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Replacing sea mud with attachment of suspension cage can improve growth and gut health for sea cucumber Apostichopus japonicus

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Abstract

During the suspension cage culture procedure, a substantial quantity of attachments from the suspension cage will amass in the tidal flats, resulting in environmental pollution and resource wastage. The aim of the present study was to explore the feasibility of using attachments of suspension cage (ASC) as a raw feed material for sea cucumbers. Different ASC concentrations (0, 25, 50, 75, and 100%) were used in sea cucumber (*Apostichopus japonicus*) fed for 60 d. Replacing sea mud with 50% ASC significantly improved sea cucumber growth, reduced the feed coefficient, significantly increased the activity of intestinal digestive enzymes, improved the activities of acid phosphatase and alkaline phosphatase, improved the intestinal structure, and enriched intestinal microbiome diversity (P<0.05). Replacing sea mud with 75% and 100% ASC significantly improved sea cucumber total antioxidant capacity and total superoxide dismutase (P<0.05). Furthermore, expressions of *c-myc* gene, *mapk-7* gene and *fgfr-1* gene, which all three growth genes, significantly increased in the 50% ASC treatment compared to that in the control; whereas, that of *gdf-8* gene, a negative growth regulator, was inhibited (P<0.05). Based on the quadratic regression analysis for the weight gain rate, the appropriate levels of ASC substitution were estimated as to be 44.28%. The results suggested the potential of ASC as a new raw feed material for sea cucumbers.

Experimental diets

Table 1. Experimental diet composition and nutrient levels (g/kg)

Ingredient	Experimental diet (g/kg)				
	O1	O2	O3	O4	O5
Sargassum	580	580	580	580	580
Sea mud	200	150	100	50	0
ASC[1]	0	50	100	150	200
Wheat meal	60	60	60	60	60
Fish meal	90	90	90	90	90
Soybean meal	50	50	50	50	50
Vitamin mixture	10	10	10	10	10
Mineral mixture	10	10	10	10	10
Total	100	100	100	100	100
Analyzed nutrient (% on a dry basis)					
Moisture	10.16	10.38	10.45	10.35	10.45
Crude lipid	5.01	5.01	5.04	5.06	5.06
Crude protein	18.43	18.43	18.45	18.47	18.47
Ash	55.35	56.55	56.70	57.05	57.33

[1] ASC attachments of suspension cage

Results

Growth performance

Table 2. Effects of dietary ASC content on growth performance of *Apostichopus japonicus*.

Parameter	Experimental diet				
	O1	O2	O3	O4	O5
IBW (g)	10.50±0.18	10.42±0.19	10.47±0.12	10.48±0.10	10.73±0.09
FBW (g)	21.33±0. 18^{a}	25.43±0.67^{c}	26.89±0.10^{d}	23.58±0.18^{b}	22.45±0.36^{ab}
WGR (%)	103.34±4.98^{a}	143.97±2.42^{c}	156.80±2.49^{d}	125.01±0.74^{b}	109.16±1.57^{a}
SGR (%/d)	1.26±0.04^{a}	1.59±0.02^{c}	1.68±0.02^{d}	1.45±0.01^{b}	1.31±0.01^{a}
FCR	1.85±0.06^{d}	1.33±0.04^{a}	1.21±0.01^{a}	1.52±0.01^{b}	1.70±0.04^{c}
SR	100	100	100	100	100

Values (mean ± SE; n = 3) in the same row with different superscripts were significantly different (P < 0.05). IBW: initial body weight; FBW: final body weight; WGR: weight gain rate; SGR: specific growth rate; FCR: feed conversion ratio.

Results

Growth performance

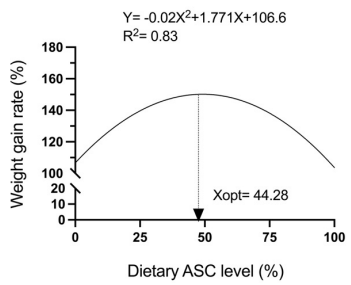

Fig.1 Regression analysis illustrating the relationship between attachments of suspension cage (ASC) content and Weight gain rate of *Apostichopus japonicus*.

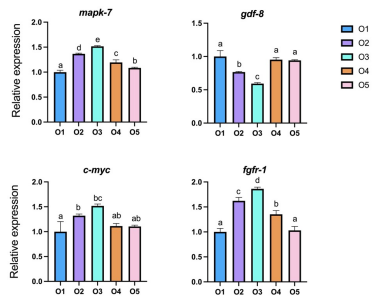

Fig.2 Effects of dietary attachments of suspension cage (ASC) on the expression of growth-related genes in *Apostichopus japonicus*. O1: 0% ASC, O2: 25% ASC, O3: 50% ASC instead, O4: 75% ASC, AND O5: 100% ASC instead of sea mud. A significant difference (P < 0.05) is indicated by values (mean ± SE) with different superscripts.

Intestinal structure

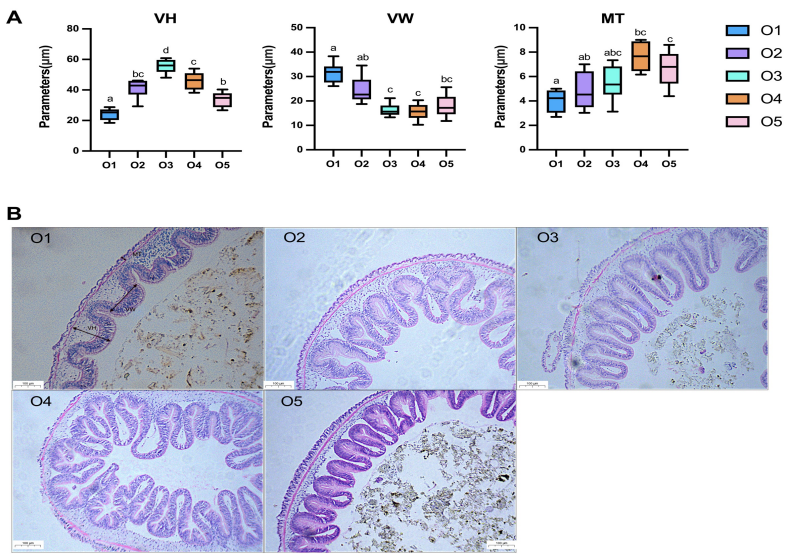

Fig. 3. Effect of replacement of sea mud with dietary attachments of suspension cage (ASC) on intestinal morphology of *Apostichopus japonicus*. (**A**) Midgut morphological characteristics of *A. japonicus* after receiving an experimental diet for 8 weeks. MT: muscle layer thickness, VH: villus height, VW: villus width. The error bar is min to max. Mean values with different superscripts are significantly different (P < 0.05). n = 10. (**B**) Effects of dietary ASC on the intestinal (midgut) morphology of *A. japonicus*. Magnification = 40×.

Intestinal flora

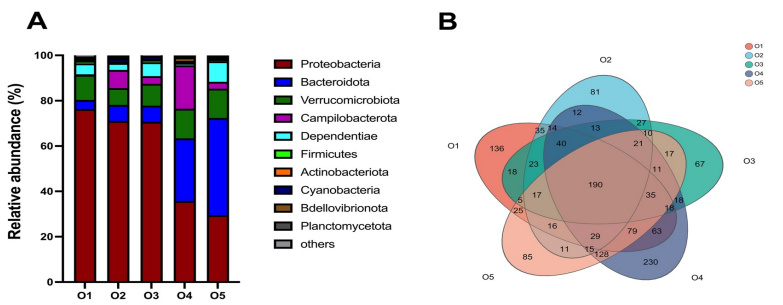

Fig. 4. Effect of replacement of sea mud with dietary attachments of suspension cage (ASC) on gut microflora of *Apostichopus japonicus*. (A) Venn diagram of bacterial community operational taxonomic unit (OTU) distribution in *A. japonicus* intestines. (B) Composition and relative phylum abundance levels for the dominant microbes in *Apostichopus japonicus* intestine. Data represent the mean values of nine *A. japonicus* samples.

Conclusion

Overall, this study has demonstrated that ASC represents a viable raw feed material for sea cucumbers. Specifically, the use of ASC promoted sea cucumber growth, reduced the feed coefficient, and positively influenced intestinal flora. According to the quadratic regression analysis for WGR, the appropriate levels of ASC substitution are estimated as to be 44.28%. Thus, the incorporation of ASC as a substitute for sea mud will significantly contribute to the development of new raw feed materials for sea cucumbers.