (Fig. 1, Table 3). Trout fed the SFM33 diet gained significantly more weight and had a significantly lower FCR than those fed the SBM20.

At the beginning of the ambient water temperature experiment, trout which were to be fed the SBM49 diet weighed significantly less than fish receiving SBM20 and SFM33 diets, however, there was no difference between initial trout weights for the SFM33 and SBM20 diets (Fig. 2, Table 4). At the conclusion of the experiment, trout fed the SFM33 diet weighed significantly more and had significantly higher weight gains than those fed the SBM20 or SBM49 diets (Table 4). Fish fed the SBM20 diet weighed more and had higher weight gains than the SBM49 fish and these differences were significant. The average sampling period FCR's were not significantly different between diets, trout fed the SBM49 diet had an average of 0.18 g gain per sampling period with many sampling periods showing no gain or loss

Table 4. Performance of Rainbow Trout Fed Experimental Diets of Sunflower and Soybean Meals

	Ambient Temperature Experiment			
	SFM33	SBM20	SBM49	CV (%)
Average initial weight (g)	44A[a]	40A	35B	16.0
Average final weight (g)	81A	62B	38C	21.6
Average gain/sampling period (g)	5.64A	3.13B	0.18C	19.4
Average FCR/sampling period	2.29A	2.49A	4.7A	150.6
Percent mortality	4.4	11.0	4.4	

[a] Means in the same line followed by different letters are significantly different ($P \leq 0.05$).

in weight (Fig. 2). Therefore, the FCR for the SBM49 diet may not adequately reflect the very poor growth of fish fed this diet (Fig. 2). Comparing the FCR's for the SFM33 and SBM20, trout fed the sunflower diet had a lower ratio, 2.29 to 2.49, respectively. These were not significant but did reflect better growth with the SFM diet. Poor growth on the SBM49 diet agrees with Smith's (1977) conclusion that trout fed diets containing greater than 20% non-heated commercial SBM had poor growth. The soybean meal used to make both SBM diets had a 12.8 TIU/mg^{-1} level of the trypsin inhibitor. This level indicates that the SBM had undergone the normal degree of heat treatment resulting from commercial solvent-extraction process. Such treatment does not completely destroy the inhibitor and may account for the poor growth of trout fed the SBM49 diet. Overall, both ambient and controlled water temperature trout fed sunflower meal had better growth rates, weighed more, and had better conversion than those fed soybean diets. The SBM20 diet contained 20% soybean meal which is comparable to commercially available trout diets. The better growth and similar conversions indicate that a 35% protein sunflower meal can adequately replace soybean meal which has undergone normal commercial heat treatment in the solvent extraction process. The sunflower meal has the added advantage of not containing the trypsin inhibitor.

The sunflower meal (35% protein) used in test diets was processed from partially dehulled seeds and contained 17.45% fiber (Table 2). This high fiber content made it necessary to use 13% more SFM than SBM to obtain the 38% protein level. Thus, fish ration formulation calculations will require a least-cost determination analysis to determine if sunflower meal is, indeed, an economical replacement for soybean meal. Expansion of processing facilities in the north and increasing interest in sunflowers as a new crop in the south, could have a significant impact on the availability of this oilseed protein source for use in commercial fish rations.

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