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Inventeur(s):

JIANG Senhao - Chine

43

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Mandataire(s):

Patent42 SA - 4081 Esch-sur-Alzette (Luxembourg)

47

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Titulaire(s):

YANCHENG TEACHERS UNIVERSITY - Yancheng,  
Jiangsu (Chine)

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**Sustained-release pellet feed for rapid growth period of southward transplanted *Apostichopus japonicus* and its preparation method.**

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The invention discloses a sustained-release pellet feed for the rapid growth period of southward transplanted *Apostichopus japonicus*, which is characterized in that the feed is prepared by mixing the following components in percentage by mass: 40%-50% of protein component composition, 6%-8% of lipid component composition and starch component, 15%-25% of starch component composition, 0.5%-0.6% of multi-vitamin, 0.7%-0.8% of multi-mineral salt, 20%-25% of functional component composition and 1.0%-1.5% of biological adhesive.

**DESCRIPTION**

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**Sustained-release pellet feed for rapid growth period of southward transplanted  
*Apostichopus japonicus* and its preparation method****TECHNICAL FIELD**

The invention relates to the field of marine culture, and in particular to a sustained-release pellet feed for the rapid growth period of southward transplanted *Apostichopus japonicus*, and a preparation method of the feed.

**BACKGROUND**

*Apostichopus japonicus* is one of the economic varieties of marine aquaculture in China. Due to the limitation of natural distribution, the traditional cultured areas of *A. japonicus* in China are mainly concentrated in the coastal areas around Liaodong and Shandong Peninsula, while the southern provinces mainly culture or catch other Holothurian species with relatively low economic value. In recent years, with the increase of market demand and considerable culturing benefits, there has been an upsurge of southward transplanted culture of *A. japonicus* in the east and south coastal areas of China (Jiangsu, Zhejiang, Fujian, Guangdong, Guangxi and Hainan, etc.). Southward transplanted culture refers that the culturing production of *A. japonicus* is carried out in the non-traditional producing areas and natural habitats along the coast of China's waters south of 35° north latitude. This method solves the problem of slow growth of *A. japonicus* in winter, and shortens the cultivation and marketing cycle of finished *A. japonicus*.

Spring and autumn are the rapid growth periods of southward transplanted *A. japonicus*. During this period, the demand for bait of southward transplanted *A. japonicus* continues to increase, and the natural bait can't meet its growth demand and production yield, so it is particularly necessary to supplement feeding. At the same time, in the early stage of rapid growth (after overwintering and aestivation), there are still some problems, such as weak physique of cultured *A. japonicus*, high requirements for feed nutrition supply level and supply continuity, etc. According to the ecological characteristics of culturing in the rapid growth period of southward transplanted *A. japonicus*, it is an effective method to develop the sustained-release pellet feed used in this period to obtain higher growth performance and yield, and to improve the culturing efficiency and economic benefits of southward transplanted *A. japonicus*.

**SUMMARY**

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In order to solve the above shortcomings in the prior art, the invention provides a sustained-release pellet feed which can effectively promote the digestion, absorption and utilization of nutrients by cultured animals, and improve the growth performance, cultivation yield and economic benefits of southward transplanted *Apostichopus japonicus*, and also discloses a preparation method of the feed.

The technical solution of the invention is: a sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus*, which is characterized in that the feed is prepared by mixing the following components in percentage by mass:

40%-50% of protein component composition, 6%-8% of lipid component composition, 15%-25% of starch component composition, 0.5%-0.6% of multi-vitamin, 0.7%-0.8% of multi-mineral salt, 20%-25% of functional component composition and 1.0%-1.5% of biological adhesive.

The protein component composition is composed of the following components in percentage by mass: 40%-55% of protein nutrition enhancing composition, 15%-25% of *Hizikia fusiforme* powder, 5%-8% of *Porphyra* powder, 15%-20% of *Suaeda* powder, 5%-6% of shrimp head powder and 2% -3% of *Mytilus* powder;

the protein nutrition enhancing composition is prepared by mixing the following components according to the mass ratio:

*Gracilaria* powder: *Salicornia* powder: flounder hemline powder: *Nereis* powder=5:3:2:2.

The lipid component composition is prepared by mixing the following components according to the mass ratio:

fish oil: palm oil: *Suaeda* seed oil =2:3:1.

The starch component composition is prepared by mixing the following components in percentage by mass: 40%-55% of bread crumbs, 25%-40% of biscuit crumbs and 15%-30% of corn germ powder.

The functional component composition is prepared by mixing the following components in percentage by mass: 5%-8% of *Sepia* visceral mass powder, 2%-3% of soy sauce residue powder, 20%-25% of digestion and absorption promoting composition, 60%-65% of bottom mud powder and 5% of *Sepia* inner shell powder;

the digestion and absorption promoting composition is prepared by mixing the following components according to the mass ratio: LU502646

hawthorn residue powder: orange peel powder: *Alpinia Katsamdai* powder =7:3:2.

The biological adhesive is prepared by mixing the following components according to the mass ratio: fish scale gelatin powder: locust bean gum powder =3:1.

A preparation method of sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus*, characterized in that:

superfine comminution of solid feed ingredients are carried out by 200-300 meshes, the pulverized ingredients are stirred and evenly mixed, then 55°C distilled water accounting for 20% of the solid ingredients is added to cure them, and lipid components accounting for 6%-8% of the solid ingredients are added in the curing process; the lipid component is prepared by mixing fish oil, palm oil and *Suaeda* seed oil according to the mass ratio of 2:3:1; after continuous stirring, it is extruded into crumby structure, and the materials are put into a granulator to prepare cylindrical pellet feed with a diameter of 3 mm-5 mm and a water content of 10%-12%; after sealing and packaging, the finished sustained-release pellet feed is prepared.

Compared with the existing technology, the invention has the following advantages:

The sustained-release pellet feed disclosed by the invention can provide high-level, special and continuous nutrition supply for the southward transplanted *A. japonicus* in the rapid growth period in spring and autumn, obviously improve the growth rate, body-wall weight ratio and other production performance of the southward transplanted *A. japonicus* in this specific period, and ensure the good aquaculture production effect in the rapid growth period. The protein nutrition-enhancing composition in the feed can provide high-level and enhanced nutrition supply for the southward transplanted *A. japonicus* in the rapid growth period, which significantly improves the production performance of southward transplanted *A. japonicus* in this period. However, specific components of promoting digestion and absorption can significantly enhance the digestion and absorption capacity of southward transplanted *A. japonicus* in the rapid growth period, and promote the improvement of the production performance of cultured animals. Meanwhile, the specific combination components of biological adhesive, through the scientific proportion and addition of biological adhesive, make the pellet feed of the invention obtain good sustained-release property, effectively prolong the feeding time of southward transplanted *A. japonicus* to feed, and improve the feed utilization rate.

The feed of the invention has simple preparation method and strong standardization and operability of technical process. Good palatability can be achieved through a single maturation technology, and the feed has a strong food attraction effect, so that the aggregation and tendency of southward transplanted *A. japonicus* to the feed of the invention are obvious. The main materials of this feed are pure natural animal and plant components, which will not cause eutrophication or chemical pollution of aquaculture water and surrounding sea areas during use, and it is a green and environment-friendly feed.

### DESCRIPTION OF THE INVENTION

The specific embodiments of the present invention will be described below.

A sustained-release pellet feed for the rapid growth period of southward transplanted *Apostichopus japonicus* is prepared by mixing the following components in percentage by mass:

40%-50% of protein component composition, 6%-8% of lipid component composition, 15%-25% of starch component composition, 0.5%-0.6% of multi-vitamin, 0.7%-0.8% of multi-mineral salt, 20%-25% of functional component composition and 1.0%-1.5% of biological adhesive.

The protein component composition is composed of the following components in percentage by mass: 40%-55% of protein nutrition enhancing composition, 15%-25% of *Hizikia fusiforme* powder, 5%-8% of *Porphyra* powder, 15%-20% of *Suaeda* powder, 5%-6% of shrimp head powder and 2% -3% of *Mytilus* powder;

the protein nutrition enhancing composition is prepared by mixing the following components according to the mass ratio:

*Gracilaria* powder: *Salicornia* powder: flounder hemline powder: *Nereis* powder=5:3:2:2.

The lipid component composition is prepared by mixing the following components according to the mass ratio:

fish oil: palm oil: *Suaeda* seed oil =2:3:1.

The starch component composition is prepared by mixing the following components in percentage by mass: 40%-55% of bread crumbs, 25%-40% of biscuit crumbs and 15%-30% of corn germ powder.

The functional component composition is prepared by mixing the following components in percentage by mass: 5%-8% of *Sepia* visceral mass powder, 2%-3% of soy sauce residue powder,

20%-25% of digestion and absorption promoting composition, 60%-65% of bottom mud powder LU502646 and 5% of *Sepia* inner shell powder;

the digestion and absorption promoting composition is prepared by mixing the following components according to the mass ratio:

Hawthorn residue powder: orange peel powder: *Alpinia Katsamдай* powder =7:3:2.

The biological adhesive is prepared by mixing the following components according to the mass ratio: fish scale gelatin powder: locust bean gum powder =3:1.

A preparation method of sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus*, characterized in that: superfine comminution of solid feed ingredients are carried out by 200-300 meshes, the pulverized ingredients are stirred and evenly mixed, then 55°C distilled water accounting for 20% of the solid ingredients is added to cure them, and lipid components accounting for 6%-8% of the solid ingredients are added in the curing process; the lipid component is prepared by mixing fish oil, palm oil and *Suaeda* seed oil according to the mass ratio of 2:3:1; after continuous stirring, it is extruded into crumbly structure,, and the materials are put into a granulator to prepare cylindrical pellet feed with a diameter of 3 mm-5 mm and a water content of 10%-12%; after sealing and packaging, the finished sustained-release pellet feed is prepared.

#### Embodiment 1

To prepare the sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus*, the feed is prepared according to the proportion of 46% of protein component composition, 6.6% of lipid component composition, 20% of starch component composition, 0.5% of multi-vitamin, 0.7% of multi-mineral salt, 25% of functional component composition and 1.2% of biological adhesive component composition.

Protein component composition includes: 9% of *Hizikia fusiforme* powder (9% of the total mass, the same below), *Porphyra* powder 3%, 6% of *Suaeda* powder, 3% of shrimp head powder, 1% of *Mytilus* powder, and 24% of protein nutrition enhancing composition, while protein nutrition enhancing composition includes 10% of *Gracilaria* powder, 6% of *Salicornia*, 4% of flounder hemline powder and 4% of *Nereis* powder.

The lipid composition includes: 2.2% of fish oil (2.2% of the total mass, the same below), 3.3% of palm oil and 1.1% of *Suaeda* seed oil;

the starch composition includes: bread crumbs 10% (10% of the total mass, the same below),  
biscuit crumbs 6% and corn germ powder 4%. LU502646

The functional composition includes: 2% of *Sepia* viscera powder (2% of the total mass, the same below), 0.5% of soy sauce residue powder, 6% of specific composition for promoting digestion and absorption, 15% of bottom mud powder and 1.5% of *Sepia* inner shell powder; the specific composition for promoting digestion and absorption includes 3.5% of hawthorn residue powder, 1.5% of orange peel powder and 1% of *Alpinia Katsamdai* powder .

The biological adhesive composition includes: 0.9% of fish scale gelatin powder (0.9% of the total mass, the same below) and 0.3% of locust bean gum powder. According to the preparation method of the invention, the feed A is prepared by using the above ingredients.

Take the invented feed A for culturing contrast experiment:

The experiment lasted for 8 weeks and is carried out in the experimental enclosure of mariculture pond in spring. Enclosures are made of polyethylene mesh with a pore diameter of 0.5 cm, with an area of 16 m<sup>2</sup>/ind. (length× width =4 m×4 m), and each group deals with three parallel enclosures. The initial body mass of the experimental southward transplanted *A. japonicus* is 10.43±0.12 g, and stocking density is 5 ind./m<sup>2</sup>. The experimental southward transplanted *A. japonicus* are fed with the feed A, the formula feed B, the formula feed C and the formula feed D respectively, once a day at 17:00, and the daily feeding amount is calculated according to 6%-8% of the body weight of the cultured southward transplanted *A. japonicus*.

Formula feed B, formula feed C and formula feed D here are common commercial formula feeds.

Ingredient and proportion of formula feed B: 30 kg of *Sargassum thunbergii* powder, 22 kg of *Sargassum Pallidum* powder, 10 kg of degummed brown algae powder, 5 kg of fish powder, 4 kg of shrimp powder, 6 kg of soybean protein powder, 1.5 kg of shell powder, 0.6 kg of multi-vitamins, 0.9 kg of multi-minerals, 20 kg of sea mud powder (per 100 kg dry matter).

Ingredient and proportion of formula feed C: 30 kg of degummed kelp powder, 22 kg of *Sargassum Pallidum* powder, 14 kg of *Ulva pertusa* powder, 5 kg of fish powder, 5 kg of flour, 2.0 kg of shell powder, 0.5 kg of multi-vitamins, 0.5 kg of multi-minerals and 21 kg of sea mud powder (per 100 kg of dry matter).

Ingredient and proportion of formula feed D: 48 kg of *Sargassum thunbergii* powder, 22 kg of *Sargassum Pallidum* powder, 4 kg of *Spirulina* powder, 3 kg of oyster shell powder, 2 kg of

*Rhodotorula benthica* powder, 0.5 kg of multi-vitamins, 0.5 kg of multi-minerals and 20 kg of sea mud powder (per 100 kg of dry matter). LU502646

During the experiment, the water temperature of the pond is 12.2°C-22.5°C, the salinity is 26.8-33.2, the pH value is 8.0±0.3, the dissolved oxygen content is 6.28 mg/L-9.75 mg/L, and the ammonia nitrogen concentration is 0.06 mg/L-0.16 mg/L. The experimental results are shown in Table 1.

Table 1 Experimental results of feeding southward transplanted *A. japonicus* with different formula feeds (Embodiment 1)

Item	Invented feed A	Formula feed B	Formula feed C	Formula feed D
Daily specific growth rate	1.83 ± 0.27 <sup>a</sup>	1.12 ± 0.19 <sup>c</sup>	0.87 ± 0.15 <sup>c</sup>	1.59 ± 0.13 <sup>b</sup>
Wall body weight ratio	63.2 ± 1.5	60.5 ± 1.4	59.4 ± 2.3	62.8 ± 2.0
Survival rate	97.2 ± 2.4	95.7 ± 3.1	92.6 ± 4.6	93.5 ± 3.3
Feed coefficient	1.07 ± 0.05 <sup>a</sup>	1.39 ± 0.04 <sup>b</sup>	1.68 ± 0.07 <sup>c</sup>	1.37 ± 0.06 <sup>b</sup>
Protease activity	2.88 ± 0.06 <sup>a</sup>	1.65 ± 0.08 <sup>c</sup>	1.57 ± 0.05 <sup>c</sup>	2.21 ± 0.06 <sup>b</sup>
Lipase activity	0.38 ± 0.03 <sup>a</sup>	0.25 ± 0.04 <sup>b</sup>	0.21 ± 0.02 <sup>b</sup>	0.27 ± 0.04 <sup>b</sup>

Note: Daily specific growth rate, %·d<sup>-1</sup>; Wall body weight ratio, %; Survival rate, %; the protease activity is 1μg tyrosine produced by hydrolyzing casein per minute, which is one enzyme activity unit, μg/min; the lipase activity is 1μmol fatty acid produced by catalysis per minute, which is 1 enzyme activity unit, μmol/min.

#### Embodiment 2

To prepare the sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus*, the feed is prepared according to the proportion of 50% of protein component composition, 6% of lipid component composition, 16.5% of starch component composition, 0.6% of multi-vitamins, 0.7% of multi-mineral salt, 25% of functional component composition and 1.2% of biological adhesive component composition.

Among them, the protein component composition includes: 27% of protein nutrition enhancing combination (27% of the total mass, the same below), 10% of *Hizikia fusiforme* powder, 2% of *Porphyra* powder, 7.5% of *Suaeda* powder, 2.5% of shrimp head powder and 1%

of *Mytilus* powder; the nutritional enhancement combination of protein includes 11.2% of *Gracilaria* powder, 6.8% of *Salicornia*, 4.5% of flounder hemline powder and 4.5% of *Nereis* powder.

The lipid composition comprises: 2% of fish oil (2% of the total mass, the same below), 3% of palm oil and 1% of *Suaeda* seed oil.

The starch composition comprises 8% of bread crumb powder (8% of the total mass, the same below), 5% of biscuit crumb powder and 3.5% of corn germ powder.

The functional composition includes: 1.8% of *Sepia* viscera powder (1.8% of the total mass, the same below), 0.6% of soy sauce residue powder, 6% of specific composition for promoting digestion and absorption, 15% of bottom mud powder and 1.6% of *Sepia* inner shell powder; the specific composition for promoting digestion and absorption comprises 3.5% of hawthorn residue powder, 1.5% of orange peel powder and 1% of *Alpinia Katsamdai* powder.

The specific biological adhesive composition comprises: 0.9% of fish scale gelatin powder (0.9% of the total mass, the same below) and 0.3% of locust bean gum powder.

According to the preparation method of the invention, the feed E is prepared by using the above ingredients.

To prepare the sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus*, the feed is prepared according to the proportion of 42% of protein component composition, 6% of lipid component composition, 25% of starch component composition, 0.6% of multi-vitamin, 0.7% of multi-mineral salt, 24.5% of functional component composition and 1.2% of biological adhesive.

Among them, the protein component composition includes: 16.8% of protein nutrition enhancing combination (16.8% of the total mass, the same below), 10.5% of *Hizikia fusiforme* powder, 3.2% of *Porphyra* powder, 8% of *Suaeda* powder, 2.5% of shrimp head powder and 1% of *Mytilus* powder; the nutritional enhancement combination of protein includes *Gracilaria* powder 7%, *Salicornia* 4.2%, flounder hemline powder 2.8% and *Nereis* powder 2.8%.

The lipid component composition comprises: 2% of fish oil (2% of the total mass, the same below), 3% of palm oil and 1% of *Suaeda* seed oil.

The starch component composition comprises 12% of bread crumb powder (12% of the total mass, the same below), 8% of biscuit crumb powder and 5% of corn germ powder.

The functional composition includes: 1.9% of *Sepia* viscera powder (1.9% of the total mass, LU502646 the same below), 0.7% of soy sauce residue powder, 4.9% of specific composition for promoting digestion and absorption, 15% of bottom mud powder and 2.0% of *Sepia* inner shell powder; the specific composition for promoting digestion and absorption comprises 2.9% of hawthorn residue powder, 1.2% of orange peel powder and 0.8% of *Alpinia Katsamdai* powder .

The specific biological adhesive composition comprises: 0.9% of fish scale gelatin powder (0.9% of the total mass, the same below) and 0.3% of locust bean gum powder.

According to the preparation method of the invention, the feed F is prepared by using the above raw materials.

A comparative sustained-release pellet feed is prepared, and the feed is prepared according to the proportion of 42% of protein component composition, 6% of lipid component composition, 25% of starch component composition, 0.6% of multi-vitamin, 0.7% of multi-mineral salt, 24.5% of functional component composition and 1.2% of biological adhesive.

Among them, the protein component composition comprises: *Hizikia fusiforme* powder 17.5% (17.5% of the total mass, the same below), *Porphyra* powder 3.2%, *Suaeda* powder 12.2%, shrimp head powder 5.3% and *Mytilus* powder 3.8%.

The lipid component composition comprises: 2% of fish oil (2% of the total mass, the same below), 3% of palm oil and 1% of *Suaeda* seed oil.

The starch component composition comprises: 12% of bread crumb powder (12% of the total mass, the same below), 8% of biscuit crumb powder and 5% of corn germ powder.

The functional component composition comprises: 3% of *Sepia* viscera powder (3% of the total mass, the same below), 1% of soy sauce residue powder, 17% of bottom mud powder and 3.5% of *Sepia* inner shell powder.

The biological adhesive component composition comprises 0.9% of fish scale gelatin powder (0.9% of the total mass, the same below) and 0.3% of locust bean gum powder.

According to the preparation method of the invention, the comparative sustained-release pellet feed G is prepared by using the above ingredients.

Take the finished feed for culturing contrast experiment;

the experiment lasted for 8 weeks and is carried out in the experimental enclosure of mariculture pond in autumn. Enclosures are made of polyethylene mesh with a pore diameter of 0.5 cm, with an area of 16 m<sup>2</sup>/ind. (length×width =4 m×4 m), and each group deals with three

parallel enclosures. The initial body mass of experimental southward transplanted *A. japonicus* is 15.03±0.28 g, and stocking density is 5 ind./m<sup>2</sup>. The experimental *A. japonicus* were fed with invented feed E, formula feed F and formula feed G respectively, once a day at 17:00, and the daily feeding amount is calculated according to 6%-8% of the body weight of the cultured animals. The pond water temperature is 22.1°C-11.4°C, salinity is 28.3-32.6, pH is 8.1±0.5, dissolved oxygen is 7.42 mg/L-9.98 mg/L, and the concentration of ammonia nitrogen is 0.04 mg/L-0.19 mg/L. The experimental results are shown in Table 2.

Table 2 Experimental results of feeding southward transplanted *A. japonicus* with different formula feeds (Embodiment 2)

Item	Invented feed E	Invented feed F	Formula feedG
Daily specific growth rate	1.86 ± 0.13 <sup>a</sup>	1.75 ± 0.24 <sup>a</sup>	1.22 ± 0.35 <sup>b</sup>
Wall body weight ratio	63.2 ± 2.2	61.4 ± 1.8	58.4 ± 2.7
Survival rate	95.3 ± 3.1	98.1 ± 2.6	92.7 ± 4.2
Feed coefficient	1.08 ± 0.07 <sup>a</sup>	1.10 ± 0.05 <sup>a</sup>	1.61 ± 0.08 <sup>b</sup>
Protease activity	2.93 ± 0.05 <sup>a</sup>	2.77 ± 0.08 <sup>a</sup>	1.63 ± 0.04 <sup>b</sup>
Lipase activity	0.42 ± 0.04	0.35± 0.06	0.27 ± 0.03

Note: Daily specific growth rate, %·d<sup>-1</sup>; Wall body weight ratio, %; Survival rate, %; The protease activity is 1μg tyrosine produced by hydrolyzing casein per minute, which is one enzyme activity unit, μg/min; The lipase activity is 1μmol fatty acid produced by catalysis per minute, which is 1 enzyme activity unit, μmol/min.

### Embodiment 3

According to the material formula, proportion and preparation method of Embodiment 1 of the invention, the invented feed A is prepared.

To prepare non-sustained-release pellet feed, the feed is prepared according to the proportion of 46% of protein component composition, 6.6% of lipid component composition, 21.2% of starch component composition, 0.5% of multi-vitamin, 0.7% of multi-mineral salt, 25% of functional component composition and 1.2% of biological adhesive.

Among them, the protein component composition comprises: 24% of protein nutrition enhancing composition (24% of the total mass, the same below), 9% of *Hizikia fusiforme* powder,

3% of *Porphyra* powder, 6% of *Suaeda* powder, 3% of shrimp head powder and 1% of *Mytilus* powder; the protein component composition comprises 10% of *Gracilaria* powder, 6% of *Salicornia*, 4% of flounder hemline powder and 4% of *Nereis* powder;

The lipid component composition comprises: 2.2% of fish oil (2.2% of the total mass, the same below), 3.3% of palm oil and 1.1% of *Suaeda* seed oil;

The starch component composition comprises: 11% of bread crumb powder (11% of the total mass, the same below), 6% of biscuit crumbs powder and 4.2% of corn germ powder;

The functional composition includes: 2% of *Sepia* viscera powder (2% of the total mass, the same below), 0.5% of soy sauce residue powder, 6% of specific composition for promoting digestion and absorption, 15% of bottom mud powder and 1.5% of *Sepia* inner shell powder; the specific composition for promoting digestion and absorption includes: hawthorn residue powder 3.5%, orange peel powder 1.5% and *Alpinia Katsamdai* powder 1%.

According to the preparation method of the invention, the non-sustained-release comparative pellet feed I is prepared by using the above ingredients.

Take the finished feed for culturing contrast experiment;

The experiment lasted for 8 weeks and is carried out in the indoor controllable aquaculture research system. The experimental southward transplanted *A. japonicus* is cultured in PVC flume with a diameter of 1.0 m and a volume of 0.8 t, with three parallel flumes in each group. The initial body weight of the cultured animals is  $5.35 \pm 0.12$  g, and the culture density is 20 ind./m<sup>3</sup>. The experimental *A. japonicus* is fed with the feed A of the invention and the comparative feed I respectively, once a day at 17:00, with the daily feeding amount accounting for 8% of the body weight of the cultured animals, and cleaned and changed with water twice a week. During the experiment, the physical and chemical conditions of aquaculture pond water quality in the fast growing period are simulated. Air pump is used for aeration, the water temperature is controlled at 15°C-18°C, the salinity fluctuated from 27.8-32.1, the average pH value is  $7.9 \pm 0.3$ , and the ammonia nitrogen concentration varied from 0.02 mg/L-0.10 mg/L. The experimental results are shown in Table 3.

Table 3 Experimental results of feeding southward transplanted *A. japonicus* with sustained-release and non-sustained-release pellet feed (Embodiment 3)

Item	Invented feed A	Non-sustained-release pellet feed I
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Daily specific growth rate	2.03 ± 0.27 <sup>a</sup>	1.28 ± 0.15 <sup>b</sup>	LU502646
Wall body weight ratio	63.6 ± 1.5	61.8 ± 2.3	
Survival rate	98.4 ± 1.3	97.2 ± 2.6	
Feed dissolution rate 12 h	1.7 ± 0.2 <sup>a</sup>	12.4 ± 1.2 <sup>b</sup>	
Feed dissolution rate 24 h	5.3 ± 0.5 <sup>a</sup>	37.8 ± 1.4 <sup>b</sup>	
Feed dissolution rate 36 h	23.6 ± 1.3 <sup>a</sup>	68.9 ± 2.1 <sup>b</sup>	
Feed coefficient	1.10 ± 0.05 <sup>a</sup>	1.76 ± 0.06 <sup>b</sup>	
Aggregation rate	12.3 ± 2.5 <sup>a</sup>	5.9 ± 1.2 <sup>b</sup>	

Note: Daily specific growth rate, %·d<sup>-1</sup>; Wall body weight ratio, %; Survival rate, %; Feed dissolution rate, %; Aggregation rate, %.

The results of Table 1 show that, compared with other formula feeds, the growth rate of southward transplanted *A. japonicus* under the feed condition of the present invention is obviously faster, the activity of digestive enzymes (protease and lipase) is significantly higher, and the feed coefficient is significantly lower. The feed provided by the invention is a high-quality feed which may be used in the rapid growth period of southward transplanted *A. japonicus* in spring and autumn;

The results of Table 2 show that the growth rate and digestive enzyme (protease) activity of *A. japonicus* fed with this feed are significantly higher than those of formula feed G, while its feed coefficient is significantly lower than that of formula feed G. This is mainly due to the fact that the formula feed G doesn't contain the specific combination components of protein nutrition enhancement and digestion and absorption promotion. The relevant results fully reflect the positive promotion and guarantee effects of the specific combination components in the feed of the invention on the production performance of southward transplanted *A. japonicus* in the rapid growth period;

The results of Table 3 show that the feed of the present invention has a good sustained-release effect, and it can keep a low dissolution rate in the aquaculture water within 24 h, which is in line with the feeding characteristics and rules of southward transplanted *A.*

*japonicus*. Meanwhile, the feed coefficient of the invention is low, the aggregation rate of southward transplanted *A. japonicus* is high, the tendency is strong and utilization rate is high.

The above cultured comparative experiments show that the feed of the invention can provide high-level, effective and continuous nutrition supply for the southward transplanted *A. japonicus* in the rapid growth period in spring and autumn. Compared with other formula feeds, the feed of the invention can obviously improve the production performance of southward transplanted *A. japonicus* in a special growth period; the combination of protein nutrition enhancement and specific combination of promoting digestion and absorption in feed can obviously promote the growth performance and digestion and absorption ability of southward transplanted *A. japonicus*. The specific combination of biological adhesives makes the feed of the invention obtain good sustained release property, and together with strong attractant function (high aggregation rate), so that the feed realizes the sustained and effective nutrition supply to the southward transplanted *A. japonicus*, and ensure a good culture production effect; the preparation method of the feed of the invention is simple, the ingredients are pure natural animal and plant component, and the feed is a green and environment-friendly product. The feed provided by the invention is a high-quality sustained-release pellet feed which can be used in the rapid growth period of southward transplanted *A. japonicus*.

## CLAIMS

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1. A sustained-release pellet feed for the rapid growth period of southward transplanted *Apostichopus japonicus*, characterized in that the feed is prepared by mixing the following components in percentage by mass:

40%-50% of protein component composition, 6%-8% of lipid component composition, 15%-25% of starch component composition, 0.5%-0.6% of multi-vitamin, 0.7%-0.8% of multi-mineral salt, 20%-25% of functional component composition and 1.0%-1.5% of biological adhesive.

2. The sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus*, according to 1, characterized in that the protein component composition is composed of the following components in percentage by mass: 40%-55% of protein nutrition enhancing composition, 15%-25% of *Hizikia fusiforme* powder, 5%-8% of *Porphyra* powder, 15%-20% of *Suaeda*, 5%-6% of shrimp head powder and 2%-3% of *Mytilus* powder;

the protein nutrition enhancing composition is prepared by mixing the following components according to the mass ratio:

*Gracilaria* powder: *Salicornia* powder: flounder hemline powder: *Nereis* powder=5:3:2:2.

3. The sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus* according to 1, characterized in that the lipid component composition is prepared by mixing the following components according to the mass ratio:

fish oil: palm oil: *Suaeda* seed oil =2:3:1.

4. The sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus* according to 1, characterized in that the starch component composition is prepared by mixing the following components in percentage by mass: 40%-55% of bread crumbs, 25%-40% of biscuit crumbs and 15%-30% of corn germ powder.

5. The sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus* according to 1, is characterized in that the functional component composition is prepared by mixing the following components in percentage by mass: 5%-8% of *Sepia* visceral mass powder, 2%-3% of soy sauce residue powder, 20%-25% of digestion and absorption promoting composition, 60%-65% of bottom mud powder and 5% of *Sepia* inner shell powder;

the digestion and absorption promoting composition is prepared by mixing the following components according to the mass ratio:

hawthorn residue powder: orange peel powder: *Alpinia Katsamdai* powder =7:3:2.

LU502646

6. The sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus* according to 1, is characterized in that the biological adhesive is prepared by mixing the following components according to the mass ratio: fish scale gelatin powder: locust bean gum powder =3:1.

7. A preparation method of sustained-release pellet feed for the rapid growth period of southward transplanted *A. japonicus* according to 1, characterized in that: superfine comminution of solid feed ingredients are carried out by 200-300 meshes, the pulverized ingredients are stirred and evenly mixed, then 55°C distilled water accounting for 20% of the solid ingredients is added to cure them, and lipid components accounting for 6%-8% of the solid ingredients are added in the curing process; the lipid component is prepared by mixing fish oil, palm oil and *Suaeda* seed oil according to the mass ratio of 2:3:1; after continuous stirring, it is extruded into crumby structure, and the materials are put into a granulator to prepare cylindrical pellet feed with a diameter of 3 mm-5 mm and a water content of 10%-12%; after sealing and packaging, the finished sustained-release pellet feed is prepared.

## PATENTANSPRÜCHE

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1. Eine Pelletszuführung mit anhaltender Freisetzung für die schnelle Wachstumsphase von nach Süden verpflanztem *Apostichopus japonicus*, dadurch gekennzeichnet, dass die Zuführung durch Mischen der folgenden Komponenten in Massenprozent hergestellt wird:

40%-50% Zusammensetzung der Proteinkomponente, 6%-8% Zusammensetzung der Lipidkomponente, 15%-25% Zusammensetzung der Stärkekomponente, 0,5%-0,6% Multivitamin, 0,7%-0,8% Multimineralsalz, 20%-25% Zusammensetzung der funktionellen Komponente und 1,0%-1,5% biologischen Klebstoffs.

2. Die Pelletszuführung mit anhaltender Freisetzung für die schnelle Wachstumsphase von nach Süden verpflanztem *A. japonicus* gemäß 1, dadurch gekennzeichnet, dass die Zusammensetzung der Proteinkomponente sich aus den folgenden Bestandteilen in Massenprozent zusammensetzt: 40%-55% Zusammensetzung zur Verbesserung der Proteinnahrung, 15%-25% *Hizikia fusiforme* Pulver, 5%-8% *Porphyra* Pulver, 15%-20% *Suaeda*, 5%-6% Garnelenkopf-Pulver und 2%-3% *Mytilus* Pulver;

die Zusammensetzung zur Verbesserung der Proteinnahrung wird durch Mischen der folgenden Komponenten nach dem Massenverhältnis hergestellt:

*Gracilaria*-Pulver: *Salicornia*-Pulver: Flundersaum-Pulver: *Nereis*-Pulver=5:3:2:2.

3. Die Pelletszuführung mit anhaltender Freisetzung für die schnelle Wachstumsphase von nach Süden verpflanztem *A. japonicus* gemäß 1, dadurch gekennzeichnet, dass die Zusammensetzung der Lipidkomponente durch Mischen der folgenden Komponenten entsprechend dem Massenverhältnis hergestellt wird:

Fischöl: Palmöl: *Suaeda*-Samenöl =2:3:1.

4. Die Pelletszuführung mit anhaltender Freisetzung für die schnelle Wachstumsphase von nach Süden verpflanztem *A. japonicus* gemäß 1, dadurch gekennzeichnet, dass die Zusammensetzung der Stärkekomponente durch Mischen der folgenden Komponenten in Massenprozent hergestellt wird: 40%-55% Brotkrümel, 25%-40% Kekskrümel und 15%-30% Maiskeimpulver.

5. Die Pelletszuführung mit anhaltender Freisetzung für die schnelle Wachstumsphase von nach Süden verpflanztem *A. japonicus* gemäß 1, dadurch gekennzeichnet, dass die Zusammensetzung der funktionellen Komponente durch Mischen der folgenden Komponenten in Massenprozent hergestellt wird: 5%-8% *Sepia*-Viszeralmasse-Pulver, 2%-3%

Sojasoßenrückstandspulver, 20%-25% Zusammensetzung zum Fördern der Verdauung und Absorption, 60%-65% Bodenschlammpulver und 5% *Sepia*-Innenschalenpulver; LU502646

die Zusammensetzung zum Fördern der Verdauung und Absorption wird durch Mischen der folgenden Komponenten entsprechend dem Massenverhältnis hergestellt:

Weißdornrestepulver: Orangenschalenpulver: *Alpinia Katsamdai*-Pulver = 7:3:2.

6. Die Pelletszuführung mit anhaltender Freisetzung für die schnelle Wachstumsphase von nach Süden verpflanztem *A. japonicus* gemäß 1, dadurch gekennzeichnet, dass der biologische Klebstoff durch Mischen der folgenden Komponenten entsprechend dem Massenverhältnis hergestellt wird: Fischschuppengelatinepulver: Johannisbrotkernmehl = 3:1.

7. Ein Verfahren zur Herstellung der Pelletszuführung mit anhaltender Freisetzung für die schnelle Wachstumsphase von nach Süden verpflanztem *A. japonicus* gemäß 1, dadurch gekennzeichnet, dass die Feinstzerkleinerung von festen Futtermitteln mit 200-300 Maschen erfolgt, die pulverisierten Futtermittel gerührt und gleichmäßig gemischt werden, dann 55°C destilliertes Wasser, ausmachend 20% der festen Futtermittel, zur Aushärtung der hinzugefügt wird, und Lipidkomponenten, ausmachend 6-8% der festen Futtermittel, während des Aushärtungsprozesses hinzugefügt werden; die Lipidkomponente wird durch Mischen von Fischöl, Palmöl und *Suaeda*-Samenöl im Massenverhältnis 2:3:1 hergestellt; nach ständigem Rühren wird es zu einer krümeligen Struktur extrudiert, und die Materialien werden in einen Granulator gegeben, um zylindrische Pelletszuführung mit einem Durchmesser von 3 mm-5 mm und einem Wassergehalt von 10-12% herzustellen; nach dem Versiegeln und Verpacken wird die fertige Pelletszuführung mit anhaltender Freisetzung hergestellt.