Report 32/2020 • Published August 2020

The market for marine ingredients for food and agricultural application

Coldwater prawn (*Pandalus boralis*), Blue mussels (*Mytilus edulis*) and Brown crab (Cancer pagurus)

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Report

Title: **The market for marine ingredients for food and agricultural application Coldwater prawn (*Pandalus boralis*), Blue mussels (*Mytilus edulis*) and Brown crab (Cancer pagurus)**	ISBN 978-82-8296-649-8 (pdf) ISSN 1890-579X *Report No.:* 32/2020
Tittel: Markedet for marine restråstoff for anvendelse innen mat og jordbruk reker(*Pandalus boralis*), blåskjell (*Mytilus edulis*) og taskekrabbe (Cancer pagurus)	*Accessibility:* **Open**
Author(s)/Project manager: Morten Heide, Themis Altintzoglou and Ragnhild Dragøy Whitaker	*Date:* 6th August 2020
Department: Marketing research, Marine biotechnology	*Number of pages and appendixes:* 9
Client: ERAnet/EU/Norges Forskningsråd	*Client's ref.:* NFR 271552/O70
Keywords: Market, marine ingredients	*Project No.:* 11974

Summary/recommendation:

This report focuses on the market for marine ingredients from Coldwater prawn (*Pandalus boralis*), Blue mussels (*Mytilus edulis*) and Brown crab (Cancer pagurus). Specifically, this report focuses on the market for chitin and its derivates, astaxanthin, bioactive peptides and calcium carbonate. The potential markets covered is food applications (nutraceuticals, food preservatives and antimicrobial packaging) and agricultural applications (natural stimulants of plant health). There report also provide some price examples.

Summary/recommendation in Norwegian:

Denne rapporten omhandler markedet for marine ingredienser fra kaldtvannsreke (Pandalus boralis), blåskjell (Mytilus edulis) og taskekrabbe (Cancer pagurus). Nærmere bestemt fokuserer denne rapporten på markedet for kitin og dets derivater, astaxantin, bioaktive peptider og kalsiumkarbonat. De mulige markedsanvendelsene som dekkes er matvarer (kosttilskudd, matkonservering og antimikrobiell emballasje) og landbruk (naturlige stimulanter for plantehelse). Rapporten gir også noen priseksempler.

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1 Introduction

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1.1 Nutraceuticals

Nutraceuticals are products derived from food sources that claims to provide extra health benefits, in addition to the basic nutritional value found in foods. Depending on the jurisdiction of the country it is sold in, products may claim to prevent chronic diseases, improve health, delay the aging process, increase life expectancy, or support the structure or function of the body. Nutraceuticals can be functional foods or dietary supplements.

1.1.1 Functional food

A functional food is a food claimed to have an additional function (often one related to health-promotion or disease prevention) by adding new ingredients or more of existing ingredients.

1.1.2 Dietary supplement

A dietary supplement is a manufactured product intended to supplement the diet when taken by mouth as a pill, capsule, tablet, or liquid. A supplement can provide nutrients either extracted from food sources or synthetic, individually or in combination, in order to increase the quantity of their consumption.

1.2 Food preservatives

A food preservative is a substance or a chemical that is added to a food product to prevent decomposition by microbial growth or by undesirable chemical changes (i.e. slowing the oxidation of fats that cause rancidity). Food preservation may also include processes that inhibit visual deterioration, such as the enzymatic browning reaction in apples after they are cut during food preparation.

1.3 Antimicrobial packaging

Antimicrobial packaging is a packaging system that adds active ingredients and/or uses actively functional polymers in the packaging system to be able to kill or inhibit spoilage and pathogenic microorganisms involved in contaminating foods

1.4 Natural stimulants of plant health

Natural stimulants of plant health, often included under the term biostimulants, is a formulated product of biological origin that improves plant productivity as a consequence of the novel or emergent

properties of the complex of constituents, and not as a sole consequence of the presence of known essential plant nutrients, plant growth regulators, or plant protective compounds.

1.5 Estimation of market size

In this report we attempted to find information about market size (value and volume) for chitin and its derivates, astaxanthin, bioactive peptides and calcium carbonate based on secondary information. The main information source identified was market reports from several market research companies. We found a very large variation on the estimation of market size, indicating either that the market reports have different definitions of the products/markets, or that the information used to estimate market size is of poor quality. Based on this we will not give any estimation of market size, as we have no way of validating the information.

1.6 Price examples

Examples of market prices for the different products are given. The prices were collected in February 2020. The sources for the market price are from manufacturers webpage or alibaba.com.

2 Chitin and derivates

Coldwater prawn (*Pandalus boralis*) and Brown crab (Cancer pagurus) are both potential sources of chitin. Chitin is the second most abundant biopolymer on earth (after cellulose). The most common derivate from chitin is chitosan.

2.1 Food applications

2.1.1 Functional food

Chitin is among various compounds (vitamin C and E) that have shown antioxidant[1] effects. Thus, it could be added as an ingredient to produce functional foods which could prevent age-related and diet-related diseases (Kerch, 2015). Chitin has also been found to inhibit lipid oxidation in meat and seafood (Hamed et al., 2016).

Chitosan and Chitooligosaccharides have been used as a source of dietary fibre. They are considered functional foods because of their non-digestibility by intestinal enzymes, which allows them to act as prebiotics. They stimulate beneficial bacteria in the gastrointestinal tract (Hamed et al., 2016).

2.1.2 Dietary supplement

Chitin and its derivatives are also sold as dietary supplements with various health claims.

2.1.3 Food preservative

Chitin and its derivatives can be used as food preservatives. They have an antimicrobial activity which allows them to protect foodstuff from microbial deterioration (Hamed et al., 2016).

2.1.4 Antimicrobial packaging

The antibacterial properties of chitosan have also been used as active edible packaging. Biofilms formed from chitosan allow long term storage of food products. Antimicrobial coating of vegetables, fruits, grains, and fish retard microbial invasion as chitosan acts as a protective barrier to enhance the sensory and nutritional quality of the food. Besides being a protective barrier, edible biopolymerfilms can be used as carriers of bioactive compounds enhancing food quality (Hamed et al., 2016).

2.2 Agricultural applications

Chitosan has been used as a seed-coating agent to control pests and improve plant defences against microorganisms. The plant protective properties of chitin, chitosan, and their derivatives are highly desirable as they offer protection against fungi, viruses, bacterial diseases, and nematodes (Hamed et al., 2016).

[1] An antioxidant is a molecule which can inhibit oxidation. Oxidative damage is initiated by free radicals and reactive oxygen species (ROS). These molecules have very high reactivity and are produced by normal aerobic metabolism in organisms. Excess oxidative molecules may react with proteins, lipids and DNA through chain reaction, to cause protein and lipid oxidation and DNA damage which are associated with various disorders.

2.3 Price examples

The price of chitin and chitosan are influenced by factors like product type, purity, quality and intended use. High quality chitin from shrimp shells costs as much as 284-685 $/kg (table 1). Very high-quality chitin is even more expensive at 112 $/gram (table 1).

Table 1 Price for high quality chitin from shrimp shells (source: www.sigmaaldrich.com)

Chitin from shrimp shells	
Product description	Price
Practical grade, coarse flakes	284 $/kg
Practical grade, powder	685 $/kg
Suitable for analysis of chitinase, Bioreagent, purified powder	112 $/gram

High quality chitosan from shrimp shells costs as much as 156-168 $/100 gram (table xx). Very high-quality chitin is even more expensive at 112 $/gram (table 2).

Table 2 Price for high quality chitosan from shrimp shells (source: www.sigmaaldrich.com)

Chitosan from shrimp shells	
Product description	Price
Practical grade	156 $/100 gram
≥75% (deacetylated)	168 $/100 gram

Food grade chitin/chitosan is sold at Alibaba.com (table 3) and costs between 14 and 60 $/kg (table 3). Agriculture grade chitin/chitosan costs 14-40 $/kg at Alibaba.com (table 3). The price is influenced by product quality and order quantity (bigger volumes are cheaper).

Table 3 Price for food grade chitin/chitosan from shrimp shells (source: www.alibaba.com)

Product description	Price	Supplier
Factory supply food grade chitin chitosan powder 90%	27-37 $/kg	Xi'an Lyphar Biotech Co., Ltd.
Wholesale chitosan/chitosan powder/water soluble chitin chitosan D.A.C degree 90% 95%	25 $/kg	N&R Bio Industries Inc. (Xi'an)
Food grade prebiotic chitin chitosan powder price for slimming	33-55 $/kg	Henan Heagreen Bio-Technology Co., Ltd.
Food Grade 90% Purity Chitin Chitosan Powder	27-37 $/kg	Hunan Insen Biotech Co., Ltd.
Wholesale food grade chitin chitosan powder	14-20 $/kg	Qingdao Shellight Biotechnology Co., Ltd.
Bulk raw material food grade chitin chitosan	30-60 $/kg	Xiamen Blue Bay Science & Technology Co., Ltd.
Agriculture grade chitosan powder, chitin chitosan for agriculture use	14-20 $/kg	Qingdao Hibong Fertilizer Co., Ltd.
Factory top grade powder agricultural chitosan	25 $/kg	Xi'an Pincredit Bio-Tech Co., Ltd.
Chitosan 100% natural food/ industrial/ agriculture grade chitosan	15-40 $/kg	Xiamen Blue Bay Science & Technology Co., Ltd.

3 Astaxanthin

Astaxanthin is a xanthophyll carotenoid which is found in various microorganisms and marine animals. Coldwater prawn (*Pandalus boralis*) is a known source of astaxanthin. The use of astaxanthin as a nutritional supplement has been rapidly growing in foods, feeds, nutraceuticals and pharmaceuticals (Ambati et al., 2014).

3.1 Food applications

3.1.1 Functional food

Astaxanthin contains a unique molecular, which are responsible for high antioxidant properties. It can be added as an ingredient to produce functional foods which could prevent age-related and diet-related diseases or inhibit lipid oxidation (Ambati et al., 2014).

3.1.2 Dietary supplement

Currently there is a wide variety of Astaxanthin products sold in health food stores in the form of nutritional supplements. Most of these products are manufactured from algae or yeast extracts. Due to their high antioxidant properties these supplements have been attributed with potential properties against many diseases. Astaxanthin shows potential effects on various diseases including cancers, hypertension, diabetes, cardiovascular, gastrointestinal, liver, neurodegenerative, and skin diseases (Ambati et al., 2014).

3.1.3 Food preservative

Astaxanthin seems to be very promising novel natural preservative of potential use in food processing (Gramza-Michałowska and Stachowiak, 2010).

3.1.4 Antimicrobial packaging

Astaxanthin-based bioactive polymers backbone has shown promising results as an anti-bacterial agent in vitro, specifically against Staphylococcus aureus MRSA (Weintraub et al., 2017).

3.2 Agricultural applications

To our knowledge astaxanthin is not used for agricultural applications.

3.3 Price examples

The price of astaxanthin is influenced by factors like product type, purity, quality and intended use. High quality astaxanthin from the green microalgae Haematococcus pluvialis costs 363 $/500 milligrams (table 4).

Table 4 Price for high quality astaxanthin from Haematococcus pluvialis (source: www.sigmaaldrich.com)

Astaxanthin	
Product description	Price
Astaxanthin esters from Haematococcus pluvialis	363 $/500 milligrams

Food grade organic astaxanthin is sold at Alibaba.com and costs between 89 and 200 $/kg (table 5). The price is influenced by product quality and order quantity (bigger volumes are cheaper).

Table 5 Price for food grade organic astaxanthin (source: www.alibaba.com)

Product description	Price	Supplier
Low price bulk organic food grade Astaxanthin	125 $/kg	Xi'an Pincredit Bio-Tech Co., Ltd.
Free samples food grade Astaxanthin 10% powder	89-189 $/kg	Xi'an Rongsheng Biotechnology Co., Ltd.
Factory Price Bulk Halal Food Colorant Food Grade Astaxanthin	150-200 $/kg	Wellgreen Technology Co., Ltd.

Source: Alibaba.com

4 Bioactive peptides

Bioactive peptides can be defined as isolated small fragments of proteins which provide some physiological health benefits. They act as potential modifiers reducing the risk of many chronic diseases.

Research on the actual benefits of bioactive peptides from shrimp is quite recent, and further in-depth analysis is required for complete identification of potential bioactive peptides in shrimp.

Mussel by-products present a rich source of diverse bioactives that can find applications in food, cosmetics, packaging, dyes, marine technology, and many unexplored fields. Technological processes need to be developed to derive high value components from rejected mussels (Naik and Hayes, 2019).

4.1 Food applications

4.1.1 Functional food and dietary supplement

Shrimp shell discard hydrolysates exhibit significant antioxidant activities, which reveals the potential application of shrimp shell protein hydrolysates in foods as such as well as in functional food and possibly supplement as well as blood pressure lowering applications (Ambigaipalan and Shahidi, 2017; Djellouli et al., 2020).

Studies conducted on blue mussel hydrolysate fractions have shown the constituent peptides to display antioxidant and anti-inflammatory activity (Naik and Hayes, 2019).

Angiotensin I converting enzyme inhibitory peptide (important physiological role in regulating blood pressure) derived from fermented blue mussel sauce could potentially be utilized to develop functional foods (Je et al., 2005).

Only one study was found that identified antioxidant activities in brown crab proteins (Mileva et al., 2017). This specie should be further explored for bioactive peptides.

4.1.2 Food preservative

Hydrolysates from shrimp shows a potential to be used to produce molecules with antimicrobial attributes (Djellouli et al., 2020).

4.1.3 Antimicrobial packaging

Gelatin hydrolysates could be used as plasticizer in myofibrillar protein film (Nuanmano et al., 2015)

4.2 Price examples

Because of the diversity of this market in terms of product types, usage, origin etc. it is not possible to give any examples of price.

5 Calcium carbonate

Calcium carbonate is one of the most used raw materials in various industries, such as construction materials, food supplement, pharmaceutics, animal feed, plastic production, and others. Calcium carbonate can derive from marine wastes, like crustaceans and bivalve's shells. Blue mussel shells are a potential source of calcium carbonate.

5.1 Food applications

5.1.1 Dietary supplement

Oyster shells have enjoyed recent recognition as a source of dietary calcium. Further analysis is required for exploring the potential of blue mussel shells as a source of dietary calcium.

5.2 Agricultural applications

Calcium carbonate is suited to a wide variety of agricultural applications, including pH control, fertilizer conditioners and fillers.

5.3 Price examples

Oyster shell calcium carbonate is sold at Alibaba.com and costs between 0,19 and 0,40 $/kg (table 6). The price is influenced by product quality and order quantity (bigger volumes are cheaper).

Table 6 Price for oyster shell calcium carbonate (source: www.alibaba.com)

Product description	Price	Supplier
China manufacturer oyster shell calcium carbonate	0,19-0,23 ($/kg)	Lianyungang Crown Sue Industrial Co., Ltd.
Oyster shell calcium carbonate	0,2-0,4 ($/kg)	Shijiazhuang Kedahua Imp. & Exp. Trade Co., Ltd.

Source: Alibaba.com

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ISBN 978-82-8296-649-8 (pdf)
ISSN 1890-579X