Svetlana MAXIMOVA, Ekaterina SHADRINA, Ekatrerina PANCHISHINA

Far Eastern State Technical Fisheries University, Vladivostok, Russia

The sea stars of the Sea of Japan as a potential raw material in the technology of fodder products

Summary

The materials substantiating the urgency of the developed technology of the sea stars as a fodder additive are presented. Appropriateness of the sea stars usage as the valuable raw materials for industrial processing in feed technology is confirmed. Quality control of finished products showed that the new fodder additive will permit to expand assortment of fodder products from non-traditional raw materials, and can be recommended in the diet of agricultural poultry.

Key words: *sea stars, toxicity, technology, direct drying, fermentolysis, fodder additive, quality, safety*

Rozgwiazdy pochodzące z Morza Japońskiego, jako potencjalny surowiec w technologii produktów paszowych

Streszczenie

W pracy przedstawiono celowość opracowania technologii stosowania rozgwiazd, jako dodatków paszowych. Potwierdzono korzystny wpływ wykorzystania rozgwiazd, jako cennego surowca mającego zastosowanie w technologii pasz. Na podstawie kontroli jakości produktu końcowego można stwierdzić, że ten nowy dodatek może rozszerzyć asortyment niekonwencjonalnych surowców stosowanych jako dodatki paszowe i może być rekomendowany w żywieniu drobiu.

Słowa kluczowe: *rozgwiazdy, toksyczność, technologia, suszenie bezpośrednia, dodatek paszowy, jakość, bezpieczeństwo*

Introduction

Sea stars (the class of echinoderms) are benthic organisms living at depths where they play an important role in biological communities. Stars are the orderlies of the sea, they eat dead animals. However, some of them are predators, which are dangerous for other aquatic biological objects, as well as their own kind. In connection with the development of mariculture, these predatory echinoderms accumulate in large numbers near sea gardens. Thus, in the bay of the Northern Slavic Gulf of the Sea of Japan, a mass accumulation of sea stars destroys the sea gardens of FGBOU VO "Dalrybvtuz" for breeding scallops (*Pectinidae*) and trepang (*Apostichopus japonicas*). The spread of sea stars in the North is the reason for the difficulty of growing valuable aquatic biological objects and disturbing the natural balance of the ecosystem. In connection with the foregoing, the question of studying the sea stars of the Sea of Japan and the methods of their industrial processing is relevant at the present time (Shadrina, 2014).

The purpose of the present research of employees and students of Dalrybvtuz is to substantiate and develop the technology of biologically valuable fodder products from sea stars of the Sea of Japan. The work was carried out in several stages, during which the following tasks were solved:

· determination of the species and chemical composition of sea stars common in the northern part of the Khasansky district of the Primorye Territory;

· assessment of toxicity and safety indicators of the biological objects under study

· comparative characteristics of obtaining fodder products in ways: direct drying and enzymatic processing of raw materials;

· quality assessment of finished products.

Materials and methods of investigation

Objects of research: sea stars, fodder products. Experimental samples of fodder additives were obtained in laboratory conditions by processing the investigated raw material, taken in a natural ratio. Protozubtilin (120 PU/g), Collagenase (165 PE/g), Protamex (400 PE/g), drinking water (SanPiN 2.1.4.1074) were used as auxiliary materials.

Drying of the samples was carried out on an electric drier of infrared radiation "ESBIK-1,25/220" "Ikar" with air convection, at a temperature of 50-55°C. Investigation of the chemical composition of the samples was carried out according to standard methods in accordance with GOST 7636-85. The mass fraction of lipids was determined by the method of Bligh and Dyer (Bligh, 1959). Determination of the content of macro- and microelements and toxic metals in the samples was carried out in accordance with GOST: 26927, 26929, 26930, 26932, 26933, 30178, 30538, P 51301 on the atomic absorption spectrophotometer of the firm "Nippon Jarell Ach" model AA-885. As an atomizer, a single-alkaline burner and an acetylene-air flame were used. Assessment of the quality of organoleptic, physico-chemical and veterinary-sanitary indicators of the feed additive was carried out in

accordance with the Unified Veterinary (Veterinary and Sanitary) requirements and GOST 2116-2000.

Biotesting of the test samples was carried out using the ciliated infusoria *Tetrahymena pyriformis*. The indicator of the Relative biological value was determined by the ratio of the number of ciliate cells grown on the experimental product to the number of infusoria grown on the control product expressed as a percentage. In testing, it was taken into account that the toxicity of the tested subjects was determined by the following main indicators: the behavior and the nature of cell growth. The inhibition of mobility, growth retardation, minor deformations of the ciliates, and also their death testifies to toxicity and the presence of a factor of toxigenicity of the investigated object (Shul'gin et al., 2006).

Results and discussions

At the first stage of the study, using the atlas of the determinant (Javnov, 2010), it was established that in the in the bay of the Northern Slavic Gulf of the Sea of Japan, the following types of marine stars are most often encountered: *Patiria pectinifera* - a sea five-ray star, inhabiting various soils, at depths from 0.5 to 68 mm. The star is a predator, it attacks other marine animals. The swing of the rays reaches 180 mm (Fig. 1a). *Evastarias echinosoma* is a five-pointed sea star. The North Pacific species resides on sandy, sandy-silty-gravel soils, but sometimes the star falls on mud and rocks, at depths from 4 to 195 m. The star is a predator eating small marine animals. The swing of the rays reaches 800 mm (Fig. 1b).

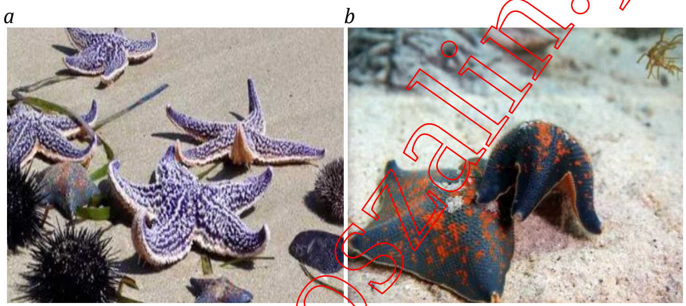

Fig. 1. Evastarias echinosoma

Rys. 1. Evastarias echinosoma

The results of the determination of the chemical composition of the various parts of the body of the marine stars surveyed in North America are given in table 1.

Table 1. Chemical composition of marine stars, % (North Bay)

Tabela 1. Skład chemiczny rozgwiazd morskich, % (North Bay)

Sample; Próbka	Water/dry matter; Woda/ sucha substancja	Protein (general nitrogen); Białko (ogólny azot)	Lipids; Tłuszcze	Mineral substances; Substancje mineral-ne	Aminosugar (galactozamin + glycosamine)	Sum of aminosugars (% for solid)
			Evastarias echinosoma			
Integumentary fabric	71.90 / 28.10	9.50 (1.520)	0.88	17.07	0.46+0.38=0.84	2.79±0.15
Interiors	74.70 / 25.30	14.34 (2.295)	6.11	2.41	1.16+0.99=2.16	8.29±0.25
Caviar	83.80/ 16.30	11.59 (1.855)	1.86	2.39	0.69+0.58=1.27	7.51±0.25
			Patiria pectinifera			
Integumentary fabric	56.74/ 43.31	9.66 (1.545)	0.77	32.04	0.41+0.33=0.74	1.65±0.05
Interiors	80.60 / 19.40	10.25 (1.640)	1.35	7.67	0.45+0.38=0.83	4.22±0.05
Caviar	81.25 / 18.81	13.15 (2.105)	3.80	1.32	0.75+0.64=1.39	7.14±0.25

Analysis of the chemical composition of the marine stars under study showed the presence of substances such as macro and microelements in their cover tissues, in addition to connective tissue proteins, and fatty acids, amino acids and amino sugars in the internal organs.

It has been established that the shell of sea stars is of interest as a source of macro- and microelements (including phosphorus and calcium) and a protein component. The internal organs of sea stars (gonads, stomachs) differ from other parts of the body with a complex of compounds of high biological activity - lipids, phospholipids, polyhydroxysteroids, glycosides, carotenoids, vitamin E (Bogdanov et al., 2015b).

The obtained results confirmed the prospects of using marine stars as raw materials for the production of biologically valuable feed products. A prerequisite for carrying out studies of the second stage, where the task of studying the toxicity of the investigated objects was being solved, were the well-known literature data on the content of toxic substances in sea stars, which contribute to their toxicity. It can be either chemical (pesticides, heavy metals, dyes, etc.) or natural (inhibitors of enzymes or hormones, saponins, glycosides, etc.) substances, and poisons (toxins) that are of microbial origin (Bogdanov et al., 2015b).

The detected toxicity of the individual anatomical parts of the marine stars under study is differentiated by levels. Toxicity due to the presence of toxins of natural origin, had gonads (caviar). In the results of deviations in the development of cells of the tetrachymene test culture (*Tetrahymena pyriformis*), characterized by a decrease in motility or fixation of individuals from strong to moderate toxicity, the integumentary tissue and viscera were evaluated. This level of toxicity is probably due to toxins of microbiological origin and depends on the season of harvesting of marine stars (Bogdanov et al., 2015a). The results of the toxicity assessment of the sites under investigation are consistent with the safety indices (Table 2, Table 3). The following factors were taken into account in justifying (or selecting) the method for processing sea stars: the content of toxic elements in the tissues and the presence of spawning changes, which depend on the catch season of the studied biological objects. Two methods of processing

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starfish were studied: direct drying and fermentolysis. As you know, drying is one of the ways to preserve raw materials, including aquatic biological resources by partially or completely removing moisture from them.

Table 2. Results of total bacterial contamination of sea stars

Tabela 2. Wyniki całkowitego bakteryjnego zanieczyszczenia rozgwiazd morskich

Sample; Próbka	Actual contents, CFU/r	The regulated level, no more, CFU/r
Evastarias echinosoma	$1.3 \cdot 10^4$	$1 \cdot 10^4$
Patiria pectinifera	$2.0 \cdot 10^4$	

Table 3. The maintenance of toxic elements in starfishes, mg·kg^{-1}

Tabela 3. Obecność metali ciężkich w rozgwiazdach, mg·kg^{-1}

Sample; Próbka	As	Pb	Cd
Evastarias echinosoma			
Integumentary fabric	1.78	0.19	0.038
Interiors	0.70	0.05	0.0067
Caviar	16.54	0.06	0.012
Patiria pectinifera			
Integumentary fabric	5.24	0.08	0.12
Interiors	4.32	0.03	0.08
Caviar	0.47	0.06	0.15
TR TU 2011 [10]	5.0	10.0	2.0

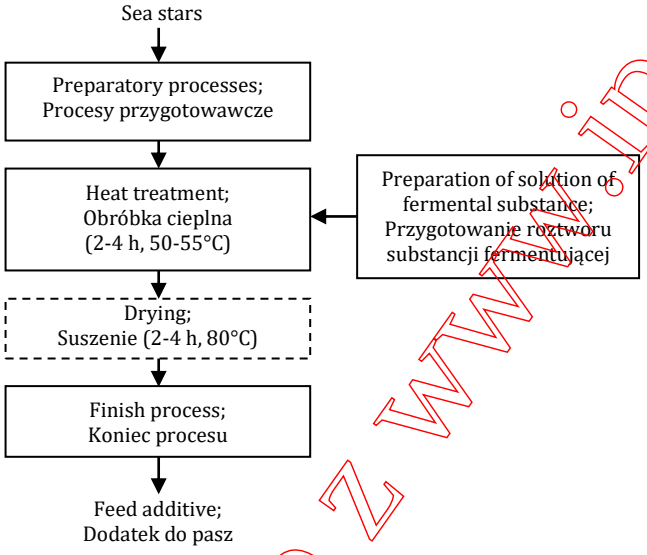

Fig. 2. Generalized technological scheme for obtaining food (dashed line designates the main operation used in the method of direct-drying treatment)

Rys. 2. Uogólniony schemat technologiczny pozyskiwania żywności (linia przerywana wyznacza główną operację stosowaną w metodzie bezpośredniego suszenia)

The second method is enzymatic hydrolysis, the most gentle way of destruction, which allows to preserve valuable components without disturbing their structure and modification. In addition, it is known that broad-spectrum enzyme preparations (which possess proteolytic activity) can destroy microbiological toxins having a protein nature, which in turn leads to detoxification of the product. The production of fodder products was carried out according to the generalized technological scheme compiled by the authors (Fig. 2).

Raw materials for processing must be free of signs of spawning changes and comply with the requirements of STO 004715115-011-2014 "Starfish refrigerated for processing ". Preparatory processes include the following operations: washing, stripping, coarse grinding, dosing of components. At the stage of final processing the following operations are carried out: fine grinding, packaging, packaging, storage. Materials on the scientific substantiation of technological processing of sea stars, shown on the diagram, are contained in separate articles (Maksimova et al., 2016). Each of the methods of processing starfish used in the technology of feed additives has its advantages.

The method of direct drying is a technological operation that allows shortening the duration of the technological process and minimizing economic costs.

Table 4. Total chemical composition of feed additives, %

Tabela 4. Całkowity skład chemiczny dodatków paszowych,%

Protein; Białka	Lipids; Tłuszcze	Mineral substances; Substancje mineralne	Including, Zawartość		Relative biological value; Względna wartość biologiczna	
			Ca	P	1	2
21.5-28.0	2.2-3.2	35.9-39.1	7.8-10.7	0.12-0.15	20.6-39.4	43.1-54.4

1- Feed additive, obtained by direct drying; dodatek paszowy, otrzymany przez bezpośrednie suszenie

2 - Feed additive, obtained by enzymatic method, dodatek paszowy, otrzymany przez metodę enzymatyczną

Table 5. Indicators of safety of feed additives from the sea stars

Tabela 5. Wskaźniki bezpieczeństwa dodatków paszowych z gwiazd morza

Indicators; Wskaźniki	Admissible level according to uniform veterinary requirements; Dopuszczalny poziom zgodnie z jednolitymi wymaganiami weterynaryjnymi	Actual value; Aktualna wartość
General bacterial obsemenennost, CFU/r, no more	$5 \cdot 10^5$	$7 \cdot 10^2$
Pathogenic microflora	not allowed	not revealed
Including a *Salmonella* in 25 g	not allowed	not revealed
Enteropatogenny *Escherichias* in 25 g	not allowed	not revealed
Botulinicheskikh toxin	not allowed	not revealed
Peroxides	no more than 0.1% on iodine	not revealed
Aldrin	not allowed	not revealed
GTsHG (sums of isomers)	no more than 0.2 [mg·kg^{-1}]	not revealed
DDT (sum of metabolites)	no more than 0.4 [mg·kg^{-1}]	not revealed
Heptachlor	not allowed	not revealed
Lead	no more than 5.0 [mg·kg^{-1}]	0.396
Cadmium	no more than 1.0 [mg·kg^{-1}]	0.396
Mercury	no more than 0.5 [mg·kg^{-1}]	not revealed
Arsenic	no more than 2.0 [mg·kg^{-1}]	0.604
Zinc	no more than 100.0 [mg·kg^{-1}]	47.6

The quality of the finished fodder products was assessed according to the following criteria: chemical composition, biological value, safety. The general chemical composition of the obtained feed additives is presented in table 4.

The results of safety studies (table 5) showed that the level of microbiological indices, the content of toxic elements in marine starfood feed additives meet veterinary and sanitary requirements according to the "Single Veterinary (Veterinary-Sanitary) requirements", applied to goods subject to veterinary control. The data of table 5 indicate that the quality and safety indicators of feed additives obtained using the developed technology meet the requirements for feed products in accordance with GOST 2116-2000. Feed additives are powder from dark cream to light brown color, without dense lumps and mold with a pleasant smell of seafood.

Then, as fermentolysis promotes the production of a product containing nutrients in an easily accessible form for digestion by the body. To prove this, the results of the third stage of the research work are presented below.

Conclusions

It should be noted that at the moment practical recommendations are being developed on the use of the cow-derived additive for poultry feeding. When choosing the consumer (hens), the feed additive was guided by the analysis of the Russian market, where the poultry industry is dynamically developing and the production of fodder is a promising direction.

Thus, in conjunction with the conclusions given in the text of this article, in general, it can be noted that the goal of research work is achieved through the solution of the tasks assigned.

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Svetlana Maximova
Russia, Vladivostok, Lugovya str. 52B
e-mail: maxsvet61@mail.ru

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