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An evaluation of two commercial feeds during rainbow trout initial rearing

Abstract

This study consisted of four consecutive trials evaluating the rearing performance of rainbow trout (*Oncorhynchus mykiss*) receiving one of two commercially-available feeds, Bio-Oregon BioVita or Optimal AquaFeed Trout. The first trial used #0 crumble (starter), the second trial #1 crumble, the third #2 crumble, and the fourth 1.5 mm pellets. In order, the trials lasted 18, 25, 27, and 26 days, respectively. At the end of the first trial, there was no significant difference between the two dietary treatments in total tank weight, gain, percent gain, feed conversion ratio, percent mortality, specific growth rate, individual fish total length, individual fish total weight, and condition factor. Similar results were observed at the end of the second trial with fish fed # 1 crumble, except that condition factor was significantly greater in the trout fed BioVita. At the end of the third trial, tanks of trout receiving BioVita were significantly heavier, had significantly greater gain, and had significantly lower feed conversion ratio compared to those tanks receiving Optimal AquaFeed. Individual trout receiving BioVita were also significantly heavier with a significantly higher condition factor. In the final trail, ending tank weight, gain, percent gain, individual fish total length, and individual fish weight were all significantly greater in the tanks receiving BioVita. Feed conversion ratio was also significantly lower. Aquaculturists can use these results to help determine which feed to use during initial rearing of rainbow trout.

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Kali A Roduner, Jill M Voorhees, Michael E Barnes*

South Dakota Department of Game, Fish and Parks, McNenny State Fish Hatchery, USA

Correspondence: Michael E Barnes, South Dakota Department of Game, Fish and Parks, McNenny State Fish Hatchery, 19619 Trout Loop, Spearfish, South Dakota 57783

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Introduction

Feeding fish is one of the most basic and important components of aquaculture.[1] Species-specific nutrient profiles in food are essential for fish growth and health.[2,3] The quantity and type of dietary protein is a major factor influencing fish production.[4] Feed quality, as determined by the nutrients provided by the ingredients, largely dictates feed conversion ratio and feed efficiency.[5] Lower feed conversion ratios and higher feed efficiencies mean less feed is needed to produce a per-unit mass of fish.[6] Feed is also a major variable cost of hatchery production.[5] With the variety of fish foods currently commercially-available, it is important to evaluate their use in relation to the success of hatchery rearing.[1,6]

Trout and salmon, family Salmonidae, are an important aquaculture group worldwide.[7,8] While a wide variety of salmonid feeds are commercially available, few studies have compared their relative performance. Significant differences in weight gain and feed conversion ratio in Chinook salmon (*Oncorhynchus tshawytscha*) among four commercially-available feeds were reported by Wipf et al.[9] Two different Chinook salmon commercial diets produced significantly different mortality during initial feeding.[10] Cutthroat trout (*Oncorhynchus clarkii*) weight, length, and survival were all significantly affected by the commercial feed fed.[11] Martin et al.,[12] reported growth and weight gain in rainbow trout (*Oncorhynchus mykiss*) differed among four commercially-available diets. However, in a similar study using three of the diets evaluated by Kindschi et al.,[11] with rainbow trout subjected to the pathogen causing bacterial coldwater disease (*Flavobacterium psychrophilum*), there were no differences among the diets.[13]

Because of the paucity of studies evaluating commercial salmonid diets, the recent availability of new commercial feeds, and the large impact of such feeds on fish growth, mortality, and hatchery economics, additional studies are definitely warranted. Thus, the objective of this study was to compare the performance of an established feed and a recently introduced feed during the hatchery rearing of juvenile rainbow trout.

Methods and materials

This experiment occurred at McNenny State Fish Hatchery, rural Spearfish, South Dakota, USA using aerated well water at a constant temperature of 11 °C (total hardness as $CaCO_3$, 360 mg/L; alkalinity as $CaCO_3$, 210 mg/L; pH, 7.6; total dissolved solids, 390 mg/L). Four feed trials were conducted. Each trial focused on a specific feed size, with the first trial evaluating starter feeds, the second trial evaluating #1 granules, the third trial #2 granules, and the fourth trial 1.5 mm pellets.

Trial 1

Trail 1 began immediately after yolk sac absorption on 9 October 2024 and ended after 18 days of feeding on 28 October 2025. Thirty individual rainbow trout swim-up fry were weighed to the nearest 0.01 g, and measured (total length), to the nearest 0.01 mm. Approximately 7,900 (weight = 0.51 kg) trout were placed into each of the eight 190-L (160-L working volume) semi-square tanks. Feeding commenced the day after placement of the fish in the tanks. Flows were similar along all tanks. Feed amounts were figured using the hatchery constant method[14], with an expected feed conversion ratio of 1.1. Growth rates were projected to be at, or slightly above, satiation and gradually increased as the fish became feed-trained. They were 0.04 cm/day for the first week of the trial, 0.05 cm/day for the second week, and 0.06 cm/day for the final four days of the trial. Feed amounts were also adjusted weekly based on the weight and total length of five fish per tank.

Two commercially-available starter diets were used in the eight tanks. Four tanks of fish received BioVita starter #0 granules (Bio-Oregon, Longview, Washington, USA) and four tanks received Optimal #0 trout granules (Optimal Fish Food LLC, Omaha, Nebraska, USA). Table 1 is the ingredient list for each diet and Table

2 is the proximate composition. Feed was delivered to each tank every 10 minutes during daylight hours with 0.5-L vibratory feeders (Pentair Aquatic Ecosystems Inc., Apopka, Florida, USA). Tanks were cleaned and mortalities were recorded daily. At the end of the trial, weight and total length from five fish per tank were recorded. In addition, total tank weights were recorded to the nearest gram.

Table 1 Ingredient list for BioVita and Optimal Trout starter (#0) feeds

BioVita Starter #0	Optimal Trout #0
Fish meal	Animal protein products
Wheat gluten	Whole wheat
Fish oil	Stabilized fish oil
Wheat flour	Wheat gluten
Krill meal	Corn gluten
Condensed fish protein digest	Lecithin
Dried whey	Lysine
Monoammonium phosphate	Choline chloride
L-lysine	Taurine
Ethoxyquin	DL methionine
Choline chloride	Mono Di-calcium phosphate
Vitamin E	Calcium L-Ascorbate-2-Monosphosphate
DL-methionine	Threonine vitamin E
Calcium L-ascorbyl-2-monophosphate	Magnesium sulfate
Dried yeast	Nicotinamide
Paracoccus pigment	Inositol
Yeast extract	Propionic acid
Roughage products	D-Calcium pantothenate
Zinc sulfate	Riboflavin
Ferrous sulfate	Zinc proteinate
Inositol	Menadione sodium bisulfite complex
Niacin	Zinc sulfate
Calcium pantothenate	Pyridoxine hydrochloride
Manganese sulfate	Thiamine mononitrate
Riboflavin	Copper proteinate
Mineral oil	Manganese proteinate
Pyridoxine hydrochloride	Manganese sulfate
Vitamin B12	Folic acid
Menadione sodium bisulfite complex	Calcium iodate
Copper sulfate	Cobalt proteinate
Biotin	Cobalt sulfate
Thiamine mononitrate	Vitamin A
Vitamin A acetate	Biotin
Folic acid	Vitamin B-12
Vitamin D3	Sodium selenite
Calcium iodate	Vitamin D
Sodium selenite	

Table 2 Proximate composition for BioVita and Optimal Trout starter (#0) feeds

	BioVita Starter #0	Optimal Trout #0
Protein (%)	53	52
Fat (%)	18	16
Fiber (%)	1	2
Phosphorus (%)	1.2	1
Sodium (%)	1.1	-
Calcium (%)	2.6	-
Ash (%)	12	9

Trial 2

Trial 2 began on 29 October 2025, the day after the conclusion of the first trial. After final data collection for Trial 1, all of the fish for each treatment group were pooled (i.e. all four tanks for each diet were combined into one tank) and equally separated into four, 2,000-L circular tanks (1.8 m diameter × 0.6 m deep) tanks. Because absolute gain was greater in Trial 1 for the fish fed BioVita compared to those fed Optimal, initial tank weights were 1.636 kg for the four BioVita-fed tanks compared to 1.535 kg for the four Optimal-fed tanks. Flows in the tank were set to maintain dissolved oxygen levels above 7.0 mg/L.

Feeding commenced the day after the fish were placed into the tanks. Fish were fed the same brand of feed that they received in the first trial, but the feed size was increased to #1 granules. The ingredient list and proximate composition for each of the feeds is listed in Tables 3 & 4. Feed amounts were figured using the hatchery constant method,[14] with an expected feed conversion ratio of 1.1 and projected growth rate of 0.09 cm/day. Tanks of fish were fed using Arvo-Tec drum filters (Arvo-Tec Oy, Huutokoski, Finland) with feed dispensed for eight seconds every 10 minutes. Tanks were cleaned and mortalities removed daily. The trial lasted for 25 days, ending on 22 November 2025. At the end of the trial, five fish from each tank were weighed to the nearest 0.01 g and measured (total length) to the nearest 0.01 mm. Total tank weights to the nearest g were also recorded.

Table 3 Ingredient list for BioVita and Optimal Trout #1 and #2 granules

BioVita	Optimal
Fish meal	Animal protein products
Wheat gluten	Whole wheat
Fish oil	Stabilized fish oil
Wheat flour	Wheat gluten
Krill meal	Corn gluten
Condensed fish protein digest	Lecithin
Dried whey	Lysine
Monoammonium phosphate	Choline chloride
L-Lysine	Taurine
Ethoxyquin	DL methionine
Choline chloride	Mono Di-calcium phosphate
Vitamin E	Calcium L-Ascorbate-2-Monophosphate
DL-methionine	Threonine vitamin E
Calcium L-ascorbyl-2-monophsophate	Magnesium sulfate
Dried yeast	Nicotinamide
Paracoccus pigment	Inositol
Yeast extract	Propionic acid
Roughage products	D-Calcium pantothenate
Zinc sulfate	Riboflavin
Ferrous sulfate	Zinc proteinate
Inositol	Menadione sodium bisulfite complex
Niacin	Zinc sulfate
Calcium pantothenate	Pyridoxine hydrochloride
Manganese sulfate	Thiamine mononitrate
Riboflavin	Copper proteinate
Mineral oil	Manganese proteinate
Pyridoxine hydrochloride	Manganese sulfate
Vitamin B12	Folic acid
Menadione sodium bisulfite complex	Calcium iodate

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Table 3 Continued....

Copper sulfate	Cobalt proteinate
Biotin	Cobalt sulfate
Thiamine mononitrate	Vitamin A
Vitamin A acetate	Biotin
Folic acid	Vitamin B-12
Vitamin D3	Sodium selenite
Calcium iodate	Vitamin D
Sodium selenite	

Table 4 Proximate composition for BioVita and Optimal Trout #1 and #2 granules

	BioVita	Optimal
Protein (%)	52	52
Fat (%)	20	16
Fiber (%)	1	2
Phosphorus (%)	1.2	1
Sodium (%)	1.1	-
Calcium (%)	2.6	-
Ash (%)	-	9

Trial 3

Trial 3 began immediately after the conclusion of the second trial. The methods were similar to Trial 2, with fish of the same treatment pooled and equally-distributed among four tanks (8.530 kg/tank for BioVita and 7.700 kg/tank for Optimal). Feeding commenced the day after fish placement in the tank, and fish again continued to receive the same brand of feed, with the feed size increased to #2 granules. Trial 3 lasted for 27 days, ending on 19 December 2025.

Trial 4

Trial 4 began immediately after the conclusion of the third trial on 19 December 2025. After being pooled by the same treatment, tanks were reloaded at either 32.23 kg/tank for BioVita and 28.85 kg/tank for Optimal. Fish continued to receive the same brand of feed, but feed sizes were increased to 1.5 mm. Feed ingredient lists and proximate composition are listed in Tables 5 & 6, respectively. Feeding rates and other methods were the same as Trials 2 and 3. Trial 4 lasted for 26 days, ending on 15 January 2025.

Table 5 Ingredient list for BioVita and Optimal Trout 1.5 mm pellets

BioVita	Optimal Trout
Fish meal	Animal protein products
Fish oil	Wheat flour
Wheat gluten meal	Stabilized fish oil
Wheat flour	Hydrolyzed soy protein
Brewer's yeast	Wheat germ
Vitamin A Acetate	Corn gluten
Vitamin D3	Wheat gluten
Ascorbyl Polyphosphate C	Lecithin
Vitamin E	Lysine
Inositol	Choline chloride
Zinc Sulphate	Taurine
Nicotinic Acid	Mono di-calcium phosphate
Calcium Pantothenate	DL methionine
Manganese Sulphate	Calcium L-Ascorbate-2-Monophosphate
Riboflavin	Threonine
Pyridoxine Hydrochloride (B6)	Vitamin E
Thiamine Mononitrate	Magnesium sulfate

Table 5 Continued....

Menadione Sodium Bisulfite Complex	Nicotinamide
Copper Sulfate	Inositol
Folic acid	Propionic acid
Calcium iodate	D-Calcium pantothenate
D-biotin	Riboflavin
Sodium selenite	Zinc proteinate
Vitamin B12	Menadione sodium bisulfite complex
Ethoxyquin	Zinc sulfate
Calcium L-Ascorbyl-2-Monophosphate	Pyridoxine hydrochloride
Vitamin E	Thiamine mononitrate
Choline chloride	Copper proteinate
Paracoccus pigment	Manganese proteinate
	Manganese sulfate
	Folic acid
	Calcium iodate
	Cobalt proteinate
	Cobalt sulfate
	Vitamin A
	Biotin
	Vitamin B-12
	Sodium selenite
	Vitamin D

Table 6 Proximate composition for BioVita and Optimal Trout 1.5 mm

	BioVita	Optimal Trout
Protein (%)	50	47
Fat (%)	22	17
Fiber (%)	1	2
Phosphorus (%)	1.2	1
Sodium (%)	1	-
Calcium (%)	2.7	-
Ash (%)	-	9

Equations

The following equations were used in this study:

$$Gain = end\ weight - start\ weight$$

$$Percent\ Gain\,(\%) = \frac{gain}{start\ weight}$$

$$\text{Percent Gain } (\%) = \frac{\text{gain}}{\text{start weight}}$$

$$Feed\ conversion\ ration\ (FCR) = \frac{food\ fed}{gain}$$

$$Specific\ growth\ rate\ (SGR) = 100 * \frac{\ln(end\ weight) - ln(start\ weight)}{number\ of\ days}$$

$$Condition\ factor\ (K) = 10^5 * \frac{fish\ weight}{fish\ lengt\,h^3}$$

Statistical analysis

The SPSS (24.0, IBM, Armonk, New York, USA) statistical program was used for analysis of data. One way Analysis of variance (ANOVA) was used for comparisons between treatments. Because the tanks, and not individual fish, were the experimental unit, the mean of individual fish data for each tank was used for subsequent analysis in ANOVA. Percentage data were log transformed before analysis to stabilize the variances.[15]

Results

Trial 1

Ending tank weights, gain, percent gain, and feed conversion ratio were not significantly different in tanks of fish receiving either diet (Table 7). Mortality was relatively high at 17.9% and 20.3% in the tanks fed BioVita and Optimal, respectively. At 31.6 mm and 31.3 mm, fish total lengths were nearly identical, as were ending individual weights at 0.28 g and 0.27 g (Table 8). There was no significant difference in specific growth rate or condition factor between the dietary treatments.

Table 7 Mean (SE) final weights, gain, feed conversion ratio (FCR)[1], and mortality of tanks of rainbow trout receiving either BioVita or Optimal starter diets for 18 days starting with initial feeding (Trial 1; N = 4)

	BioVita	Optimal	P
Weight start (kg)	0.51	0.51	-
Weight end (kg)	1.64 (0.11)	1.53 (0.06)	0.173
Gain (kg)	1.13 (0.11)	1.02 (0.06)	0.173
Gain (%)	220.7 (22.3)	200.9 (12.6)	0.173
Feed fed (g)	1.35	1.35	-
FCR[1]	1.21 (0.12)	1.32 (0.08)	0.17
Mortality (%)	17.91 (5.42)	20.26 (6.07)	0.584

[1]FCR = food fed/gain

Table 8 Mean (SE) final individual fish total length, weight, specific growth rate (SGR)[1], and condition factor (K)[2] of rainbow trout receiving either BioVita or Optimal starter diets for 18 days starting with initial feeding (Trial 1; N = 4)

	BioVita	Optimal	P
Length start (mm)	22.91	22.91	-
Length end (mm)	31.63 (1.23)	31.33 (0.67)	0.682
Weight start (g)	0.06	0.06	-
Weight end (g)	0.28 (0.03)	0.27 (0.01)	0.309
SGR[1]	8.58 (0.63)	8.25 (0.12)	0.345
K[2]	0.89 (0.02)	0.86 (0.05)	0.398

[1]Specific Growth Rate (SGR) = 100 * (ln (end weight) − ln (start weight))/(number of days)

[2]Condition Factor (K) = 10^5 * (fish weight)/(fish length)^3

Trial 2

Similarly to Trial 1, ending tank weights, gain, percent gain, and feed conversion ratio were not significantly different in tanks of fish receiving either diet (Table 9). Feed conversion ratio was 1.03 in the BioVita tanks and 1.12 in the Optimal tanks. Mortality decreased dramatically from Trial 2 and was also not significantly different between the dietary treatments. Condition factor was significantly greater in fish fed BioVita compared to Optimal (Table 10). None of the other individual fish metrics (length, weight, specific growth rate) were significantly different, however.

Table 9 Mean (SE) final weight, gain, feed conversion ratio (FCR)[1], and mortality of tanks of rainbow trout receiving either BioVita or Optimal #1 granule diets from 19 to 44 days after initial feeding (Trial 2; N = 4)

	BioVita	Optimal	P
Weight start (kg)	1.64	1.53	-
Weight end (kg)	8.54 (0.60)	7.70 (0.63)	0.103
Gain (kg)	6.90 (0.60)	6.17 (0.63)	0.142
Gain (%)	421.9 (36.8)	402.0 (40.8)	0.494
Feed fed (g)	7.04	6.86	-
FCR[1]	1.03 (0.10)	1.12 (0.13)	0.274
Mortality (%)	2.26 (1.35)	2.51 (0.58)	0.747

[1]FCR = food fed/gain

Table 10 Mean (SE) individual fish total length, weight, specific growth rate (SGR)[1] and condition factor (K)[2] of rainbow trout receiving either BioVita or Optimal #1 granule diets from 19 to 44 days after initial feeding (Trial 2). Means followed by different letters are significantly different (P < 0.05; N = 4)

	BioVita	Optimal	P
Length start (mm)	31.63	31.33	-
Length end (mm)	53.23 (2.44)	51.72 (1.97)	0.373
Weight start (g)	0.28	0.26	-
Weight end (g)	1.65 (0.21)	1.38 (0.18)	0.099
SGR[1]	7.07 (0.51)	6.66 (0.54)	0.307
K[2]	1.09 (0.04) x	0.99 (0.02) y	0.004

[1]Specific Growth Rate (SGR) = 100 * (ln (end weight) − ln (start weight))/(number of days)

[2]Condition Factor (K) = 10^5 * (fish weight)/(fish length)^3

Trial 3

At the end of this trial, total tank weight and gain were all significantly greater in tanks of trout receiving BioVita compared to those receiving Optimal (Table 11). At 0.81 versus 0.89, the feed conversion ratio was also significantly lower in the tanks fed BioVita versus those fed Optimal. Mortality was less than one percent in both treatments but was significantly greater in the BioVita-fed tanks. Individual fish fed BioVita #2 granules were significantly heavier and also had a significantly greater condition factor than those fish fed Optimal #2 granules (Table 12).

Table 11 Mean (SE) final weight, gain, feed conversion ratio (FCR)[1], and mortality of tanks of rainbow trout receiving either BioVita or Optimal #2 granule diets from 45 to 72 days after initial feeding (Trial 3). Means followed by different letters are significantly different (P < 0.05; N = 4)

	BioVita	Optimal	P
Weight start (kg)	8.54	7.7	-
Weight end (kg)	32.23 (0.73) x	28.85 (0.75) y	0.001
Gain (kg)	23.70 (0.73) x	21.15 (0.75) y	0.003
Gain (%)	277.5 (8.5)	274.5 (9.8)	0.656
Feed fed (g)	19.23	18.86	-
FCR[1]	0.81 (0.03) y	0.89 (0.03) x	0.007
Morts (%)	0.79 (0.20) x	0.27 (0.06) y	0.002

[1]FCR = food fed/gain

Table 12 Mean (SE) individual fish total length, weight, specific growth rate (SGR)[1] and condition factor (K)[2] of rainbow trout receiving either BioVita or Optimal #2 granule diets from 45 to 72 days after initial feeding (Trial 3). Means followed by different letters are significantly different (P < 0.05; N = 4)

	BioVita	Optimal	P
Length start (mm)	53.23	51.72	-
Length end (mm)	81.53 (2.05)	80.84 (1.53)	0.609
Weight start (g)	1.65	1.38	-
Weight end (g)	6.41 (0.37) x	5.55 (0.35) y	0.015
SGR[1]	5.02 (0.21)	5.14 (0.24)	0.489
K[2]	1.18 (0.04) x	1.05 (0.02) y	0.001

[1]Specific Growth Rate (SGR) = 100 * (ln (end weight) − ln (start weight))/(number of days)

[2]Condition Factor (K) = 10^5 * (fish weight)/(fish length)^3

Trial 4

Final tank weight, gain, percent gain, and feed conversion ratio were all significantly greater in the tanks receiving BioVita compared to those receiving Optimal (Table 13). Percent mortality was

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significantly lower in the tanks receiving Optimal. Individual total lengths and weights were also significantly greater in fish fed BioVita (Table 14). However, specific growth rate was identical between the treatments at 3.76, and there was also no significant difference in condition factor.

Table 13 Mean (SE) final weight, gain, feed conversion ratio (FCR)[1], and mortality of tanks of rainbow trout receiving either BioVita or Optimal 1.5 mm pellets from 73 to 99 days after initial feeding (Trial 4). Means followed by different letters are significantly different (P < 0.05; N = 4)

	BioVita	Optimal	P
Weight start (kg)	32.23	28.85	-
Weight end (kg)	84.48 (1.02) x	72.55 (0.70) y	0
Gain (kg)	52.25 (1.02) x	43.70 (0.70) y	0
Gain (%)	162.1 (3.2) x	151.5 (2.4) y	0.038
Feed fed (g)	41.66	39.7	-
FCR[1]	0.80 (0.02) y	0.91 (0.01) x	0.002
Mortality (%)	1.10 (0.02) x	0.15 (0.02) y	0

[1]FCR = food fed/gain

Table 14 Mean (SE) individual fish total length, weight, specific growth rate (SGR)[1] and condition factor (K)[2] of rainbow trout receiving either BioVita or Optimal 1.5 mm pellet diets from 73 to 99 days after initial feeding (Trial 4). Means followed by different letters are significantly different (P < 0.05; N = 4)

	BioVita	Optimal	P
Length start (mm)	81.53	80.84	-
Length end (mm)	111.27 (0.53) x	106.91 (1.69) y	0.049
Weight start (g)	6.41	5.55	-
Weight end (g)	17.03 (0.25) x	14.79 (0.71) y	0.025
SGR[1]	3.76 (0.06)	3.76 (0.18)	0.999
K[2]	1.24 (0.02)	1.21 (0.02)	0.438

[1]Specific Growth Rate (SGR) = 100 * (ln (end weight) − ln (start weight))/(number of days)

[2]Condition Factor (K) = 105 * (fish weight)/(fish length)^3

Discussion

The results of the four trials in this study indicated that overall rainbow trout receiving BioVita grew faster and used feed more efficiently than rainbow trout fed Optimal feeds. It is difficult to compare nutritional profiles for the feeds from the two companies because of the ambiguities present in the ingredient lists. For example, the first and primary ingredient of BioVita is fishmeal, which is a defined and standard fish food protein source. The Optimal feeds' primary ingredient is animal protein products. Animal protein products that have been used in fish food include shrimp meal, blood meal, bone meal, meal from a variety of insects, hydrolyzed feather meal, poultry by-product meal, krill meal, and fish silage.[16-34] Several animal protein products lack some of the essential amino acids required by fish and vary in nutritional value.[32,35,36]

The use of generic animal protein sources on fish growth in comparison to just fish meal appears to depend on the amount and type of animal protein used. Partial replacement of fish meal by animal meal products had no effect on growth performance in rainbow trout[37-39] but a higher percentage or complete replacement of fish meal by animal meal products resulted in a significant decrease in rainbow trout growth.[38,39] Steffens[37] reported that partial replacement of fish meal with poultry-by-product had no effect during rainbow trout rearing, but amino acid supplementation was required for complete substitution. Rimoldi et al.,[40] reported replacement by animal by-product meals does not affect growth performance. In contrast, Burr et al.[41] observed that replacement of fish meal with blends of alternative proteins, including poultry-by-product meal, significantly decreased growth performance in rainbow trout fingerlings and early-stage Atlantic salmon (*Salmo salar*). The National Research Council[2] suggests that animal protein ingredients can be suitable for fish meal replacement, although the high variability of nutritional content in animal meal protein suggests it is unreliable as a main protein source.[2] Thus, the inclusion of generic animal protein products may have influenced the significantly lower growth rates observed in the rainbow trout fed Optimal feeds in this study.

Bio-Oregon BioVita contained a higher percentage of fat and a higher percentage of protein in its #0 Crumble and 1.5 mm. Protein content can act as a lipid source; thus, both are potential energy sources.[2] When lipids supply the appropriate amount energy, it can reduce the amount of protein needed, thus, feeds with a higher lipid level will support higher growth rates.[2]

Other ingredients may have influenced the results of this study. BioVita contained dried yeast and yeast extract, while the Optimal feed did not. Yeast has been recognized as an important ingredient of aquaculture feeds because of its promising role in nutrition and immunostimulation.[2,42,43] Yeast as an additive to fish feeds improves fish growth and decreases mortalities in rainbow trout[42,44-46] and in other fish species.[44,43,47-50] Yeast has also shown immunostimulant properties.[43,45,49,51] Yeast content may have influenced the significantly greater growth rates in the rainbow trout fed BioVita in this study.

The higher mortality observed in this study in the tanks of trout receiving BioVita may have been because of the relatively high feeding rates used and relatively high protein levels in BioVita. High growth rates in other salmonids can increase the risk of developing vertebral deformities through poor mineralization at early stages.[52,53] These deformities could possibly lead to mortality. Protein levels in the BioVita feeds were at or above 50%. This is higher than the 48% recommended by the National Research Council[2] for rainbow trout weighing less than 20 g. Dietary protein levels are then recommended to decrease exponentially as fish size increases.[2] Protein excess[54,55] and lipid imbalances[55,56] can inhibit growth and suppress immune functions in fishes, potentially leading to mortality.

The four trials in this study had relatively short durations, ranging from 18 to 27 days, which could be problematic. The National Research Council[2] recommended minimal feed trial durations of 56 days, However, Weatherup and McCracken[57] stated that the duration of feed studies must only run long enough for significant differences to be observed. Four trials in a feed comparison study of Chinook salmon had durations ranging from 21 to 41 days, with significant differences being observed in all trials.[9] Thus, the significant differences in rainbow trout growth observed among the diets are notable.

The results from the first trial were likely affected by the inability of the vibratory feeders to uniformly disperse starter feeds. In particular, the Optimal starter diet was extremely oily, clumping to itself and also sticking to the feeder parts; it did not dispense readily from the feeders.

Lastly, because commercial feed formulations are proprietary and subject to change, the results may only be applicable to feeds used at the time of the study. However, the overall results of this study indicate that the BioVita feeds used led to increased rainbow trout growth and feeding efficiency in comparison to the Optimal feeds.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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