IN SILICO APPROACH TO CHECK THE EFFECT OF RED ALGAE *Pyropia umbilicalis*

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Session: July-December 2019

A thesis submitted in the partial fulfillment of the requirements for the degree of Master of Science in Applied Human Nutrition and Dietetics

Department of Applied Food Science and Nutrition

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AUGUST 2022

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Dedication

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

I would like to express my deep sense of gratitude to my Almighty, my creator for giving me the sound health, abilities and courage to perform & complete my work in successful manner and without help of God I was not able to do my work perfectly.

I would like to reimburse my profound respect to my supervisor **Ms. Taslima Ahmed**, Assistant Professor, Department of Applied Food Science and Nutrition, CVASU due to her generous and gracious guidance. I am also grateful to her for helping me to understand some miniature issues as well as those issues, which I have failed to understand during the preparation of the report.

It gives me great pleasure to extend my heartfelt gratitude to my co-supervisor **Ms. Kazi Nazira Sharmin**, Associate Professor & Head of the Department of Applied Food Science and Nutrition, CVASU for her tremendously guidance, encouragement, suggestions, support and dedication throughout this research. As my co-supervisor, she has taught me more than I could ever give her credit for here. Without her continuous encouragement and quality supervision, all the works would not possibly been completed in time.

I am grateful to Professor **Md. Ashraf Ali Biswas**, Dean, Faculty of Food Science and Technology, CVASU for his kind cooperation and for providing the necessary facilities to carry out this research.

Finally, I would like to pay my profound gratefulness and cordial love to my friends, juniors, family members, and all well-wishers for their helping hand, understanding, endless patience and encouragement during my whole study period.

The Author
August,2022

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LIST OF ABBREVIATION

ACE	Angiotensin-I-Converting Enzyme
DPP-III	Dipeptidyl-peptidase-III
DPP-IV	Dipeptidyl-peptidase-IV
FASTA	FAST-All
IDF	International Diabetes Federation
NCBI	National Center for Biotechnology Information
RAS	Renin-Angiotensin-System
T2DM	Type 2 diabetes mellitus
Da	Dalton

ABSTRACT

Pyropia umbilicalis is an important marine algae. Its high protein concentration makes it a good source of peptides that are physiologically active. A time saving and effective way for determining the potential bioactivities of any protein is made possible by the growing field of bioinformatics and the numerous databases of bioactive peptides.The current in-silico study demonstrate the biotechnological characteristics of *P. umbilicalis* by identifying bioactive peptides within its protein. In this study,ficin, papain, and stem bromelain, three plant proteases, were utilized to in silico proteolyse five different *P. umbilicalis* protein sequences and release a variety of bioactive peptides. The BIOPEP-UWM database was used to assess the efficacy of these enzymes. Stem bromelain was detected to be more efficient at releasing fragments for a given activity. From these proteins, 22 biological activities were identified in total. The findings demonstrated that *P. umbilicalis* protein is a possible source of peptides with dipeptidyl peptidase-IV (DPP-IV) and angiotensin-I converting enzyme (ACE) inhibiting properties. The protein sequence of *P. umbilicalis* was compared to species possessing the same protein using NCBI database.It was found that protein sequence of *Palmaria palmate*,an economically beneficial seaweed has similarity (positivity, 92%–95%) with this seaweed protein sequence. The results of the current study suggest that *P. umbilicalis* protein can be a great source of biologically active peptides, and these results pave the way for novel applications of peptides in pharmaceuticals, biomedicine, and the food industry. Future research on the bioactive peptides generated from these seaweed proteins can be supported with these findings in both in vitro and in vivo settings.

KEYWORDS: *Pyropia umbilicalis,* In silico, DPP-IV inhibitor, ACE inhibitor, Bioactive peptides,

CHAPTER-1: INTRODUCTION

1.1 Background:

The nutritional and functional qualities of food proteins have drawn a lot of attention, especially when it comes to developing products that improve human nutrition and health. Several research have recently concentrated on the production of cryptic peptides generated from dietary proteins, their functions, and the eventual application of such peptides as functional agents with drug-like actions (Ryan et al., 2011). Even though they are inactive within the parent protein sequences, cryptic peptides are capable of being released from the parent proteins by endogenous and exogenous proteases and peptidases during the physiological digestion of food or the processing of food, such as fermentation and the processing of meat. (Udenigwe et al., 2012). It has been found that marine, plant, and animal protein sources all contain their fair amount of cryptic bioactive peptides. These peptides have demonstrated impacts on human physiological processes associated with the prevention and treatment of chronic diseases. Bioactive peptides can affect abnormal metabolic processes in the immunological, cardiovascular, gastrointestinal, and neurological systems depending on their amino acid sequence, molecular size, net charge, and spatial conformation (Korhonen et al., 2006; Ryan et al., 2011). Due to the peptides' safety and widespread perception that they have little side effects, there is an increasing focus on using food-derived cryptic bioactive peptides as a substitute to manufactured medications.

Thousands of different types of macroscopic, multicellular, marine algae are referred to as seaweed or macroalgae. Seaweeds have been grown for use by humans for a very long time. Growing seaweed for food, as a source of chemicals (such carrageenan), as animal feed, and as fertilizer has become a widespread agricultural activity in recent years. Seaweeds have been consumed by humans for many millennia, especially in China, Japan, and Korea (McHugh, 2003). Globally, 28.5 million tons of seaweeds were collected in 2014, primarily for food (FAO 2016). In the form of vitamins (A, C, and E), as well as pigments, seaweed contains an abundance range of types of antioxidants. Good amounts of iodine, a trace mineral necessary for the thyroid to function, can be found in it. In addition, seaweeds like purple laver have been found to have enough amounts of vitamin B12. The discovery of metabolites having biological activity has dramatically grown over the past three decades. It has been demonstrated

that seaweed bioactive, including as polysaccharides, pigments, fatty acids, polyphenols, and peptides, offer a variety of advantageous biological qualities that may aid within the context of the development of functional foods and nutraceuticals. Most seaweeds include metabolites that have therapeutic potential (Ireland et al., 1993). In addition to nutritional utilization, seaweed or macroalgae have been shown to exhibit a variety of bioactivities, including antihypertension,immunomodulatory,antithrombotic, antioxidant, anticancer, and antibacterial activities (Kim and Wijesekara, 2010; Elias et al.,2008).

Bioactive peptides are sequences of 2 to 30 amino acids that, when consumed, have a beneficial impact on the consumer's health (Liu et al.,2016). Utilizing marine-sourced bioactive peptides in the development of novel therapeutics and nutritional products has gained popularity in recent years (Qi et al.,2005). Inhibition of angiotensin-I converting enzyme (ACE), dipeptidyl peptidase-IV (DPP-IV) inhibition,antibacterial, antioxidative, anticancer, regulating, stimulating, immunomodulatory activities, etc., are some of the diverse biological actions of food-derived proteins that are of current interest.. Red algae often have more protein than both green and brown algae (Fleurence ,1999). Bioactive peptides are particularly abundant in seaweed that has a high protein concentration. (Freile-pelegrin,2005). When released by proteolysis, bioactive peptides can have physiological effects on people even if they are inactive within the parent protein's sequence (Roufik et al.,2006; Wijesinghe and Jeon, 2012). By applying various proteases to hydrolyse seaweed protein, seaweed bioactive peptides are frequently produced. For *Ulva intestinalis* (Sun et al.,2019*), Gracilariopsis lemaneiformis* (Cao et al.,2017), *Pyropia columbina* (Cian et al.,2015) *Undaria pinnatifida*, and *Porphyra yezoensis, i*n-vitro hydrolysis of these seaweed protein to produce bioactive peptides has been reported (Lee et al.,2015, Qu et al.,2010).

The red algae (seaweed) genus *Pyropia* belongs to the Bangiaceae family. It inhabits shallow water and intertidal zones all over the globe. When compared to green and brown seaweed, red seaweed is more protein-rich (Fleurence, 1999). Because of this, its protein, phycocyanin in particular, may serve as a substrate for the release of bioactive peptides with ACE inhibitory activity and DPP-IV inhibitory activity. Furthermore, there are numerous health risks associated with taking synthetic ACE inhibitors. Further, more and more consumers these days are concerned with their health, so they gravitate toward functional foods made with all-natural ingredients

rather than those made with synthetic chemicals. No reports of research into the viability of *Pyropia umbilicalis* proteins as a source for bioactive peptides have been found to date.

By using in silico approaches as a supplement to empirical methodologies, it is possible to evaluate proteins' potential as precursors of bioactive peptides and to predict the precise activities of some peptide sequences (Udenigwe, 2014). Compared to conducting experiments, it also saves money and time (Li-Chan, 2015). Bioactive peptides can have their potential bioactivity and associated activities predicted with the help of the BIOPEP, a database of bioactive peptide fragments (Dziuba et al., 2009).

This research will develop our knowledge of the natural and harmless DPP-IV and ACE inhibitory activity of the *Pyropia umbilicalis* protein. The pharmaceuticals sector will benefit from this research because it will aid in the identification of a suitable starting material for the development of advanced pharmaceuticals. Natural food-based products are safe and environmentally friendly, and this research could provide an alternative source for these products to health-conscious consumers (Veeresham, 2014). This research has the potential to serve as a roadmap for the food industry to follow when creating nutraceutical and high-value foods. Also, seaweed species that make products with added value could boost the economic value of the seaweed industry.

1.2 Objectives

1. To predict possible potential bioactive peptides from *Pyropia umbilicalis* proteins by in-silico bioinformatics tools.

2. To identify the proteases responsible for the greater generation of a predominant bioactive peptides.

3. To identify the potentiality of *Pyropia umbilicalis* in terms of economy.

CHAPTER 2: REVIEW OF LITERATURE

2.1 Seaweed

Although humans have been using seaweeds for hundreds of years, industrial-scale cultivation didn't begin until the middle of the twentieth century (Buchholz et al. 2012). Approximately 10,000 different species of algae make up the seaweed family. Historical records suggest that China produced edible seaweed around 1700 years ago (Yang et al., 2017). It is often referred to by its common name, "marine algae," because it grows in such abundance near the coast. The harsh environment that seaweed must endure includes extremes of temperature, light, osmotic stress, and dehydration (Gupta and Abu-Ghannam, 2011). It can be as small as individual microscopic cells or as large as the largest plants, such as giant seaweeds. Its size can range anywhere in between (Raj, 2018).

On the basis of their pigmentation, seaweeds are divided into the Chlorophyta (green), Rhodophyta (red), and Phaeophyta (brown) phyla (brown). The phycoerythrin pigment gives rhodophytes, or red algae, their characteristic red color (Raj, 2018). Phycocyanin and phycoerythrin are two examples of blue pigments found in Rhodophytes. Rhodophytes are able to reap the benefits of the red and blue pigment due to the pigment's ability to absorb blue-green light in the sea, which is necessary for the production of food by photosynthesis (Pal et al., 2014).

Ecologically, seaweed is significant because it is a key producer in the food chain that adds oxygen to the ocean and accounts for around 10% of the total marine production worldwide. In addition to its uses as food and in the creation of hydrocolloid, it is also used in the manufacture of cosmetics and fertilizers (Chan et al., 2006).

In addition to its common culinary use as a "sea vegetable," seaweed is also incorporated into a wide variety of other products and industries, including those related to fashion, health care, and beauty such as textiles, pharmaceuticals, cosmetics and in biomedical applications (Buchholz et al. 2012). Alginate, agar, and carrageenan are all examples of the type of phycocolloids that may be extracted from various types of seaweed. Brown seaweed harvests the alginate that finds applications as a thickening, clarifier, and medicinal fluid absorber (Holdt and Kraan, 2011). Gelling agents, emulsifiers, and bacteriological media are some of the many applications for the red

seaweed derivatives carrageenan and agar (Buchholz et al. 2012; Holdt and Kraan, 2011). The development of new functional foods from seaweeds has been facilitated by technological developments such as fermentation, bioprocessing, and bioreactors, as discussed by Freitas et al. (2012).

Nowadays, microalgae can be bought in the form of tablet or pills, capsules, and liquids, and they're promoted as a health food or dietary supplement. Pastas, snacks, candy bars or gums, drink mixes and beverages, etc., all integrate algae as a dietary supplement or a source of natural food coloring (Becker, 2004).

Rhodophyta, sometimes known as red seaweed, has one of the highest protein contents of any type of seaweed (Mohamed et al., 2012). Seaweed's basic nutritional profile is summarized in Table 2.1. (Rohani-Ghadikolaei et al., 2012).

Table 2.1: Nutritional component of marine algae with their proportion (Rohani-Ghadikolaei *et al*., 2012)

Composition	**Moisture**	**Lipid**	**Protein**	**Ash**	**Carbohydrate**
Dry weight basis (%)	6 – 12	1 - 5	10 - 30	12 - 30	30 – 60

The value of seaweed to society lies in its role as a source of food, agar, and a substance that gels. Now, seaweed serves as a growing medium for bacteriological research in addition to its more traditional uses in the food and pharmaceutical industries (Pal et al., 2014). Seaweed has the potential to be a nutritious food choice due to its low calorie count and high levels of nutrients like protein, carbohydrates, minerals, fiber, and vitamins (Patarra et al., 2011).

2.1.1 *Pyropia umbilicalis*

Pyropia species (Phylum- Rhodophyta; Class- Bangiophyceae; Order- Bangiales; Family- Bangiaceae) are red algae that have a discoid holdfast and a short stipe. They feature membranous, monostromatic blades that fold in various directions and come in red, brown, and dark green. These coiled blades might likewise pass for fronds at first glance. These fronds can be as long as a meter in certain species and as wide as 20 centimetres. Depending on water clarity and substrate, *Pyropia* can extend its growth

zone from the shoreline to depths of up to ten meters (Qian et al., 2015). The higher intertidal zone is home to a number of species of *Pyropia*, which are subject to a wide range of environmental challenges, such as direct sunlight, temperature swings, osmotic stress, variations in salinity, and drying out. They are very resilient to heat stress, with some *Pyropia* species being able to shut off metabolic processes like photosynthesis that aren't crucial to maintaining homeostasis (Xu et al.,2014). It's been shown that other species can combat dehydration by producing more lipids (Qian et al.,2015).

In order to boost the functional characteristics and nutritional worth of meat products, the red alga *P. umbilicalis* has been considered as an additive (emulsion model system) (Cofrades et al., 2008)

The amino acids, alanine, arginine,glycine, phenylalanine, serine, tyrosine, , and valine, as well as the protein content of a meat system, are all increased by the addition of *P. umbilicalis* (nori). High antioxidant activity in meat systems has been attributed to the phenolic compounds found in nori (2170 mg GAE/100 g) and sea spaghetti (López-López et al., 2009). To a large extent, the Fe content of the meat system was boosted by the addition of nori (López-López et al., 2009).

2.2 Bioinformatics approach

More recently, computer-based (or "in silico") simulation has been applied to the discovery of bioactive peptides hidden in dietary proteins, allowing researchers to sidestep some of the difficulties of the traditional approach (Holton et al., 2013). Bioinformatics is poised to have a revolutionary effect on the study of bioactive peptides because of the advantages it offers in analyzing many dietary proteins and proteolytic enzymes at once. The in silico method employs databases like BIOPEP (Dziuba et al., 2009) to ascertain the occurrence frequency of cryptic bioactive peptides in the basic structure of dietary proteins. Protein sequences are available in databases, the most popular of which being the UniProtKB (Udenigwe, 2014). In addition, some researchers have pointed out that bioinformatics tools can be used to pick the important process parameters for the production of certain peptides from proteins, and to identify novel peptides with the goal of synthesizing and assessing their bioactivity. This data-driven, computational method is sometimes referred to as "in silico." A particular sequence of potentially active peptides, can be searched in the BIOPEP-UWM database. UniProtKB, SwissProt, TrEMBL, and NCBI (National Center for

Biotechnology Information) are only a few examples of databases where protein sequences can be obtained for the purpose of assessing their potential bioactive peptides (Kartal et al., 2020). Due to the time and cost savings offered by the in silico approach, an increasing number of researchers are beginning to incorporate it with experimental studies. These researchers have conducted experiments that corroborate the findings of the in silico assessments. As the potential impact of bioactive peptides on human health became obvious, scientists throughout the world have become increasingly interested in incorporating an in silico method into experimental studies in order to forecast the potential beneficial health effects of bioactive peptides (Kartal et al., 2020).

The in silico method has been shown to be effective in a number of experiments, demonstrating its usefulness by demonstrating consistency with hydrolysis results obtained in the laboratory. Utilizing BIOPEP, the researchers looked at the potentially bioactive proteins found in oats (Cheung et al., 2009). They performed in silico hydrolysis using a number of different enzymes and discovered that thermolysin was the most effective enzyme for in vitro analysis. Using in vitro thermolysin hydrolysis, they were able to validate their in silico findings. Researchers might also benefit from using this strategy in their search for novel bioactive peptides. Due to the high score given by the PeptideRanker program, it was determined that Phe-Cys, which was generated by in silico hydrolyzing of RuBisCO (ls) with thermolysin, has biological potential. This was demonstrated in a study of the cereal crop RuBisCO, in which many peptides that had not been identified as bioactive were investigated through the PeptideRanker tool. According to the findings of a subsequent study on the in vitro activity of the Phe-Cys dipeptide, this dipeptide had a significant amount of antioxidative activity (Je et al. 2015; Udeniqwe et al. 2013). Bovine serum albumin has recently been found to include novel ACE and DPP-IV inhibitor peptides, as discovered by (Lafarga et al. 2016). During the course of their research, they also made use of in-computer technologies such as BIOPEP and PeptideRanker. The findings of these studies demonstrate the critical need of conducting an in silico study before conducting an in vitro enzyme action study in a wet-lab setting.

2.3 Bioactive peptide

Typically between two and twenty amino acids in length, bioactive peptides found in food are inactive when locked in their natural protein structure. They will not be freed

until protein breakdown frees them. Protein hydrolysate from algae contained peptides with a broad range of bioactive properties, including those of antioxidant (Harrysson et al., 2018), antibacterial (Shannon and Abu-Ghannam, 2016), anti-inflammatory (Lee et al., 2015), and antihypertensive (Suetsuna et al., 2004).

2.3.1 DPP IV inhibitor

Peptides isolated from seaweed have been demonstrated to effectively inhibit dipeptidyl peptidase-IV (DPP-IV; EC 3.4.14.5) and platelet-activating factor acetylhydrolase (PAF-AH; EC 3.1.1.47). (Lafarga et al., 2020). As DPP-IV inhibitors lower blood glucose levels through monitoring hyperglycemia, which has beneficial effects on weight maintenance because it remains neutral, improves glycated hemoprotein levels, and does not generate symptom, they have been deemed a safe option for the management of diabetes (Singh et al., 2017). Peptides ILAP, LLAP, and MAGVDHI, recently rumored by Harnedy, Georgia Okeeffe, and FitzGerald, are the only seaweed-derived DPP-IV restricted peptides known at this time. The DPP-IV EC50 values for the peptides ILAP, LLAP, and MAGVDHI, which were synthesized from a *Palmaria palmata* aqueous protein extract using Corolase PP, were 43.4%, 53.7%, and 159.4%, respectively. It was produced from *Palmaria palmata* by papain and has an EC50 value for PAF-AH of 2.3 mM. (Lafarga et al., 2020).

2.3.2 ACE inhibitory peptide

Angiotensin-converting enzyme (ACE) is an important enzyme in blood pressure regulation that leads to hypertension. Therefore, ACE inhibition using an ACE inhibitor is crucial for hypertension treatment (Coppey et al., 2006). Not only do angiotensin-converting enzyme (ACE) inhibitors disable the formation of angiotensin II, but they also hinder bradykinin from being broken down into inactive byproducts, increasing the bioavailability of the peptide (Gamboa et al., 2012). Therefore, angiotensin-converting enzyme (ACE) inhibitors are the first line of defense for hypertension treatment.

Due to the potential presence of carcinogenic chemicals like N-nitrosodimethylamine (NDMA) and other negative effects in synthetic ACE inhibitors such as captopril, enalapril, and lisinopril, natural food-based ACE inhibitors are preferable (Packard et al.,2002). According to the previous study, 20% of hypertension patients discontinue ACE inhibitor therapies due to adverse effects, most frequently chronic cough

(Morimoto et al., 2004). Therefore, natural ACE inhibitors derived from food-based compounds are preferred due to being non-toxic, safer, and economically friendly. More attention is being paid by scientists to the creation of natural ACE inhibitors extracted from various bio-resources and functional meals (Kumar et al., 2010). For the isolation of ACE inhibitory peptides, hydrolysis has been reported in the past to be employed on plants such seaweed, wheat mushrooms (Jang et al., 2011), spinach (Yang et al., 2003), and bitter melon seeds. Plant-based ACE inhibitory peptides have shown antihypertensive efficacy in both in vivo and in vitro studies (Gupta et al., 2018).

2.3.3 Dipeptidyl peptidase-III inhibitor

The mammalian pain modulatory system includes a number of enzymes, one of the most prominent of which is dipeptidyl peptidase III (DPP III), an enzyme responsible for the degradation of encephalin. (Bezerra et al., 2012).

Patients with cancer and neuropathic illnesses place a high value on alleviating their pain, whether it is acute or chronic (Thanawala et al., 2008). Analgesic potential has been attributed to novel pharmacological substances that block enkephalin-degrading enzyme(s). Leu-enkephalin and Met-enkephalin are two natural morphine-like compounds released by CNS and adrenal medulla nerve ends. Enkephalins, like many other neuropeptides, are promptly digested after being released at the synapse. Dipeptidyl peptidase-III (DPP-III) has micromolar affinity for encephalin and is one of the most important enkephalin degrading enzymes in the central nervous system (CNS) (Dhanda et al., 2011; Hashimoto et al., 2000; Khaket et al., 2012). Inhibitors of dipeptidyl peptidase III are widely believed to increase the half-life of enkephalins, whether those enkephalins are produced endogenously or applied exogenously (Dhanda et al., 2011).

2.3.4 Antioxidative peptide

Reactive oxygen species (ROS) like superoxide anion radical (O_2•), hydroxyl radical (•OH), hydrogen peroxide (H_2O_2), and Peroxyl radical (•OOR) oxidize lipids and proteins of food products during processing or storage, leading to undesirable changes in quality and possibly the production of toxic compounds that reduce consumer acceptability of food (Li et al., 2010). Cancer, atherosclerosis, type 2 diabetes in the elderly, inflammation, coronary heart disease, and neurological illnesses including Alzheimer's disease may all be brought on by ingestion of these highly harmful

compounds (Kitts et al., 2003). Inhibiting lipid peroxidation in both live organisms and food items through the use of antioxidant chemicals or preservatives is, thus, a crucial technique for preventing food goods from such deteriorations and protecting consumers from dangerous diseases. In biological materials, antioxidants or preservatives are chemical components often found in low quantities that delay or inhibit oxidation of a substrate, hence extending the food's shelf life (Balboa et al., 2013**).** In terms of bioactive peptides, they seem to be the most prevalent antioxidative compounds found in food. When compared to natural antioxidants, synthetic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) are more effective. However, because to their possible health concerns and toxicity, the use of these chemical antioxidants requires tight regulation (Admassu et al., 2018). To date, there has been no study on in silico analysis of bioactive peptides derived from the *Pyropia umbilicalis* protein**.**

CHAPTER 3: MATERIALS AND METHODS

3.1 Materials: Bioinformatic tools-

- **Uniprot** (https://www.uniprot.org/).

Uniprot is a free protein sequence and function database with several genome sequencing entries. The research literature provides a lot of protein biological function information.

- **BIOPEP-UWM database**

(http://www.uwm.edu.pl/biochemia/index.php/pl/biopep)

The virtual BIOPEP-UWM database is an additional resource to the current dataset of bioactive peptide sequences.

- **NCBI** (https://www.ncbi.nlm.nih.gov/)

The National Center for Biotechnology Information (NCBI) is a vital hub for bioinformatics resources, including a wide variety of databases used in the fields of biotechnology and biomedicine.

- **ToxinPred** (https://webs.iiitd.edu.in/raghava/toxinpred/index.html)

ToxinPred is an in silico tool for peptide toxicity prediction and design.

- **ClustalW2** (http://www.ebi.ac.uk/Tools/msa/clustalw2/)

ClustalW2 aligns divergent sequences physiologically. It lines up the best match for given sequences to identify similarities, differences, and identities.

3.2 Methods

Through MALDI-TOF/MS (matrix-assisted laser desorption ionization-time-of-flight/mass spectrometry), the protein extracted from *Pyropia umbilicalis* was evaluated. MALDI-TOF/MS data analysis was used to identify the protein. Using NCBI (National Center for Biotechnology Information) (https://www.ncbi.nlm.nih.gov) and BIOPEP-UWM, additional research was conducted.

An elaborate flowchart summarizing the entire procedure is provided. (Fig. 3.1).

3.2.1 Protein sequence and enzyme selection for proteolysis

Five *Pyropia umbilicalis* proteins that were found by MS analysis and had the accession numbers P51377, Q0ZHI8, P51368, Q1XDA9, and P11393 were chosen (based on

highest coverage). Using the UniProt database, which is accessible at https://www.uniprot.org/, the five proteins' FASTA-formatted protein sequences and general properties were gathered. In order to carry out in silico proteolysis and generate a number of bioactive peptides, the plant proteases ficin (EC 3.4.22.3), papain (EC 3.4.22.2), and stem bromelain (EC 3.4.22.32) were employed from the BIOPEP-UWM database (http://www.uwm.edu.pl/biochemia/index.php/pl/biopep). It was found that peptides, including ACE inhibitor and antioxidative peptides, have been successfully extracted using papain from wheat gluten, bovine muscle proteins, patatin (potato tuber protein), and quinoa (diBernardini et al. 2012; Fu et al. 2015; Nongonierma et al. 2015; Wang et al. 2007). While studying patatin in vitro with 16 different enzymes, it was found that papain generated the second-most bioactive peptides, after chymotrypsin C. (Nongonierma et al. 2015). The literature used bromelain, another plant-based protease, to explore bioactive peptides in cereal crop RuBisCO together with papain and thermolysin (Udenigwe et al. 2013). They are also food-grade enzymes that can be purchased commercially. These factors led to the selection of these food-processing proteases.

3.2.2 Analysis of the *P. umbilicalis* protein as a possible source of bioactive peptides using the BIOPEP-UWM database application

Assessment of the chosen protein sequences' potential to emit bioactive peptides was performed through the BIOPEP-UWM database, that comprises 4485 identified bioactive peptides with known biological activity (accessed on 19 June, 2022).Using the "profiles of potential biological activity" action menu in BIOPEP-UWM, number of peptides with bioactivity was calculated. All of the predicted activities of each protein were investigated. The fragment containing the particular activity was manually counted. The most frequent occurance were selected for reporting.

The following equation was used to determine the frequency of bioactive fragments (A) appeared in the protein sequence.

$$\mathbf{A = a/ N}$$

Here, ‘N’ is the total number of amino acid residues in the protein, ‘a’ is the number of fragments having a certain activity in the protein sequence. The total frequency of bioactive fragments in each of the five protein sequences ((∑A) was also calculated.

The frequency of bioactive fragments in the protein sequence was assessed independently for the ACE inhibitor, DPP IV inhibitor, DPP III inhibitor, and antioxidant. The protein's bioactivity potential is determined by its bioactive peptide frequency (A). The sequence's value indicates the number of cryptic bioactive peptides (Minkiewicz et al., 2008).

The term "potential biological activity" denotes to a protein's beneficial properties, such as ACE inhibition, antioxidant activity, DPP IV inhibition etc. From the BIOPEP-UWM analysis, the number of potential bioactive for each subclass was manually calculated (bioactivities where B values is available).To determine the potential biological activity of protein (B) the following equation was used-

$$B = \frac{\sum_{i=1}^{k} \frac{a_i}{EC_{50i}^*}}{N}$$

where a_i is the fraction of the protein sequence occupied by the i-th bioactive fragment, EC_{50i}* is the concentration of the i-th bioactive peptide corresponding to its half-maximal activity [μM] or half-maximal inhibition (IC_{50}) in the case of peptides with inhibitory activity, k is the number of distinct fragments with the given activity, and N is the total number of amino acid residues. B values were found only for ACE inhibitor, DPP IV inhibitor, renin inhibitor, alpha-glucosidase inhibitor, and opioid by BIOPEP-UWM.

3.2.3. Release of potential peptides using in silico proteolysis

For in silico proteolysis, the BIOPEP-UWM database was employed, and ficin, papain, and stem bromelain— three plant proteases were used separately for each protein sequence to release different bioactive peptides. Using the 'enzyme/s action' tool from BIOPEP-UWM, in-silico proteolysis was carried out. Thus, the frequency and relative frequency of peptides released by certain proteases (A_E and W, respectively) were estimated using the following equations:

$$A_E = \frac{d}{N}$$

Where d is the number of peptides with a specific activity that are generated from the protein sequence when a particular enzyme is applied, and N represents the total amount of amino acid residues in the protein.

$$W = \frac{A_E}{A}$$

The theoretical degree of hydrolysis (DHt) is typically employed using the following formula to estimate the percent degree of hydrolysis of in silico digestion of peptides.

$$DH_t = \frac{d}{D} \times 100\%$$

Where D is the total number of peptide bonds that are present in the primary sequence of the protein, and d is the number of peptide bonds that are hydrolyzed

3.2.4 Sequence alignment

Using NCBI, the protein sequence of *Pyropia umbilicalis* was compared to species possessing the same protein. For the sequence alignment, species that contain the five proteins seen in *P. umbilicalis* were chosen. The application ClustalW2 (http://www.ebi.ac.uk/Tools/msa/clustalw2/) was utilized in order to perform multiple sequence alignments (Larkin et al. 2007). NCBI provided the protein sequences that were used to determine sequence homology (identity).

ToxinPred (https://webs.iiitd.edu.in/raghava/toxinpred/protein.php), a suite of bioinformatics tools, was used to evaluate toxicity.To predict toxicity the support vector machine (SVM) based prediction approach with a toxicity threshold value of 0.0 was selected (Lafarga et al.,2014).

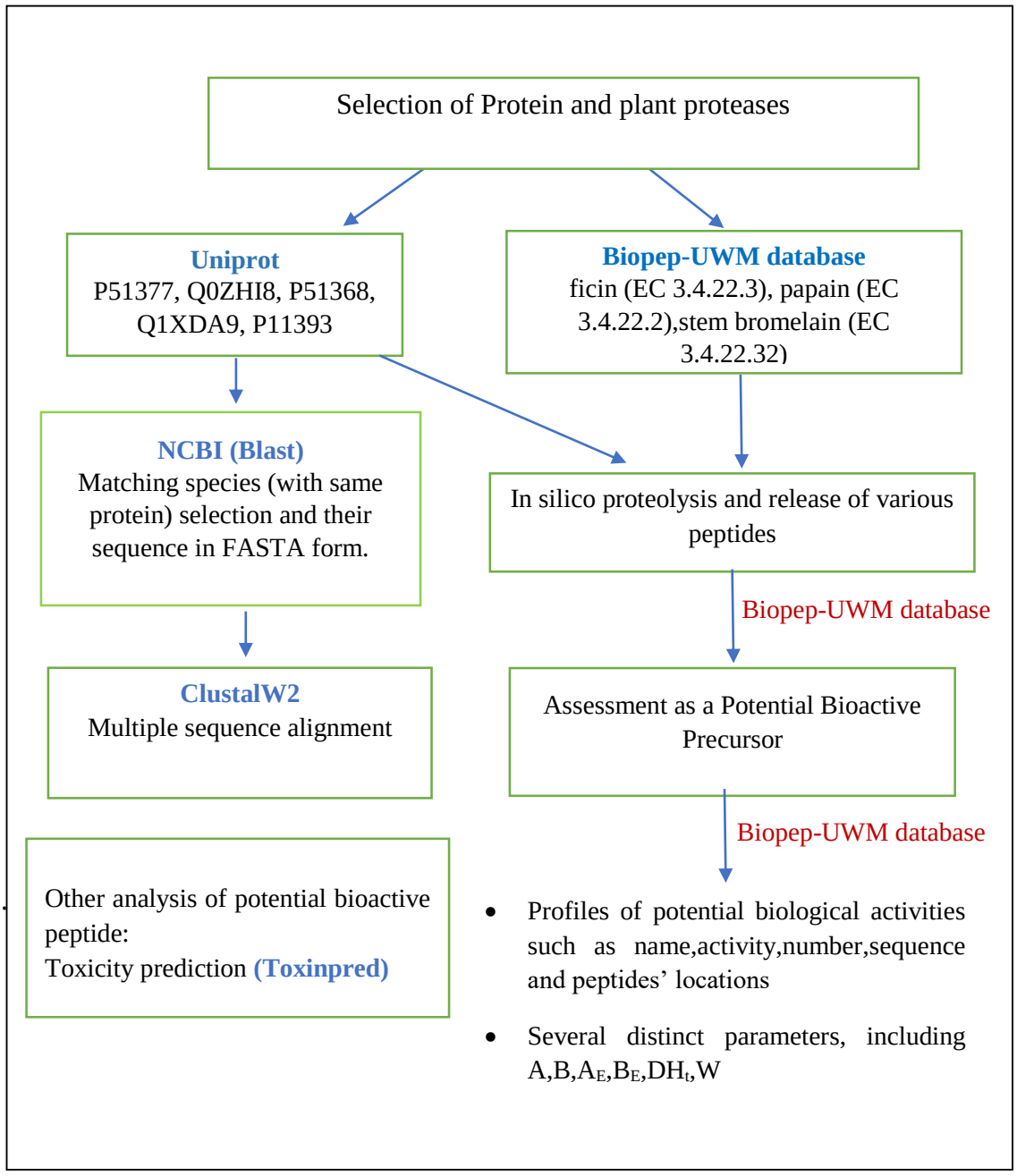

Figure 3.1: Methodology of the study.

CHAPTER 4: RESULTS

4.1 The protein Sequences of chosen proteins

The accession numbers for the identified proteins were provided in Table 4.1. There were 162–177 different types of amino acids found in the five proteins chosen for this study. The amino acid content and molecular weight of the protein B-phycoerythrin beta chain is maximum at 177 and 18,554 Da, respectively.

Table 4.1: A list of the proteins and their corresponding accession numbers that were analyzed by in silico methods.

Identified protien	Entry name(accession number)	Amino acid length	Molecular mass(Da)
C-phycocyanin beta chain	P51377	172	18,198
R-phycoerythrin beta chain	Q0ZHI8	177	18,423
R-phycoerythrin alpha chain	P51368	164	17,698
C-phycocyanin alpha chain	Q1XDA9	162	17,464
B-phycoerythrin beta chain	P11393	177	18,554

4.2 Evaluation of *P. umbilicalis* as a Bioactive Peptide Precursor

The BIOPEP-UWM database lists the anticipated total quantity of bioactive peptides that will be released from the proteins. Five different *P. umbilicalis* proteins were found to contain fragments with 22 biological activities (Fig. 2) based on data from the BIOPEP database. After analysing, the following activities: ACE inhibitor, activating ubiquitin-mediated proteolysis, alpha-glucosidase inhibitor, antiamnestic, antioxidative, CaMPDE inhibitor, dipeptidyl peptidase III inhibitor, dipeptidyl peptidase IV inhibitor, Hypotensive, regulating, renin inhibitor, and stimulating activities were found in all protein sequences (Table 4.2). The potential activities (B) were also provided by BIOPEP-UWN database. ACE inhibitor and DPP IV inhibitor fragments showed the highest biological activity. The ACE inhibitor had a higher B

value (potential bioactivity), but the DPP IV inhibitor contained more active fragments (99-112) than the ACE inhibitor did (70-86).

C-phycocyanin alpha subunit had the highest value of the bioactive peptides' total frequency, ∑A 1.6114, followed by R-phycocyanin alpha subunit, ∑A 1.4635. (Table 4.3). $A_{ACE\ inhibitor}$ of 0.5309, $A_{DPP\ IV\ inhibitor}$ of 0.6111, and $A_{antioxidative}$ of 0.1111 make up the overall frequency of occurrence, ∑A 1.6114 of C-phycocyanin alpha subunit. This suggests that ACE and DPP IV peptides account for the majority of the frequency of occurrences. For the various proteins, the occurrence ranges from 0.6111 to 0.628 (DPP IV) and 0.407 to 0.5309 (ACE Inhibitor). The total occurrences (∑A) range from 1.2906 to 1.6114 and similar observation detected regarding the major portions of each protein. Since ACE and DPP IV inhibitor activities were responsible for the vast majority of observed bioactive fragments, they were the primary focus of this research. However, no comparison can be drawn because no research on the in-silico production of bioactive peptides from this seaweed protein has been published.

No in-silico investigation using *Pyropia sp*. protein to create bioactive peptides has been published yet, therefore comparisons cannot be made.

Table 4.2: Total number of predicted bioactive peptides and predicted biological activity (B) of proteins found by BIOPEP

Activities	**Number of fragments**				
	C-phycocyani-n beta chain	**R-phycoerythri-n beta chain**	**R-phycoeryt-hrin alpha chain**	**C-phycocyani-n alpha chain**	**B-phycoeryt-hrin beta chain**
ACE inhibitor	70 (0.0062116)	77 (0.011676)	83 (0.021364)	86 (0.062475)	78 (0.007301)
Activating ubiquitin-mediated proteolysis	3	3	2	1	3
Alpha-glucosidase inhibitor	2 (5.69E-07)	2 (4.35E-07)	6 (1.95E-06)	5 (1.61E-06)	1 (2.20E-07)
Antiamnestic	2	2	2	4	2

Activities	C-phycocyani-n beta chain	R-phycoerythr-in beta chain	R-phycoeryt-hrin alpha chain	C-phycocyani-n alpha chain	B-phycoeryt-hrin beta chain
Antioxidative	5	6	7	18	8
CaMPDE inhibitor	1	1	1	1	1
Dipeptidyl peptidase III inhibitor	14	14	15	13	18
Dipeptidyl peptidase IV inhibitor	106 (0.0004496)	112 (0.000325)	103 (0.000169)	99 (0.000138)	110 (0.000243)
Hypolipidemic	1	-	-	-	
Hypotensive	2	6	5	4	4
Regulating	2	2	4	7	3
Renin inhibitor	6	5	2	7	7(0.000614)
Stimulating	6	8	4	4	7
Anticancer	-	1	-		-
Antithrombotic	-	2	2	4	-
Bacterial permease ligand	-	1	-	-	-
Anti-inflammatory	-	-	1	1	-
Neuropeptide	-	-	3	4	-
Chemotactic	-	-	-	1	-
inhibitor	-	-	-	1	-
Opioid	-	-	-	1 (6.17E-06)	-
Tyrosinase inhibitor	-	-	-	1	-

Table 4.3: Occurrence of activity-specific peptides in defined protein sequences with a given activity (A)

Proteins	No of activities	∑A	A_1 (ACE inhibitor)	A_2 (DPP IV Inhibitor)	A_3 (DPP III Inhibitor)	A_4 (Antioxidative)
C-phycocyanin beta chain	14	1.2906	0.407	0.6163	0.0814	0.0291
R-phycoerythrin beta chain	15	1.3521	0.4302	0.6257	0.0782	0.0335
R-phycoerythrin alpha chain	15	1.4635	0.5061	0.628	0.0915	0.0427
C-phycocyanin alpha chain	19	1.6114	0.5309	0.6111	0.0741	0.1111
B-phycoerythrin beta chain	14	1.3839	0.4407	0.6215	0.1017	0.0452

4.3 In silico proteolysis of *P. umbilicalis* protein to produce peptides

Enzymolysis is the process by which bioactive peptides produced from natural dietary protein are released for their functions. Numerous bioactive peptides were previously produced from these natural dietary sources utilizing various enzymes (Fu et al., 2016; Lin et al., 2018). There are 33 different types of enzymes included in the BIOPEP-UWM database, but for this investigation, ficin, papain, and stem bromelain— plant proteases were selected since they are plant proteases and readily available in the market. Utilizing the "Enzyme action" tool of BIOPEP-UWM, in-silico analysis was carried out. By using in silico proteolysis, hydrolysates with DHt values between

39.2045% and 62.5731% were obtained (Table 4.4). Stem bromelain produced the highest percentage of DHts for all protein sequences out of the three proteases used. Peptide release and bioactive peptide release were not proportional. Several plant proteins, including wheat gluten, bovine muscle protein, patatin (the protein found in potato tubers), and quinoa, have been demonstrated to efficiently generate ACE inhibitor and antioxidative peptides when treated with papain (Agirbasli and Cavas, 2017).An earlier in silico analysis of the proteins from Quinoa and Soybeans revealed that stem bromelain had the highest DH (Guo et al.,2020). Papain hydrolysis in the green alga *Ulva lactuca* can release ACE-1 inhibitor and renin inhibitory peptides, according to an in vitro study (Garcia et al., 2019)

Table 4.4: The degree of hydrolysis (DH_t) that was calculated using in silico proteolysis.

Accession number	Protein	Papain (DH_t[%])	Ficin (DH_t[%])	Stem Bromolain (DH_t[%])
P51377	C-phycocyanin beta chain	44.5087	39.7661	62.5731
Q0ZHI8	R-phycoerythrin beta chain	39.7727	39.2045	60.7955
P51368	R-phycoerythrin alpha chain	39.8773	41.7178	57.6687
Q1XDA9	C-phycocyanin alpha chain	44.0994	44.0994	57.1429
P11393	B-phycoerythrin beta chain	39.7727	41.4773	61.9318

This study also estimated the parameters A_E, W, and B_E for each protein sequence (Table 4.5). The relative frequency of releasing fragments with given activity by selected enzymes (W) was higher in the antioxidative bioactivity (0.2862) released from stem bromolain protease, whereas the release frequency (A_E) was higher in DPP-IV inhibitory peptides (0.1207) produced from papain protease. The relative frequency of release of fragments (W) ranged between 0.0465 and 0.2435 for ACE inhibitory peptides, with the release frequency of occurrence falling between 0.0247 and

0.1073. DPP IV inhibitor's A_E and W ranges were 0.0565 to 0.1207 and 0.0893 to 0.1981, respectively.

Table 4.5(a): The estimated frequency of bioactive fragments release from a *certain P. umbilicalis* protein using in silico enzymolysis (ACE inhibitor, DPP IV Inhibitor)

Protien	Enzyme	ACE inhibitor		DPP IV Inhibitor	
		A_E	W	A_E	W
C-phycocyanin beta chain	Papain	0.0698	0.1715	0.1207	0.1981
	Ficin	0.0349	0.0857	0.064	0.1038
	Stem Bromolain	0.0581	0.1428	0.1105	0.1793
R-phycoerythrin beta chain	Papain	0.0339	0.0779	0.0904	0.1429
	Ficin	0.0395	0.0908	0.0565	0.0893
	Stem Bromolain	0.0904	0.2078	0.096	0.1517
R-phycoerythrin alpha chain	Papain	0.0793	0.1567	0.0793	0.1263
	Ficin	0.0488	0.0964	0.0854	0.136
	Stem Bromolain	0.0793	0.1567	0.0854	0.136
C-phycocyanin alpha chain	Papain	0.0679	0.1279	0.0679	0.1111
	Ficin	0.0247	0.0465	0.0617	0.101
	Stem Bromolain	0.0741	0.1396	0.0864	0.1414
B-phycoerythrin beta chain	Papain	0.0565	0.1282	0.096	0.1545
	Ficin	0.0508	0.1153	0.0678	0.1091
	Stem Bromolain	0.1073	0.2435	0.113	0.1818

Table 4.5(b): The estimated frequency of bioactive fragments release from a *certain P. umbilicalis* protein using in silico enzymolysis (DPP III Inhibitor, Antioxidative)

Protien	Enzyme	DPP - III Inhibitor		Antioxidative	
		A_E	W	A_E	W
C-phycocya-nin beta chain	Papain	-	-	-	-
	Ficin	-	-	-	-
	Stem Bromolain	0.0233	0.2862	0.0058	0.1993
R-phycoer-ythrin beta chain	Papain	0.0056	0.0708	-	-
	Ficin	-	-	-	-
	Stem Bromolain	0.0226	0.2857	-	-
R-phycoery-thrin alpha chain	Papain	-	-	-	-
	Ficin	0.0061	0.0667	0.0061	0.1429
	Stem Bromolain	0.0305	0.3333	-	-
C-phycocya-nin alpha chain	Papain	-	-	0.0185	0.1665
	Ficin	0.0062	0.0837	0.0247	0.2223
	Stem Bromolain	0.0123	0.1660	0.0185	0.1665
B-phycoery-thrin beta chain	Papain	0.0056	0.0056	-	-
	Ficin	-	-	0.0056	0.1239
	Stem Bromolain	0.0395	0.3884	0.0056	0.1239

Table 4.6 lists the projected peptides that will be released from Pyropia proteins by in silico enzymolysis, including DPP-IV, ACE inhibitory, DPP - III Inhibitor, and Antioxidative peptides. The database already contains these peptides. According to in-silico proteolysis papain and stem bromelain had a higher potential for releasing bioactive peptides.

Table 4.6: Bioactive peptides expected to be generated from *P. umbilicalis* protein based on in silico enzymolysis

Enzyme	ACE inhibitors	DPP-IV inhibitors	DPP - III Inhibitor	Antiox id-ative
Papain	52 AF (6), AG (11), AI (1), AR (7), AV (3), AEL (1), ASL (1), DG (2), DR (3), DY (1), ER (1), EF (1), KF (1), NG (3), PG (1), PT (2), QP (1), QG (3), SF (1), SG (1), VG (1)	78 AE (1), AD (2), AF (6), AG (11), AL (13), APG (1), AS (3), AT (3), AV (3), DR (3), ET (1), KF (1), ML (3), NE (1), NG (3), NL (2), NN (1), NR (3), NT (2), PG (1), PT (2), QG (3), QL (2), QP (1), SF (1), SL (2), YI (2), VG (1)	2 YI(2)	3 EL(2),YYL(1)
Ficin	34 TG(2),NG(4),NK(3),AR(3),EF(1),DR(3),VG(3),AG(3),VR(1),DG(2),IAPG(1),AY(1),AF(1),DY(2),VY(1),QG(1),IR(1),PG(1),	57 VV(1),AL(5),DR(3),MK(3),ML(3),NG(4),TG(2),VL(3),VS(4),VR(1),AG(3),AS(4),VG(3),AF(1),AY(1),ES(1),MR(1),NH(1),NL(2),PS(2),TL(1),WY(1),PY(1),QG(1),QY(1),TK(1),VY(1),IR(1),PG(1)	2 MR(1),VY(1)	6 AY(1),EL(2),WY(1),VY(1),IR(1)
Stem Bromelain	63 YA(4),DA(8),EG(1),NG(4),PG(2),YV(4),EF(1),DR(2),IA(5),DG(3),KA(3),EV(2),PT(4),PR(1),YL(3),QG(3),EA(6),CF(1),IG(2),HG(2),KF(2)	77 IA(5),YT(3),KF(2),MV(3),NG(4),NV(2),PS(3),PT(4),QA(5),QG(3),QS(2),YA(4),YL(3),KA(3),DR(1),ES(1),EV(2),NL(2),PV(1),YR(1),YV(4),ML(2),NA(4),NR(2),NT(2),PG(2),EG(1),ET(1),KV(1),QL(1),YF(1),MA(2)	18 DA(8),KA(3),YL(3),PR(1),YF(1),YR(1),PR(1)	7 EL(5),YYL(2)

4.4 Sequence alignment

As a result of multiple sequence alignment of different protiens of *Pyropia umbilicalis* by ClustalW2, it was found that *Palmaria palmate*,an economically beneficial seaweed contains similar protein sequence homology. The positivity in protein between *Pyropia umbilicalis* and *Palmaria palmate* is 92%–95%. A sample multiple sequence alignment is given. This allows us to compare them based on the homology of their sequences.

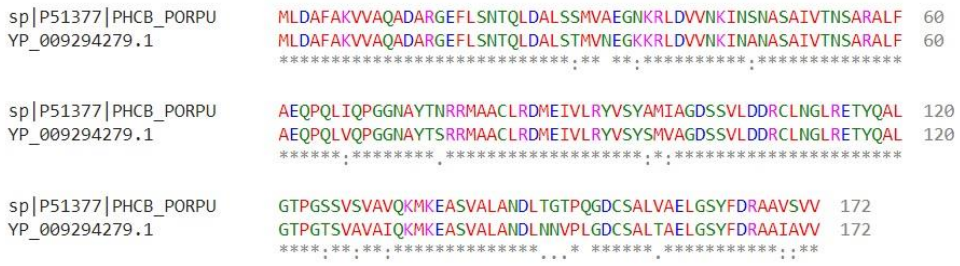

Figure 4.1(a): Sequence alignment of *Pyropia umbilicalis* vs *Palmaria palmate* (C-phycocyanin beta chain)

C-phycocyanin beta chain of *Pyropia umbilicalis* vs *Palmaria palmate* showed 100% query coverage [Figure 4.1(a)]. The length of the both sequence was 172.Identities was 154/172(90%) and the positivity was 165/172(95%).

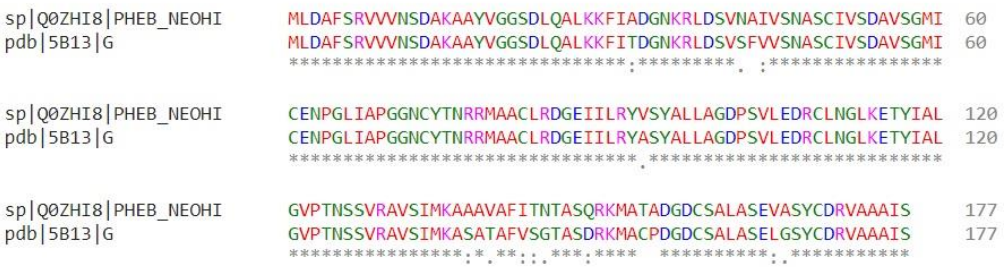

Figure 4.1(b): Sequence alignment of *Pyropia umbilicalis* vs *Palmaria palmate* (R-phycoerythrin beta chain)

R-phycoerythrin beta chain of *Pyropia umbilicalis* vs *Palmaria Palmate* showed 100% query coverage [Figure 4.1(b)]. The length of the both sequence was 177.Identities was 162/177(92%) and the positivity was 168/177(94%).

Figure 4.1(c): Sequence alignment of *Pyropia umbilicalis* vs *Palmaria palmate* (R-phycoerythrin alpha chain)

R-phycoerythrin alpha chain of *Pyropia umbilicalis* vs *Palmaria palmate* showed 99% query coverage. The length of the both sequence was 164.Identities was 145/163(89%) and the positivity was 153/163(93%) [Figure 4.1(c)].

Figure 4.1(d): Sequence alignment of *Pyropia umbilicalis* vs *Palmaria palmate* (C-phycocyanin alpha chain)

C-phycocyanin alpha chain of *Pyropia* vs *Palmaria palmate* showed 100% query coverage.The length of the both sequence was 162.Identities was 144/162(89%) and the positivity was 154/162(95%)[Figure 4.1(d)].

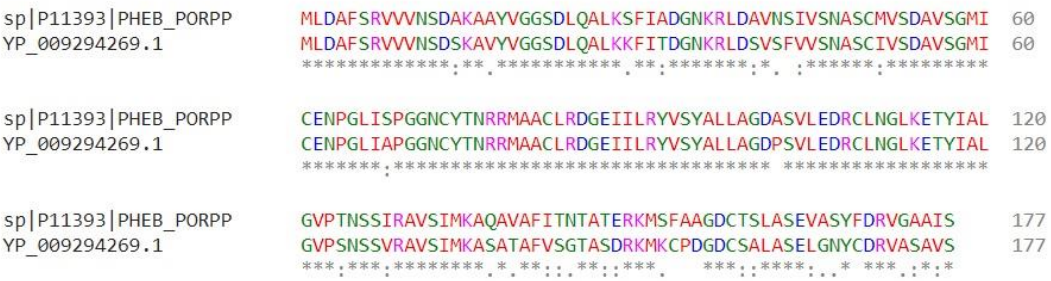

Figure 4.1(e): Sequence alignment of *Pyropia umbilicalis* vs *Palmaria palmate* (B-phycoerythrin beta chain)

B-phycoerythrin beta chain of *Pyropia umbilicalis* vs *Palmaria palmate* showed 100% query coverage.The length of the both sequence was 177.Identities was 149/177(84%) and the positivity was 163/177(92%)[Figure 4.1(e)].

Among Caulerpa species, researchers discovered that there is a wide range in RuBisCO (ls) values (92-100%) (Agirbasli and Cavas, 2017).

Based on in silico predictions of protein toxicity, it was determined that all of the chosen dipeptides are nontoxic and safe for further research and development into pharmaceutical products.

CHAPTER 5: DISCUSSION

5.1 Prediction of bioactive peptides

The most elusive bioactive peptides in *P. umbilicalis*'s protein were those with dipeptidyl peptidase-IV (DPP IV) inhibitory characteristics, according to artificial proteolysis of this seaweed's protein. Additionally, in silico analyses showed that these proteins include cryptic bioactive peptides that have the ability to lower blood pressure by inhibiting the angiotensin converting enzyme (ACE). Bioactive peptides with properties of DPP - III Inhibition, antioxidative activity were also found in this artificial proteolysis of *Pyropia umbilicalis*.

5.1.1. DPP-IV inhibitory peptide

DPP-IV is the predominant bioactive peptide in the result. Serine protease DPP-IV (EC 3.4.1.4.5) is a dipeptidyl amino peptidase that specifically cleaves X-Pro or X-Ala dipeptides from the N terminal (Hildebrandt et al.,2000) Dipeptidyl peptidase IV (DPP-IV), which is involved in the processing of incretin hormones and thus is important for glycemic control, has been mentioned in earlier literature. (Nongonierma & FitzGerald, 2019).

The decrease of insulinotropic function is caused by the fast degradation and inactivation of glucagon-like peptide 1 and gastric inhibitory peptide by DPP IV (Zeng et al, 2016). Therefore, type 2 diabetes can be treated by inhibiting DPP IV activity (Agirbasli and Cavas, 2017). DPP-IV inhibitory properties may be used to treat conditions including type 2 diabetes, oxidative stress, cardiovascular disease, and nervous system diseases, according to many studies. (Fu et al., 2016).

Diabetes is a long-term metabolic condition that causes persistently elevated blood sugar levels. The most prevalent kind of diabetes, type 2 diabetes mellitus (T2DM), is brought on by the body's inefficient utilisation of insulin. Diabetes has recently risen to the top of the list of killers on a global scale. Around 425 million individuals worldwide were diabetes patients in 2017, according to the International Diabetes Federation (IDF). By 2040, this number will reach 642 million (http://www.diabetesatlas.org). Synthetic DPP-IV medications, however, have been linked to several negative side effects, including gastrointestinal issues, allergic responses, skin-related issues, and musculoskeletal abnormalities (Liu et al., 2019). As it has been identified from numerous sepsis cases, macro algae can be a great natural source of peptides that inhibit

DPP-IV.A study conducted in vitro revealed that *G. opuntia* has strong inhibitory effects against α-amylase, α-glucosidase, and DPP-4 (IC50 0.09 mg/mL) (Makkar and Chakraborty, 2017). The enzymatic hydrolysates of numerous dietary proteins, such as milk proteins (Uchida et al., 2011), rice bran (Hatanaka et al., 2012), oat proteins (Bleakley et al.,2017), and fish proteins (Huang et al., 2012; Sila et al., 2016) have also been found to contain a large number of DPP-IV inhibitory peptides. *Gracilaria changii* protein showed in study to contain large amount of DPP-IV inhibitory peptides in in silico analysis (Sharmin et al.,2022).

5.1.2. ACE inhibitory peptide

The frequency results showed that Antihypertensive effective peptides (ACE inhibitory peptides) were the second-most released bioactive peptide. Due to its position in the renin-angiotensin system (RAS) and kallikrein-kinin system, ACE plays a significant regulatory role. In RAS, ACE converts inactive vasoconstrictor angiotensin I into the active vasoconstrictor angiotensin II. As a result of the constriction of blood vessels, ACE indirectly raises blood pressure. One of the main goals in the treatment of hypertension is the suppression of ACE activity (Shahidi and Zhong, 2008).For the treatment of cardiovascular disorders, ACE inhibitors like captopril and enalapril are frequently used as pharmaceuticals. But they frequently result in negative side effects like coughing, rashes, and taste problems. Natural ACE inhibitory peptides are a safe substitute for manufactured medications. Proline and aliphatic amino acids (isoleucine and leucine) are frequently found at the N-terminus of ACE-inhibitory peptide sequences (Lee and Hur, 2017). *Porphyra columbina* protein hydrolyzed by enzyme exhibited antihypertensive properties with >35% of ACE inhibitor (Cian et al., 2012). Inhibitory action against ACE has also been found in *Spirulina* (Lu et al., 2010; Heo et al., 2017). *Gracilaria changii* protein showed in study to contain large amount of ACE inhibitory peptides in in silico analysis (Sharmin et al.,2022).

5.1.3. Other bioactive peptides

The result revealed that DPP-III inhibitory peptide and antioxidative peptide were lower in number. A zinc-dependent hydrolase called DPP-III Inhibitor is responsible for breaking down oligopeptides of 4–12 amino acid residues. DPP III regulate endogenous opioids, which results in the modulation of pain (Sato et al., 2003). It has been linked to a number of pathophysiological functions, such as controlling blood pressure, pain

signaling, and cancer cells' oxidative stress defence (Kumar et al., 2016). Inhibitors of the crucial enkephalin-degrading enzyme dipeptidyl peptidase-III are anticipated to show promise in the treatment of pain (Khaket et al., 2015). DPP-III inhibitors are anticipated to extend the effects of naturally occurring or exogenously administered enkephalins (Dhanda et al., 2011).

Previous studies claimed that reactive oxygen causes food products to become poisonous. These harmful substances are the root cause of many chronic illnesses that affect humans, such as cancer, arteriosclerosis, aging, diabetes mellitus, inflammation, coronary heart disease, and neurological disorders. Therefore, one major technique is suppression of lipid peroxidation occurring in the living body and food items by utilizing antioxidant compounds or preservatives. This would prevent food products from such deteriorations and safeguard consumers from catastrophic diseases (Li-Chan, 2015). Preservatives, also known as antioxidants, are chemical substances that are found in biological materials but are often found in low concentrations. They work to extend the shelf life of food by preventing or delaying the oxidation of a substrate in the food. The majority of naturally occurring antioxidants are bioactive peptides (Admassu *et al*., 2018).Water-soluble molecules, such as peptides and Maillard reaction products, may potentially contribute to scavenging reactions in addition to phenolic compounds that exhibit superoxide anion radical scavenging activity (Kuda and Ikemori 2009). Biologically active peptides from *Pyropia umbilicalis* also promise antioxidative properties.

5.2. Sequence alignment

Palmaria palmata is a type of red macroalga that has gained popularity due to its high protein content and edible nature (Lopes et al., 2019).Based on the homology of their sequences, *Pyropia umbilicalis* and *Palmaria palmata* were compared. Red algae *Palmaria palmata* can be found in the Atlantic Ocean's coastal region, close to the coasts of Canada, Europe, and West Africa. It is well-known for both its medicinal and cosmetic value. *Palmaria palmata* is valued for its high protein content (Lopes et al., 2019).It is a popular macroalga for human consumption.Sequence alignment of *Pyropia umbilicalis* and *Palmaria palmata* revealed 89% sequence homology, they are mostly identical(89% sequence homology). The sequence homology value of RuBisCO subunits from cereal crops was estimated to be 92% .When paired with the grains the Caulerpa group's 49% sequence homology decreased to 39%. (Udenigwe et al., 2013).

CHAPTER 6: CONCLUSION

Bioinformatics technology have enabled extensive and low-cost research into the bioactive peptides synthesized from the proteins of food crops. In addition to helping to enhance peptide features, these in silico methods also provide information regarding peptide conformations and the interacting mechanisms of molecules within peptides. This study used ficin, papain, and stem bromelain- plant proteases to evaluate the release of biologically active peptides in silico.It reveals that a number of bioactive peptides with various activity are present in the five *Pyropia umbilicalis* protein sequences. The in silico proteolysis data revealed that all the studied plant proteases released ACE and DPP-IV inhibitory peptides more often, indicating that these proteins were involved in the synthesis of these peptides.This red algae also showed similar protein sequence to Palmaria palmate,a economically beneficial seaweed. In conclusion, this in silico study shown that *P. umbilicalis* is suited for more research to identify several bioactive peptides. The research indicates that owing to their therapeutic effects on type 2 diabetes and cardiovascular illnesses, this red algae could be regarded for the production of functional foods or pharmaceuticals. According to the findings, research conducted in vitro is necessary in order to obtain ACE and DPP-IV inhibitors, DPP-III inhibitors, and antioxidative peptides from this species.

CHAPTER 7: RECOMMENDATIONS AND FUTURE PERSPECTIVE

The seaweed, *Pyropia umbilicalis* protein extract needs to be the subject of more research in order to produce pharmaceuticals, functional products, or value-added products from this seaweed protein. The recommendations for additional research are as follows.

- Research on *P. umbilicalis* protein's ability to produce potentially bioactive peptides, particularly DPP-IV and ACE inhibitory peptides should be carried out.

- Seaweed protein extract should be studied for its potential to generate bioactive peptides with antioxidant, anti-diabetic, and antibacterial activities.
- Seaweed powder's physiochemical characteristics can be investigated. Research on the physicochemical characteristics of seaweed protein extract.
- Study on fractionation and purification of digestive enzymes from seaweed protein extract can be implemented.

- It is recommended that research be conducted to determine the mechanism of ACE inhibition and to identify the active elements of the seaweed protein extract (amino acid sequence).

- Research on developing pharmaceutical products aimed at boosting both the commercial viability of existing drugs and the quality of life for patients.

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Appendices

Appendix-A: Profiles of protiens potential biological activity

C-phycocyanin beta chain (P51377)

ID	Name of peptide	Activity	Number	Sequence
3460	Prolyl endopeptidase inhibitor	antiamnestic	2	PG
3257	beta-lactokinin	ACE inhibitor	1	RL
3380	ACE inhibitor	ACE inhibitor	1	RY
3551	ACE inhibitor (from bovine beta-Lg)	ACE inhibitor	1	LF
3563	ACE inhibitor	ACE inhibitor	1	AY
7562	ACE inhibitor from soy hydrolysate	ACE inhibitor	1	IA
7583	ACE inhibitor	ACE inhibitor	1	AF
7585	ACE inhibitor	ACE inhibitor	1	LA
7586	ACE inhibitor	ACE inhibitor	1	KR
7588	ACE inhibitor	ACE inhibitor	2	RA
7589	ACE inhibitor	ACE inhibitor	1	YA
7590	ACE inhibitor	ACE inhibitor	2	AA
7599	ACE inhibitor	ACE inhibitor	1	GL
7600	ACE inhibitor	ACE inhibitor	1	AG
7606	ACE inhibitor	ACE inhibitor	3	DA
7607	ACE inhibitor	ACE inhibitor	2	GS
7612	ACE inhibitor	ACE inhibitor	2	GT
7615	ACE inhibitor	ACE inhibitor	1	GE
7616	ACE inhibitor	ACE inhibitor	1	GG
7617	ACE inhibitor	ACE inhibitor	1	QG
8193	ACE inhibitor	ACE inhibitor	1	AI
7619	ACE inhibitor	ACE inhibitor	2	LG
7620	ACE inhibitor	ACE inhibitor	2	GD
7621	ACE inhibitor	ACE inhibitor	1	TG
7622	ACE inhibitor	ACE inhibitor	1	EG
7623	ACE inhibitor	ACE inhibitor	1	EA
7624	ACE inhibitor	ACE inhibitor	1	NG
7625	ACE inhibitor	ACE inhibitor	2	PG
7635	ACE inhibitor from k-CN (fr. 51-53)	ACE inhibitor	1	VAV
7649	ACE inhibitor from red algae	ACE inhibitor	1	LRY
7680	ACE inhibitor from pea vicilin	ACE inhibitor	1	QK
7684	ACE inhibitor from garlic	ACE inhibitor	2	SY
7698	ACE inhibitor from wakame	ACE inhibitor	2	NK
7741	ACE inhibitor	ACE inhibitor	1	RR
7742	ACE inhibitor	ACE inhibitor	2	AR
7826	ACE inhibitor	ACE inhibitor	1	EI

7832	ACE inhibitor	ACE inhibitor	1	LN
7834	ACE inhibitor	ACE inhibitor	1	TQ
7837	ACE inhibitor	ACE inhibitor	2	PQ
7839	ACE inhibitor	ACE inhibitor	1	ME
7841	ACE inhibitor	ACE inhibitor	1	KE
8184	ACE Inhibitor	ACE inhibitor	1	IQP
8951	ACE inhibitor	ACE inhibitor	2	AV
9073	ACE inhibitor	ACE inhibitor	2	TP
9075	ACE inhibitor	ACE inhibitor	1	DM
9077	ACE inhibitor	ACE inhibitor	1	YV
9088	ACE inhibitor	ACE inhibitor	1	AEL
9173	ACE inhibitor	ACE inhibitor	1	RG
9213	ACE inhibitor	ACE inhibitor	3	LR
9566	ACE inhibitor	ACE inhibitor	2	QP
9942	ACE inhibitor	ACE inhibitor	1	EF
10091	ACE inhibitor	ACE inhibitor	2	DR
3285	Antithrombotic peptide	antithrombotic	2	PG
8320	Glucose uptake stimulating peptide	stimulating	2	VL
8321	Glucose uptake stimulating peptide	stimulating	1	LV
8322	Glucose uptake stimulating peptide	stimulating	2	IV
8324	Glucose uptake stimulating peptide	stimulating	1	LI
2754	peptide regulating the stomach mucosal membrane activity	regulating	2	PG
7866	peptide from Okara protein	antioxidative	1	AY
7888	antioxidative peptide	antioxidative	1	EL
8219	antioxidative peptide	antioxidative	1	TY
9879	Antioxidative peptide	antioxidative	1	SVL
10051	Antioxidative peptide	antioxidative	1	RY
10259	Antioxidative peptide	antioxidative	1	LAN
10141	Hypotensive peptide	hypotensive	2	AA
4005		activating ubiquitin-mediated proteolysis	2	RA
4006	Ubiqitin-mediated proteolysis activating peptide	activating ubiquitin-mediated proteolysis	1	LA
3172	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	5	VA
3173	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MA

3175	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LA
3176	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	FA
3183	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	VV
8503	Dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	TP
8525	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IA
8526	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	RA
8532	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	QP
8555	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	FL
8559	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	5	AL
8561	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GL
8637	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	AA
8693	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IQP
8696	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YT
8757	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AD
8758	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	AE
8759	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AF
8760	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AG

8762	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	AS
8764	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	AV
8765	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AY
8769	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	DR
8770	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EG
8772	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EI
8774	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	ET
8781	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GE
8783	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GG
8804	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IN
8805	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IQ
8808	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KE
8812	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KI
8814	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KR
8817	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KV
8821	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LI
8823	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LN

8824	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LT
8825	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LV
8826	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	ME
8830	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MI
8831	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MK
8832	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	ML
8837	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MV
8839	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	NA
8840	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	ND
8843	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NG
8849	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NR
8850	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NT
8855	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	PG
8861	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	PQ
8867	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	QA
8871	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QG
8874	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	QL

8882	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RG
8886	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RL
8887	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RM
8889	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RR
8895	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	5	SV
8897	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	SY
8901	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TG
8907	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	TN
8908	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TQ
8914	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TY
8922	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VL
8924	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VN
8925	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VQ
8926	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	VS
8927	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VT
8932	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YA
8935	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YF

8943	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YQ
8946	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YV
9650	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	1	EA
9695	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	1	AD
9478	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	3	LR
9480	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	YF
9485	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	RR
9487	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	GE
9492	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	3	DA
9499	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	LA
9500	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	FA
9502	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	FL
9507	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	SM
8250	CaMPDE inhibitor	CaMPDE inhibitor	1	EF
2842	Renin inhibitor	renin inhibitor	3	LR
8251	Renin inhibitor	renin inhibitor	1	EF
9430	Renin inhibitor	renin inhibitor	1	NR
9433	Renin inhibitor	renin inhibitor	1	YA
9580	Hypolipidemic peptide	hypolipidemic	1	EF

R-phycoerythrin beta chain (Q0ZHI8)

ID	Name of peptide	Activity	Number	Sequence
3460	Prolyl endopeptidase inhibitor	antiamnestic	2	PG

3257	beta-lactokinin	ACE inhibitor	1	RL
3380	ACE inhibitor	ACE inhibitor	1	RY
3518	ACE inhibitor	ACE inhibitor	1	VAA
3563	ACE inhibitor	ACE inhibitor	1	AY
7507	ACE inhibitor from Alaskan pollack skin	ACE inhibitor	1	PGL
7562	ACE inhibitor from soy hydrolysate	ACE inhibitor	3	IA
7583	ACE inhibitor	ACE inhibitor	2	AF
7584	ACE inhibitor	ACE inhibitor	1	AP
7585	ACE inhibitor	ACE inhibitor	2	LA
7586	ACE inhibitor	ACE inhibitor	1	KR
7587	ACE inhibitor	ACE inhibitor	1	VP
7588	ACE inhibitor	ACE inhibitor	1	RA
7589	ACE inhibitor	ACE inhibitor	1	YA
7590	ACE inhibitor	ACE inhibitor	6	AA
7594	ACE inhibitor	ACE inhibitor	1	VG
7597	ACE inhibitor	ACE inhibitor	1	GM
7599	ACE inhibitor	ACE inhibitor	2	GL
7600	ACE inhibitor	ACE inhibitor	1	AG
7606	ACE inhibitor	ACE inhibitor	3	DA
7607	ACE inhibitor	ACE inhibitor	1	GS
7608	ACE inhibitor	ACE inhibitor	1	GV
7615	ACE inhibitor	ACE inhibitor	1	GE
7616	ACE inhibitor	ACE inhibitor	2	GG
8193	ACE inhibitor	ACE inhibitor	2	AI
7618	ACE inhibitor	ACE inhibitor	1	SG
7619	ACE inhibitor	ACE inhibitor	1	LG
7620	ACE inhibitor	ACE inhibitor	2	GD
7624	ACE inhibitor	ACE inhibitor	1	NG
7625	ACE inhibitor	ACE inhibitor	2	PG
7628	ACE inhibitor from kappa-CN (fr. 67-68)	ACE inhibitor	1	VR
7649	ACE inhibitor from red algae	ACE inhibitor	1	LRY
7681	ACE inhibitor from soy	ACE inhibitor	3	DG
7684	ACE inhibitor from garlic	ACE inhibitor	2	SY
7692	ACE inhibitor	ACE inhibitor	1	KF
7698	ACE inhibitor from wakame	ACE inhibitor	1	NK
7741	ACE inhibitor	ACE inhibitor	1	RR
7743	ACE inhibitor	ACE inhibitor	2	KA
7819	ACE inhibitor from wheat gliadin	ACE inhibitor	1	IAP
7822	ACE inhibitor from micro algae	ACE inhibitor	1	IAPG
7826	ACE inhibitor	ACE inhibitor	1	EI
7828	ACE inhibitor	ACE inhibitor	1	EV
7831	ACE inhibitor	ACE inhibitor	1	LQ

7832	ACE inhibitor	ACE inhibitor	1	LN
7833	ACE inhibitor	ACE inhibitor	1	PT
7841	ACE inhibitor	ACE inhibitor	1	KE
8126	ACE inhibitor	ACE inhibitor	1	VAF
8951	ACE inhibitor	ACE inhibitor	3	AV
9077	ACE inhibitor	ACE inhibitor	2	YV
9079	ACE inhibitor	ACE inhibitor	1	IL
9213	ACE inhibitor	ACE inhibitor	2	LR
9326	ACE inhibitor	ACE inhibitor	1	LGV
10091	ACE inhibitor	ACE inhibitor	2	DR
3285	Antithrombotic peptide	antithrombotic	2	PG
8320	Glucose uptake stimulating peptide	stimulating	1	VL
8322	Glucose uptake stimulating peptide	stimulating	2	IV
8323	Glucose uptake stimulating peptide	stimulating	1	IL
8324	Glucose uptake stimulating peptide	stimulating	1	LI
8325	Glucose uptake stimulating peptide	stimulating	1	II
8326	Glucose uptake stimulating peptide	stimulating	1	LL
8330	Stimulating vasoactive substance release	stimulating	1	SE
2754	peptide regulating the stomach mucosal membrane activity	regulating	2	PG
8318	Dvl protein binding	anticancer	1	VVV
7866	peptide from Okara protein	antioxidative	1	AY
8217	Antioxidative peptide	antioxidative	2	LK
8219	antioxidative peptide	antioxidative	1	TY
9879	Antioxidative peptide	antioxidative	1	SVL
10051	Antioxidative peptide	antioxidative	1	RY
3751		bacterial permease ligand	1	KK
10141	Hypotensive peptide	hypotensive	6	AA
4005		activating ubiquitin-mediated proteolysis	1	RA
4006	Ubiqitin-mediated proteolysis activating peptide	activating ubiquitin-mediated proteolysis	2	LA
3172	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	VA

3173	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	MA
3174	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	KA
3175	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	LA
3177	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AP
3181	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VP
3182	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LL
3183	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VV
8500	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	APG
8525	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	IA
8526	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RA
8530	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NP
8531	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	TA
8559	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	4	AL
8561	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	GL
8594	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VR
8637	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	6	AA

8645	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LIAP
8649	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VGGSDLQALK
8696	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YT
8757	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	AD
8759	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	AF
8760	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AG
8762	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	4	AS
8763	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AT
8764	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	AV
8765	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AY
8767	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	DP
8769	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	DR
8772	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EI
8774	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	ET
8775	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EV
8781	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GE

8783	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	GG
8786	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GV
8801	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	II
8802	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IL
8803	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IM
8808	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KE
8809	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KF
8813	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KK
8814	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KR
8821	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LI
8823	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LN
8830	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MI
8831	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MK
8832	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	ML
8839	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	NA
8843	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NG

8849	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NR
8850	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NT
8855	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	PG
8862	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PS
8863	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PT
8867	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QA
8885	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RK
8886	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RL
8887	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RM
8889	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RR
8893	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SI
8895	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	SV
8897	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	SY
8907	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	TN
8914	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TY
8918	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VG

8922	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VL
8924	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VN
8926	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	5	VS
8932	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YA
8938	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YI
8946	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	YV
9334	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VAAA
9695	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	2	AD
9478	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	LR
9485	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	RR
9487	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	GE
9491	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	RV
9492	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	3	DA
9499	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	LA
9510	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	YI
9511	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	KA
8249	CaMPDE inhibitor	CaMPDE inhibitor	1	KF

2842	Renin inhibitor	renin inhibitor	2	LR
8248	Renin inhibitor	renin inhibitor	1	KF
9430	Renin inhibitor	renin inhibitor	1	NR
9433	Renin inhibitor	renin inhibitor	1	YA

R-phycoerythrin alpha chain (P51368)

ID	Name of peptide	Activity	Number	Sequence
3460	Prolyl endopeptidase inhibitor	antiamnestic	1	PG
3461	Prolyl endopeptidase inhibitor	antiamnestic	1	GP
3257	beta-lactokinin	ACE inhibitor	3	RL
3489	ACE inhibitor from sake lees	ACE inhibitor	1	RF
3492	ACE inhibitor from sake	ACE inhibitor	1	VY
3494	ACE inhibitor from sake	ACE inhibitor	1	HY
3502	ACE inhibitor (BSA fr. 221-222)	ACE inhibitor	1	FP
3537	ACE inhibitor	ACE inhibitor	1	PR
3550	ACE inhibitor (from bovine beta-Lg)	ACE inhibitor	1	YL
3563	ACE inhibitor	ACE inhibitor	1	AY
7512	ACE inhibitor from Alaskan pollack skin	ACE inhibitor	1	GP
7545	ACE inhibitor	ACE inhibitor	1	GPV
7558	ACE inhibitor from buckwheat	ACE inhibitor	1	VK
7562	ACE inhibitor from soy hydrolysate	ACE inhibitor	1	IA
7583	ACE inhibitor	ACE inhibitor	1	AF
7585	ACE inhibitor	ACE inhibitor	1	LA
7587	ACE inhibitor	ACE inhibitor	1	VP
7588	ACE inhibitor	ACE inhibitor	1	RA
7589	ACE inhibitor	ACE inhibitor	1	YA
7590	ACE inhibitor	ACE inhibitor	5	AA
7594	ACE inhibitor	ACE inhibitor	1	VG
7596	ACE inhibitor	ACE inhibitor	1	GI
7598	ACE inhibitor	ACE inhibitor	1	GA
7600	ACE inhibitor	ACE inhibitor	6	AG
7603	ACE inhibitor	ACE inhibitor	1	GR
7606	ACE inhibitor	ACE inhibitor	2	DA
7608	ACE inhibitor	ACE inhibitor	1	GV
7612	ACE inhibitor	ACE inhibitor	1	GT
7613	ACE inhibitor	ACE inhibitor	1	WG
7615	ACE inhibitor	ACE inhibitor	1	GE
7616	ACE inhibitor	ACE inhibitor	1	GG
7617	ACE inhibitor	ACE inhibitor	1	QG
7620	ACE inhibitor	ACE inhibitor	2	GD

7621	ACE inhibitor	ACE inhibitor	1	TG
7623	ACE inhibitor	ACE inhibitor	4	EA
7625	ACE inhibitor	ACE inhibitor	1	PG
7644	ACE inhibitor from porcine myosin (306-308)	ACE inhibitor	1	ITT
7682	ACE inhibitor from garlic	ACE inhibitor	1	NY
7684	ACE inhibitor from garlic	ACE inhibitor	1	SY
7685	ACE inhibitor from garlic	ACE inhibitor	1	SF
7690	ACE inhibitor from red algae	ACE inhibitor	1	AKYSY
7691	ACE inhibitor from wakame	ACE inhibitor	1	KY
7693	ACE inhibitor from wakame	ACE inhibitor	1	KL
7698	ACE inhibitor from wakame	ACE inhibitor	1	NK
7742	ACE inhibitor	ACE inhibitor	3	AR
7751	ACE inhibitor from shark meat hydrolysate	ACE inhibitor	1	CF
7752	ACE inhibitor from shark meat hydrolysate	ACE inhibitor	1	EY
7828	ACE inhibitor	ACE inhibitor	1	EV
7829	ACE inhibitor	ACE inhibitor	1	VE
7832	ACE inhibitor	ACE inhibitor	1	LN
7833	ACE inhibitor	ACE inhibitor	1	PT
7838	ACE inhibitor	ACE inhibitor	1	EW
7840	ACE inhibitor	ACE inhibitor	2	EK
7841	ACE inhibitor	ACE inhibitor	1	KE
8951	ACE inhibitor	ACE inhibitor	1	AV
9036	ACE inhibitor	ACE inhibitor	1	YVA
9072	ACE inhibitor	ACE inhibitor	1	DY
9075	ACE inhibitor	ACE inhibitor	1	DM
9077	ACE inhibitor	ACE inhibitor	1	YV
9151	ACE inhibitor	ACE inhibitor	1	TGP
9183	ACE inhibitor	ACE inhibitor	1	GTG
9196	ACE inhibitor	ACE inhibitor	1	AVV
9227	ACE Inhibitor	ACE inhibitor	1	VYRT
9228	ACE Inhibitor	ACE inhibitor	1	LDY
10091	ACE inhibitor	ACE inhibitor	1	DR
10092	ACE inhibitor	ACE inhibitor	1	LP
3283	Antithrombotic peptide	antithrombotic	1	GP
3285	Antithrombotic peptide	antithrombotic	1	PG
3355	Stimulating vasoactive substance release	stimulating	1	SSS
8321	Glucose uptake stimulating peptide	stimulating	2	LV
8325	Glucose uptake stimulating peptide	stimulating	1	II
8310	Anxiolytic peptide	neuropeptide	1	YL
9534	Kyotorphin	neuropeptide	2	YR

2749	peptide regulating ion flow	regulating	1	DY
2753	peptide regulating the stomach mucosal membrane activity	regulating	1	GP
2754	peptide regulating the stomach mucosal membrane activity	regulating	1	PG
9955	Regulator of phosphoglycerate kinase activity	regulating	1	SL
7866	peptide from Okara protein	antioxidative	1	AY
7972	synthetic peptide	antioxidative	1	YSY
8217	Antioxidative peptide	antioxidative	1	LK
8224	antioxidative peptide	antioxidative	1	VY
8453	Antioxidant peptide from marine bivalve (Mactra veneriformis)	antioxidative	1	LDY
9082	Antioxidative peptide	antioxidative	1	WG
9359	Antioxidative peptide	antioxidative	1	CLV
9869	Anti-inflammatory peptide	anti inflammatory	1	HY
10141	Hypotensive peptide	hypotensive	5	AA
4005		activating ubiquitin-mediated proteolysis	1	RA
4006	Ubiqitin-mediated proteolysis activating peptide	activating ubiquitin-mediated proteolysis	1	LA
3169	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GP
3172	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VA
3175	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LA
3176	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	FA
3180	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LP
3181	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VP
3183	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VV

8506	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	FP
8524	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GA
8525	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IA
8526	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RA
8530	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NP
8558	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	EK
8560	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SL
8637	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	5	AA
8697	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	WG
8757	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AD
8758	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AE
8759	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AF
8760	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	6	AG
8762	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	AS
8764	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AV
8765	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AY

8769	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	DR
8773	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	ES
8775	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EV
8776	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EW
8777	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EY
8781	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GE
8783	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GG
8785	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GI
8786	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GV
8790	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	HE
8799	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	HY
8801	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	II
8804	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IN
8805	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IQ
8808	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KE
8815	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KS

8817	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KV
8819	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KY
8823	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LN
8825	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	LV
8831	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MK
8836	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MR
8844	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NH
8845	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	NL
8853	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NY
8855	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PG
8862	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PS
8863	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PT
8864	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PV
8867	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QA
8869	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QE
8871	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QG

8886	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	RL
8891	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SF
8895	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	SV
8897	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SY
8901	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TG
8903	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TI
8905	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TL
8910	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TS
8911	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	TT
8915	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VD
8916	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VE
8918	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VG
8920	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VI
8921	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VK
8924	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VN
8925	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VQ

8929	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VY
8932	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YA
8938	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YI
8940	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YL
8941	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YM
8944	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	YR
8945	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YS
8946	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YV
9116	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GPV
9650	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	4	EA
9693	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	1	VE
9695	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	1	AD
9479	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	MR
9482	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	YL
9484	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	YR
9487	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	GE

9489	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	PR
9490	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	RF
9492	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	DA
9499	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	LA
9500	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	3	FA
9509	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	VY
9510	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	YI
9947	CaMPDE inhibitor	CaMPDE inhibitor	1	AGA
9432	Renin inhibitor	renin inhibitor	1	SF
9433	Renin inhibitor	renin inhibitor	1	YA

C-phycocyanin alpha chain (Q1XDA9)

ID	Name of peptide	Activity	Number	Sequence
3459	Prolyl endopeptidase (PEP) inhibitor	antiamnestic	1	PGP
3460	Prolyl endopeptidase inhibitor	antiamnestic	1	PG
3461	Prolyl endopeptidase inhibitor	antiamnestic	2	GP
3257	beta-lactokinin	ACE inhibitor	1	RL
3380	ACE inhibitor	ACE inhibitor	1	RY
3489	ACE inhibitor from sake lees	ACE inhibitor	1	RF
3492	ACE inhibitor from sake	ACE inhibitor	2	VY
3502	ACE inhibitor (BSA fr. 221-222)	ACE inhibitor	1	FP
3532	ACE inhibitor	ACE inhibitor	1	GY
3541	ACE inhibitor	ACE inhibitor	1	LSP
3550	ACE inhibitor (from bovine beta-Lg)	ACE inhibitor	3	YL
3580	ACE Inhibitor	ACE inhibitor	1	DIGYY
7512	ACE inhibitor from Alaskan pollack skin	ACE inhibitor	2	GP
7562	ACE inhibitor from soy hydrolysate	ACE inhibitor	1	IA

7588	ACE inhibitor	ACE inhibitor	1	RA
7589	ACE inhibitor	ACE inhibitor	2	YA
7590	ACE inhibitor	ACE inhibitor	4	AA
7594	ACE inhibitor	ACE inhibitor	1	VG
7595	ACE inhibitor	ACE inhibitor	3	IG
7598	ACE inhibitor	ACE inhibitor	3	GA
7599	ACE inhibitor	ACE inhibitor	2	GL
7600	ACE inhibitor	ACE inhibitor	1	AG
7603	ACE inhibitor	ACE inhibitor	2	GR
7604	ACE inhibitor	ACE inhibitor	1	KG
7607	ACE inhibitor	ACE inhibitor	1	GS
7610	ACE inhibitor	ACE inhibitor	1	GQ
7611	ACE inhibitor	ACE inhibitor	1	GK
7614	ACE inhibitor	ACE inhibitor	1	HG
7615	ACE inhibitor	ACE inhibitor	1	GE
7617	ACE inhibitor	ACE inhibitor	1	QG
8193	ACE inhibitor	ACE inhibitor	4	AI
7618	ACE inhibitor	ACE inhibitor	1	SG
7619	ACE inhibitor	ACE inhibitor	1	LG
7621	ACE inhibitor	ACE inhibitor	2	TG
7623	ACE inhibitor	ACE inhibitor	3	EA
7624	ACE inhibitor	ACE inhibitor	2	NG
7625	ACE inhibitor	ACE inhibitor	1	PG
7685	ACE inhibitor from garlic	ACE inhibitor	1	SF
7692	ACE inhibitor	ACE inhibitor	1	KF
7742	ACE inhibitor	ACE inhibitor	2	AR
7743	ACE inhibitor	ACE inhibitor	1	KA
7752	ACE inhibitor from shark meat hydrolysate	ACE inhibitor	1	EY
7826	ACE inhibitor	ACE inhibitor	1	EI
7829	ACE inhibitor	ACE inhibitor	1	VE
7830	ACE inhibitor	ACE inhibitor	1	TE
7831	ACE inhibitor	ACE inhibitor	2	LQ
7833	ACE inhibitor	ACE inhibitor	1	PT
7834	ACE inhibitor	ACE inhibitor	1	TQ
8382	ACE inhibitor from as2-CN (170-172)	ACE inhibitor	1	RYQ
8968	ACE inhibitor	ACE inhibitor	1	ASL
9031	ACE inhibitor	ACE inhibitor	1	LEE
9035	ACE inhibitor	ACE inhibitor	1	GSH
9038	ACE inhibitor	ACE inhibitor	1	SVY
9052	ACE inhibitor	ACE inhibitor	1	GPM
9072	ACE inhibitor	ACE inhibitor	1	DY
9073	ACE inhibitor	ACE inhibitor	1	TP
9077	ACE inhibitor	ACE inhibitor	2	YV
9151	ACE inhibitor	ACE inhibitor	1	TGP

9160	ACE inhibitor	ACE inhibitor	1	TLS
9213	ACE inhibitor	ACE inhibitor	1	LR
9228	ACE Inhibitor	ACE inhibitor	1	LDY
9939	ACE inhibitor	ACE inhibitor	1	SVYT
9946	ACE inhibitor	ACE inhibitor	1	YY
10044	ACE inhibitor	ACE inhibitor	1	YLR
10045	ACE inhibitor	ACE inhibitor	1	LRM
3283	Antithrombotic peptide	antithrombotic	2	GP
3284	antithrombotic peptide	antithrombotic	1	PGP
3285	Antithrombotic peptide	antithrombotic	1	PG
3786		opioid	1	GYY
8321	Glucose uptake stimulating peptide	stimulating	2	LV
8324	Glucose uptake stimulating peptide	stimulating	1	LI
8329	Stimulating vasoactive substance release	stimulating	1	EE
2890	neuropeptide	neuropeptide	1	GQ
8310	Anxiolytic peptide	neuropeptide	3	YL
2749	peptide regulating ion flow	regulating	1	DY
2753	peptide regulating the stomach mucosal membrane activity	regulating	2	GP
2754	peptide regulating the stomach mucosal membrane activity	regulating	1	PG
2756	peptide regulating the stomach mucosal membrane activity	regulating	1	PGP
9955	Regulator of phosphoglycerate kinase activity	regulating	2	SL
7867	antioxidative peptide from Okara protein	antioxidative	1	GYY
7888	antioxidative peptide	antioxidative	2	EL
7898	peptide from bovine b-lactoglobulin	antioxidative	1	WY
7941	synthetic peptide	antioxidative	1	YYL
8219	antioxidative peptide	antioxidative	2	TY
8224	antioxidative peptide	antioxidative	2	VY
8453	Antioxidant peptide from marine bivalve (Mactra veneriformis)	antioxidative	1	LDY
8474	Antioxidant peptide from as2-CN (170-172)	antioxidative	1	RYQ
8983	Antioxidative peptide	antioxidative	2	GAA
9359	Antioxidative peptide	antioxidative	1	CLV
9362	Antioxidative peptide	antioxidative	1	YVE
9954	Antioxidative peptide	antioxidative	1	GSH
10009	Antioxidative peptide	antioxidative	1	SVYT
10051	Antioxidative peptide	antioxidative	1	RY

9856	Anti-inflammatory peptide	anti inflammatory	1	PY
3046	inhibitor of insulin secretion	inhibitor	1	PGP
3464	Chemotactic peptide	chemotactic	1	PGP
10141	Hypotensive peptide	hypotensive	4	AA
4005		activating ubiquitin-mediated proteolysis	1	RA
3169	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	GP
3171	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MP
3172	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VA
3174	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KA
3183	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VV
8503	Dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TP
8505	Dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SP
8506	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	FP
8524	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	GA
8525	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IA
8526	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RA
8555	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	FL
8559	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AL

8560	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	SL
8561	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	GL
8637	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	4	AA
8683	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	WY
8696	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YT
8757	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AD
8760	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AG
8762	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	AS
8763	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AT
8772	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EI
8777	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EY
8781	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GE
8788	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GY
8804	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	IN
8809	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KF
8810	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KG

8816	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KT
8821	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LI
8824	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LT
8825	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	LV
8831	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MK
8837	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MV
8839	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NA
8841	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NE
8843	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	NG
8847	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NN
8849	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NR
8850	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NT
8851	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NV
8855	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PG
8857	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PI
8859	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PM

8862	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PS
8863	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PT
8866	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PY
8867	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QA
8871	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QG
8873	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QI
8877	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QS
8881	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	QY
8886	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RL
8887	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RM
8891	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SF
8892	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SH
8895	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SV
8896	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SW
8899	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TE
8901	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	TG

8904	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TK
8905	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TL
8907	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TN
8908	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TQ
8914	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	TY
8916	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VE
8918	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VG
8927	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VT
8929	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VY
8932	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	YA
8938	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YI
8940	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	YL
8943	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YQ
8946	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	YV
8948	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YY
9117	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GPM

9650	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	3	EA
9693	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	1	VE
9695	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	1	AD
9476	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	YY
9478	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	LR
9482	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	3	YL
9487	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	GE
9490	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	RF
9502	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	FL
9509	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	VY
9510	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	YI
9511	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	KA
8249	CaMPDE inhibitor	CaMPDE inhibitor	1	KF
2842	Renin inhibitor	renin inhibitor	1	LR
8248	Renin inhibitor	renin inhibitor	1	KF
9430	Renin inhibitor	renin inhibitor	1	NR
9432	Renin inhibitor	renin inhibitor	1	SF
9433	Renin inhibitor	renin inhibitor	2	YA
10010	renin inhibitor	renin inhibitor	1	SVYT
10220	Tyrosinase inhibitor	tyrosinase inhibitor	1	FPY

B-phycoerythrin beta chain (P11393)

ID	Name of peptide	Activity	Number	Sequence
3460	Prolyl endopeptidase inhibitor	antiamnestic	2	PG
3257	beta-lactokinin	ACE inhibitor	1	RL
3258	beta-lactokinin	ACE inhibitor	1	IR
3380	ACE inhibitor	ACE inhibitor	1	RY
3547	ACE inhibitor	ACE inhibitor	1	IRA
3563	ACE inhibitor	ACE inhibitor	1	AY
7507	ACE inhibitor from Alaskan pollack skin	ACE inhibitor	1	PGL
7562	ACE inhibitor from soy hydrolysate	ACE inhibitor	2	IA
7583	ACE inhibitor	ACE inhibitor	2	AF
7585	ACE inhibitor	ACE inhibitor	2	LA
7586	ACE inhibitor	ACE inhibitor	1	KR
7587	ACE inhibitor	ACE inhibitor	1	VP
7588	ACE inhibitor	ACE inhibitor	1	RA
7589	ACE inhibitor	ACE inhibitor	1	YA
7590	ACE inhibitor	ACE inhibitor	4	AA
7594	ACE inhibitor	ACE inhibitor	2	VG
7597	ACE inhibitor	ACE inhibitor	1	GM
7598	ACE inhibitor	ACE inhibitor	1	GA
7599	ACE inhibitor	ACE inhibitor	2	GL
7600	ACE inhibitor	ACE inhibitor	2	AG
7606	ACE inhibitor	ACE inhibitor	5	DA
7607	ACE inhibitor	ACE inhibitor	1	GS
7608	ACE inhibitor	ACE inhibitor	1	GV
7615	ACE inhibitor	ACE inhibitor	1	GE
7616	ACE inhibitor	ACE inhibitor	2	GG
8193	ACE inhibitor	ACE inhibitor	1	AI
7618	ACE inhibitor	ACE inhibitor	1	SG
7619	ACE inhibitor	ACE inhibitor	1	LG
7620	ACE inhibitor	ACE inhibitor	2	GD
7624	ACE inhibitor	ACE inhibitor	1	NG
7625	ACE inhibitor	ACE inhibitor	2	PG
7649	ACE inhibitor from red algae	ACE inhibitor	1	LRY
7681	ACE inhibitor from soy	ACE inhibitor	2	DG
7684	ACE inhibitor from garlic	ACE inhibitor	2	SY
7685	ACE inhibitor from garlic	ACE inhibitor	2	SF
7698	ACE inhibitor from wakame	ACE inhibitor	1	NK
7741	ACE inhibitor	ACE inhibitor	1	RR
7743	ACE inhibitor	ACE inhibitor	2	KA
7826	ACE inhibitor	ACE inhibitor	1	EI
7828	ACE inhibitor	ACE inhibitor	1	EV
7830	ACE inhibitor	ACE inhibitor	1	TE

7831	ACE inhibitor	ACE inhibitor	1	LQ
7832	ACE inhibitor	ACE inhibitor	1	LN
7833	ACE inhibitor	ACE inhibitor	1	PT
7841	ACE inhibitor	ACE inhibitor	1	KE
8126	ACE inhibitor	ACE inhibitor	1	VAF
8951	ACE inhibitor	ACE inhibitor	4	AV
9077	ACE inhibitor	ACE inhibitor	2	YV
9079	ACE inhibitor	ACE inhibitor	1	IL
9213	ACE inhibitor	ACE inhibitor	2	LR
9326	ACE inhibitor	ACE inhibitor	1	LGV
9944	ACE inhibitor	ACE inhibitor	1	ER
10091	ACE inhibitor	ACE inhibitor	2	DR
3285	Antithrombotic peptide	antithrombotic	2	PG
8320	Glucose uptake stimulating peptide	stimulating	1	VL
8322	Glucose uptake stimulating peptide	stimulating	1	IV
8323	Glucose uptake stimulating peptide	stimulating	1	IL
8324	Glucose uptake stimulating peptide	stimulating	1	LI
8325	Glucose uptake stimulating peptide	stimulating	1	II
8326	Glucose uptake stimulating peptide	stimulating	1	LL
8330	Stimulating vasoactive substance release	stimulating	1	SE
2754	peptide regulating the stomach mucosal membrane activity	regulating	2	PG
9955	Regulator of phosphoglycerate kinase activity	regulating	1	SL
8318	Dvl protein binding	anticancer	1	VVV
7866	peptide from Okara protein	antioxidative	1	AY
8215	Antioxidative peptide	antioxidative	1	IR
8217	Antioxidative peptide	antioxidative	2	LK
8219	antioxidative peptide	antioxidative	1	TY
8983	Antioxidative peptide	antioxidative	1	GAA
9879	Antioxidative peptide	antioxidative	1	SVL
10051	Antioxidative peptide	antioxidative	1	RY
10141	Hypotensive peptide	hypotensive	4	AA
4005		activating ubiquitin-mediated proteolysis	1	RA
4006	Ubiqitin-mediated proteolysis activating peptide	activating ubiquitin-mediated proteolysis	2	LA

3172	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VA
3173	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MA
3174	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	KA
3175	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	LA
3176	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	FA
3181	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VP
3182	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LL
3183	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VV
8505	Dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SP
8524	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GA
8525	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	IA
8526	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RA
8530	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NP
8531	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TA
8559	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	AL
8560	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SL

8561	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	GL
8637	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	4	AA
8649	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VGGSD LQALK
8696	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YT
8757	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AD
8759	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	AF
8760	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	AG
8762	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	4	AS
8763	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AT
8764	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	4	AV
8765	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	AY
8769	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	DR
8772	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EI
8774	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	ET
8775	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	EV
8781	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GE

8783	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	GG
8786	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	GV
8801	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	II
8802	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IL
8803	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IM
8806	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	IR
8808	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KE
8814	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KR
8815	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	KS
8821	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LI
8823	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	LN
8830	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MI
8831	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MK
8832	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	ML
8837	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	MV
8839	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NA

8843	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NG
8849	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NR
8850	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	NT
8855	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	PG
8863	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	PT
8867	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	QA
8885	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RK
8886	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RL
8887	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RM
8889	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	RR
8891	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	SF
8893	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	SI
8895	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	SV
8897	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	SY
8899	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TE
8907	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	3	TN

8910	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TS
8914	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	TY
8918	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VG
8922	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	VL
8924	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	VN
8926	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	5	VS
8932	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YA
8935	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YF
8938	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	1	YI
8946	dipeptidyl peptidase IV inhibitor (DPP IV inhibitor)	dipeptidyl peptidase IV inhibitor	2	YV
9695	Alpha-glucosidase inhibitor	alpha-glucosidase inhibitor	1	AD
9478	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	LR
9480	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	YF
9485	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	RR
9487	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	GE
9491	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	RV

9492	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	5	DA
9499	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	LA
9500	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	FA
9510	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	1	YI
9511	DPP-III inhibitor	dipeptidyl peptidase III inhibitor	2	KA
8247	CaMPDE inhibitor	CaMPDE inhibitor	1	IR
2842	Renin inhibitor	renin inhibitor	2	LR
8246	renin inhibitor	renin inhibitor	1	IR
9430	Renin inhibitor	renin inhibitor	1	NR
9432	Renin inhibitor	renin inhibitor	2	SF
9433	Renin inhibitor	renin inhibitor	1	YA

Appendix-B: Sequence homology of *Pyropia umbilicalis* and *Palmaria palmate*

1. C-phycocyanin beta chain

Score	Expect	Method	Identities	Positives	Gaps
320 bits(820)	1e-109	Compositional matrix adjust.	154/172(90%)	165/172(95%)	0/172(0%)

```
Query  1    MLDAFAKVVAQADARGEFLSNTQLDALSSMVAEGNKRLDVVNKINSNASAIVTNSARALF  60
            MLDAFAKVVAQADARGEFLSNTQLDALS+MV EG KRLDVVNKIN+NASAIVTNSARALF
Sbjct  1    MLDAFAKVVAQADARGEFLSNTQLDALSTMVNEGKKRLDVVNKINANASAIVTNSARALF  60

Query  61   AEQPQLIQPGGNAYTNRRMAACLRDMEIVLRYVSYAMIAGDSSVLDDRCLNGLRETYQAL 120
            AEQPQL+QPGGNAYT+RRMAACLRDMEIVLRYVSY+M+AGDSSVLDDRCLNGLRETYQAL
Sbjct  61   AEQPQLVQPGGNAYTSRRMAACLRDMEIVLRYVSYSMVAGDSSVLDDRCLNGLRETYQAL 120

Query  121  GTPGSSVSVAVQKMKEASVALANDLTGTPQGDCSALVAELGSYFDRAAVSVV  172
            GTPG+SV+VA+QKMKEASVALANDL   P GDCSAL AELGSYFDRAA++VV
Sbjct  121  GTPGTSVAVAIQKMKEASVALANDLNNVPLGDCSALTAELGSYFDRAAIAVV  172
```

2. R-phycoerythrin beta chain

Score	Expect	Method	Identities	Positives	Gaps
326 bits(835)	9e-112	Compositional matrix adjust.	162/177(92%)	168/177(94%)	0/177(0%)

```
Query  1    MLDAFSRVVVNSDAKAAYVGGSDLQALKKFIADGNKRLDSVNAIVSNASCIVSDAVSGMI  60
            MLDAFSRVVVNSDAKAAYVGGSDLQALKKFI DGNKRLDSV+ +VSNASCIVSDAVSGMI
Sbjct  1    MLDAFSRVVVNSDAKAAYVGGSDLQALKKFITDGNKRLDSVSFVVSNASCIVSDAVSGMI  60

Query  61   CENPGLIAPGGNCYTNRRMAACLRDGEIILRYVSYALLAGDPSVLEDRCLNGLKETYIAL 120
            CENPGLIAPGGNCYTNRRMAACLRDGEIILRY SYALLAGDPSVLEDRCLNGLKETYIAL
Sbjct  61   CENPGLIAPGGNCYTNRRMAACLRDGEIILRYASYALLAGDPSVLEDRCLNGLKETYIAL 120

Query  121  GVPTNSSVRAVSIMKAAAVAFITNTASQRKMATADGDCSALASEVASYCDRVAAAIS  177
            GVPTNSSVRAVSIMKA+A AF++ TAS RKMA  DGDCSALASE+ SYCDRVAAAIS
Sbjct  121  GVPTNSSVRAVSIMKASATAFVSGTASDRKMACPDGDCSALASELGSYCDRVAAAIS  177
```

3. R-phycoerythrin alpha chain

Score	Expect	Method	Identities	Positives	Gaps
281 bits(718)	2e-94	Compositional matrix adjust.	147/163(90%)	155/163(95%)	0/163(0%)

```
Query  1    MKSVITTTISAADAAGRFPSSSDLESVQGNIQraaarleaaeklaSNHEAVVKEAGDACF  60
            MKSV+TTTISAADAAGRFPSSSDLESVQGNIQRAAARLEAAEKLASNHEAVVKE GDACF
Sbjct  1    MKSVMTTTISAADAAGRFPSSSDLESVQGNIQRAAARLEAAEKLASNHEAVVKEGGDACF  60

Query  61   AKYSYLKNPGEAGDSQEKVNKCYRDVDHYMRLVNYCLVVGGTGPVDEWGIAGAREVYRTL 120
            AKYSYLKNPGEAGDSQEKVNKCYRDVDHYMRLVNY LVVGGTGP+DEW IAGAREVYRTL
Sbjct  61   AKYSYLKNPGEAGDSQEKVNKCYRDVDHYMRLVNYSLVVGGTGPLDEWAIAGAREVYRTL 120

Query  121  NLPTSAYVASFAFARDRLCVPRDMSAQAGVEYAGNLDYIINSL  163
            NLP+++YVA+FAF RDRLCVPRDMSAQAG EY   LDYI+N+L
Sbjct  121  NLPSASYVAAFAFTRDRLCVPRDMSAQAGGEYVAALDYIVNAL  163
```

4. C-phycocyanin alpha chain

Score	Expect	Method	Identities	Positives	Gaps
286 bits(731)	2e-96	Compositional matrix adjust.	144/162(89%)	154/162(95%)	0/162(0%)

```
Query  1    MKTPITEAIASADSQGRFLSNGELQAINGRYQraaaslgaarslTNNAQRLITGAAQSVY  60
            MKTPITEAIASADSQGRFLSN ELQ+INGRY+RA++SL AA SLTN+AQRLITGAAQ+VY
Sbjct  1    MKTPITEAIASADSQGRFLSNAELQSINGRYERASSSLEAAASLTNSAQRLITGAAQAVY  60

Query  61   TKFPYVTQMPGPTYASSAIGKAKCARDIGYYLRMVTYCLVVGATGPMDEYLVAGLEEINR 120
             KFP+ TQMPGPTYASSAIGKAKCARDIGYYLRM TYCLVVGATGPMDEYLVAGLEEINR
Sbjct  61   MKFPFTTQMPGPTYASSAIGKAKCARDIGYYLRMTTYCLVVGATGPMDEYLVAGLEEINR 120

Query  121  SFELSPSWYVEALQYIKGSHGLSGQIGNEANVYLDYAINTLS  162
            SFELSPSWY+EALQYIK SHGLSGQ+GNEAN Y+DYAINTLS
Sbjct  121  SFELSPSWYIEALQYIKSSHGLSGQVGNEANTYVDYAINTLS  162
```

5. B-phycoerythrin beta chain

Score	Expect	Method	Identities	Positives	Gaps
299 bits(765)	4e-101	Compositional matrix adjust.	144/177(81%)	162/177(91%)	0/177(0%)

```
Query  1    MLDAFSRVVVNSDAKAAYVGGSDLQALKSFIADGNKRLDAVNSIVSNASCMVSDAVSGMI  60
            MLDAFSRVVVNSD+KA YVGGSDLQALK FI DGNKRLD+V+ +VSNASC+VSDAVSGMI
Sbjct  1    MLDAFSRVVVNSDSKAVYVGGSDLQALKKFITDGNKRLDSVSFVVSNASCIVSDAVSGMI  60

Query  61   CENPGLISPGGNCYTNRRMAACLRDGEIILRYVSYALLAGDASVLEDRCLNGLKETYIAL
120
            CENPGLI+PGGNCYTNRRMAACLRDGEIILRYVSYALLAGD SVLEDRCLNGLKETYIAL
Sbjct  61   CENPGLIAPGGNCYTNRRMAACLRDGEIILRYVSYALLAGDPSVLEDRCLNGLKETYIAL
120

Query  121  GVPTNSSIRAVSIMKAQAVAFITNTATERKMSFAAGDCTSLASEVASYFDRVGAAIS  177
            GVP+NSS+RAVSIMKA A AF++ TA++RKM    GDC++LASE+ +Y DRV +A+S
Sbjct  121  GVPSNSSVRAVSIMKASATAFVSGTASDRKMKCPDGDCSALASELGNYCDRVASAVS  177
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Brief Biography

Israt Jesmin passed the Secondary School Certificate (SSC) Examinations in 2011 with a Grade Point Average (GPA) of 5.00 from Dr. Khastagir Govt Girls' High School, Chattogram followed by the Higher Secondary Certificate (HSC) Examination in 2013 with a GPA of 5.00 from Bangladesh Mahila Samity Girls' High School & College. She received the B.Sc. (Hon's) in Food Science and Technology in 2018 (exam held in 2019) from Chattogram Veterinary and Animal Sciences University (CVASU), Bangladesh. Now, she is a candidate for the degree of MS in Applied Human Nutrition and Dietetics under the Department of Applied Food Science and Nutrition, CVASU. She is very interested in researching clinical nutrition and dietetics with the goal of enhancing people's overall nutritional status of Bangladesh by providing appropriate recommendations and guidance.