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Health & Welfare

Diets affect abalone meat quality, shell color

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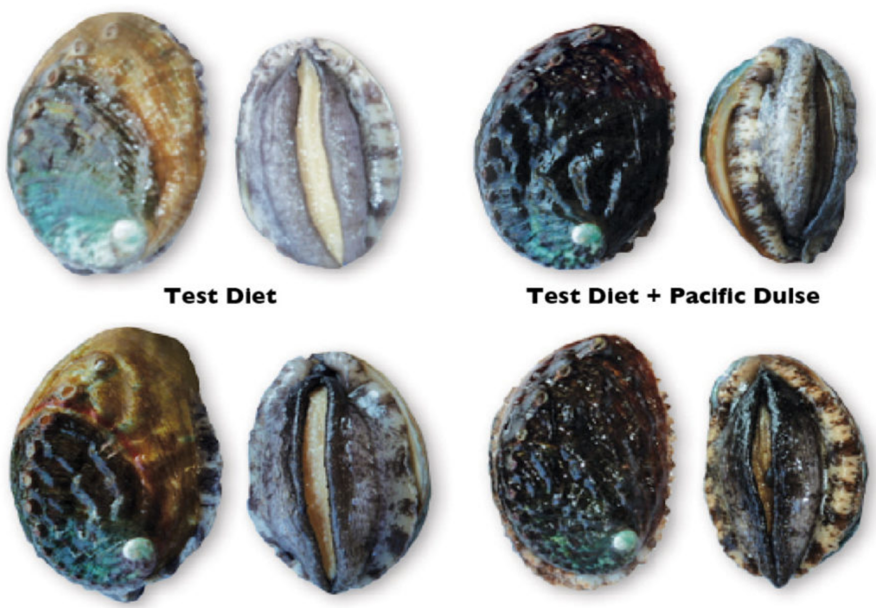
Artificial feed can partially replace seaweed for current production



The shell color and meat of abalone varied relative to the diets fed to the animals.

Abalone is a highly prized seafood. Pacific abalone, Haliotis discus hannai, is the most important species of abalone cultured in Hawaii, USA.

Wild Pacific abalone eat red and brown seaweeds and have a dark-brown shell. Hawaii Abalone Co. has used a red seaweed, Pacific dulse (Palmaria mollis), to culture abalone and obtain a dark-brown shell color, which is preferred by the international seafood market, especially in Japan. However, feeding Pacific abalone with an artificial, commercially available diet has typically resulted in the abalone appearing yellow, green or pink in color.

There is great demand for the development of a formulated diet for cultured abalone to support sustainable production of this shellfish. Unfortunately, culturing seaweed is expensive, and it is difficult to mass produce. The authors therefore performed research to evaluate the effects of artificial diets, the seaweed *P. mollis*, and combinations thereof on abalone growth, meat quality and shell color.

Diet preparation, feeding methods

An artificial test diet was prepared by extrusion through a single-screw extruder at the feed mill of the **Oceanic Institute** (https://www.aquaculturealliance.org/advocate/spf-broodstock-shrimp/?__hstc=236403678.03c004d07fe4faeba63c47aa257d4412.1681020935508.1681020935508.1681020935508.1&__hssc=236403678.1.1681020935509&__hsf

in Hawaii. Each of five, 2,000-L tanks was stocked with about 5,000 juvenile Pacific abalone of similar size, reflecting a total biomass of about 35 kg. The mean weight and shell size of the abalone were 7.1 g and 35.3 mm, respectively. Each tank received approximately 500 L/hour of 200 μ-filtered seawater at ambient temperatures of 17.5 to 19.5 degrees C, with pH at 8.2 ± 0.2 and salinity of 32 to 35 ppm.

For the first week of the trial, all abalone were fed Pacific dulse. After the first week, each tank received one of the following diets: Pacific dulse as a control, a test diet, the test diet plus Pacific dulse, an imported commercial feed, and the commercial feed plus Pacific dulse. The feeding trial lasted 220 days. The abalone were fed three times weekly in the single-diet treatment, but twice with the artificial diet plus one time Pacific dulse weekly for the combination diet treatments.

Diet composition

The proximate composition of the diets is shown in Table 1. The 29.4 percent crude protein content of the test diet was lower than the 35.7 percent protein content of the commercial feed, but its crude lipid content was over double that of the commercial feed. Freeze-dried Pacific dulse had only 22.1 percent crude protein and less carbohydrate and gross energy, but higher ash content than the two artificial diets.

Ju, Nutritional composition, Table 1

Feed	Dry Matter (percent)	Crude Protein (percent)	Crude Lipid (percent)	Ash (percent)	Carbohydrate (percent)	Gross Energy (cal/g)
Pacific dulse	95.3	22.1	2.1	38.5	32.6	2,510
Test diet	91.8	29.4	4.7	7.3	50.6	4,312
Commercial feed	91.2	35.7	1.6	6.0	47.9	4,126

The amino acid profiles of the diets and abalone meat were also analyzed. The percentages of seven essential amino acids in the test diet, commercial feed and Pacific dulse were higher than those in abalone meat, which may suggest they should meet the requirements for abalone growth. However, levels of arginine and threonine were 19 to 43 and 57 to 124 percent lower, respectively, than those in abalone meat. These two essential amino acids might be limiting in these diets.

Growth, survival

Table 2 shows the growth rates of the abalone based on weight and accumulative mortality after 220 days of feeding. Feeding abalone with the test diet or the commercial feed alone resulted in growth rates of 2.07 and 2.91 g/month, respectively, compared to monthly growth of 3.20 g for abalone on the seaweed diet. Combining Pacific dulse with the test diet or the commercial feed improved abalone growth by 39 and 21percent, respectively. Pacific dulse fed alone and in combination with the test diet also reduced abalone mortality.

Ju, Abalone growth, Table 2

Feed	Stocking Weight (g)	Stocking Size (mm)	Harvest Weight (g)	Harvest Size (mm)	Monthly Growth Weight (g)	Monthly Growth Size (mm)	Mortality
Pacific dulse	6.93	35.07	29.98	57.25	3.20	3.08	7.64
Test diet	7.08	35.32	21.96	51.58	2.07	2.26	22.33
Test diet + Pacific dulse	7.62	36.20	28.27	56.13	2.87	2.77	4.38
Commercial feed	6.77	34.80	27.70	55.75	2.91	2.91	10.94
Commercial feed + Pacific dulse	6.95	35.10	32.24	58.65	3.51	3.27	22.86

Table 2. Abalone growth and survival after 220 days feeding with different diets.

Abalone meat composition, shell color

Feeding the natural and artificial diets resulted in different nutrient compositions in abalone meat samples (Table 3). Feeding Pacific dulse resulted in a 79.61 percent higher crude protein content than feeding the test diet (60.19 percent) or commercial feed (55.03 percent). Combining Pacific dulse with one of the two diets increased crude protein, but lowered the level of carbohydrate in abalone meat.

Ju, Nutritional composition, Table 3

Feed	Crude Protein (percent)	Crude Lipid (percent)	Ash (percent)	Carbohydrate (percent)
Pacific dulse	79.61	3.83	8.86	4.38
Test diet	60.19	2.74	6.44	27.10
Test diet + Pacific dulse	69.82	3.23	7.38	15.58
Commercial feed	55.03	2.59	6.36	33.13
Commercial feed + Pacific dulse	66.18	3.20	7.98	19.11

Table 3. Nutritional composition of dry abalone meat from different diet treatments.

Feeding abalone with Pacific dulse alone resulted in dark-brown shells for all abalone produced. Feeding the two artificial diets resulted in yellow or pink shells and light meat color, while combining Pacific dulse with the two diets led to dark-brown shells and dark meat color.

It is not clear why Pacific dulse improved the abalone meat protein content and growth rate. Previous research reported that abalone fed an artificial diet had substantially higher glycogen content than abalone fed Gracilaria species red seaweed, which is consistent with these results.

It is possible the high accumulation of the carbohydrate may depress the growth of abalone. The high energy level of the current artificial diets may also have impaired feed intake. Thus, the abalone might not have received enough nutrients for protein synthesis and growth. Furthermore, the amino acid balance for the test diets might not have been optimized for the nutritional requirements of this species.

Finally, the low ash and high carbohydrate content in the artificial diets may not be optimal for growth of the abalone based on the nutritional profile of the seaweed that promoted the best growth in this study. The two artificial diets might also lack pigments or some essential factors for the dark-brown appearance for abalone. Further research will be needed to address these issues.

Perspectives

Based on growth performance and effects on the finished product, neither the test diet nor the commercial feed could compete with the seaweed for Pacific abalone aquaculture. However, combining the test diet with the seaweed improved culture performance. These results suggested that artificial feed can partially replace seaweed for current production. More research is warranted for developing an optimal diet for Pacific abalone production.

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