CRYOPROTECTIVE EFFECT OFLOW SWEETNESS SUGAR ON PHYSICOCHEMICAL PROPERTIES OF THREADFIN BREAM (*NEMIPTERUS* SPP.) SURIMI DURING FROZEN STORAGE

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LIST OF ABBREVIATIONS

a*	redness
ATP	adenosin tryphosphate
b*	yellowness
C	celcius
Cm	centimeter
DSC	differential scanning calorimetry
DTNB	5, 5'-dithio-bis (2-nitrobenzoic-acid)
G	gram
kDa	kilodalton
Kg	kilogram
L^*	lightness
M	molarity
mg	miligram
min	minute
ml	mililiter
mm	millimeter
mM	milimolar
µPi	microphosphate inorganic
N	normality
N	newton
nm	nanometer
S	second
SD	standart deviation
SDS-PAGE	sodium dedocyl sulfate polyacrylamide gel electrophoresis
SEM	scanning electron microscopy
SH	sulfhydryl
STPP	sodium trypolyphosphate
T_{max}	maximum temperature
TPA	texture profile analysis
V	volt
w/v	weight/volume

KESAN KRIOAWETAN GULA KURANG MANIS PADA SIFAT FIZIKO-KIMIA SURIMI IKAN KERISI (*Nemipterus* spp.) SEMASA PENYIMPANAN SEJUK BEKU

ABSTRAK

Penyelidikan ini terdiri daripada dua fasa eksperimen. Eksperimen pertama mengkaji perubahan sifat fiziko-kimia surimi ikan kerisi dengan krioawetan yang berbeza (laktitol, maltodekstrin, palatinit, polidekstros, sorbitol, sukrosa, dan trehalos) semasa enam bulan penyimpanan sejukbeku. Analisis yang dilakukan adalah darjah keputihan, uji lipatan, kekuatan gel, keluaran kelembapan, analisa profil tekstur, mikroskop penskanan elektron, aktiviti Ca^{2+}-ATPase, kalorimetripenskanan perbezaan, kandungan air, pH, keterlarutan protein, kandungan sulfhidril, elektroforesis dan keupayaan mengikat air. Kadar pengikatan air oleh polidekstros ialah 77.0%, manakala darjah keputihan ialah 98.6%, uji lipatan pula sebanyak 100%, dan kekuatan gel adalah 53.6% berbanding nilai awalan selama enam bulan penyimpanan. Sukrosa pula mampu mengikat air sebanyak 80.3%, darjah keputihan pula 98.6%, uji lipatan 75%, dan kekuatan gel 56.8%. Surimi mentah (tanpa penambahan krioawetan) hanya mampu mengikat air sebanyak 62.2%, darjah keputihan 98.7%, uji lipatan 75%, dan kekuatan gel 36.0% berbanding nilai awalan. Hasil kajian tahap pertama ini menunjukkan bahawa polidekstros merupakan krioawetan yang berpotensi berbanding sampel yang lain.

Eksperimen kedua pula mengkaji perubahan sifat fiziko-kimia surimi ikan kerisi dengan kandungan polidekstros yang berbeza (3%, 6%, 9%, 12%), surimi mentah, surimi dengan penambahan natrium tripolifosfat dan surimi komersil (sukrosa) selama enam bulan penyimpanan sejukbeku. Analisis yang dilakukan

meliputi pengukuran aktiviti Ca^{2+}-ATPase, kandungan sulfhidril, keterlarutan protein, elektroforesis, kalorimetri penskanan perbezaan dan mikroskop penskanan elektron. Aktiviti Ca^{2+}-ATPase, kandungan sulfhidril, dan keterlarutan protein ditambah dengan 3%, 6%, 9%, dan 12% polidekstros antara 151.8-421.1 μg Pi/mg protein/10 min, 5.0-14.4 mol SH/10^5 g protein, 22.1-69.3%, masing-masing selama enam bulan penyimpanan sejukbeku. Kalorimetri penskanan perbezaan menunjukkan penurunan dalam kestabilan termal pada myosin berkaitan dengan suhu peralihan. Analisis mikroskop penskanan elektron menunjukkan bahawa jumlah liang-liang meningkat selepas penyimpanan. Kajian ini menunjukkan bahawa surimi dengan 6% polidekstros sebagai krioawetan mampu mengekalkan sifat fiziko-kimia surimi lebih baik berbanding dengan surimi mentah dan surimi komersil (sukrosa).

CRYOPROTECTIVE EFFECT OF LOW SWEETNESS SUGAR ON PHYSICOCHEMICAL PROPERTIES OF THREADFIN BREAM (*Nemipterus* spp.) SURIMI DURING FROZEN STORAGE

ABSTRACT

This study consists of two parts of experiment. The first experiment investigated the changes of physicochemical properties of threadfin bream surimi with different cryoprotectants (lactitol, maltodextrin, palatinit, polydextrose, sorbitol, sucrose, trehalose) at level 6% with 0.3% sodium tripolyphosphate (STPP) added in each surimi during six months of frozen storage. The analyses conducted included color, folding test, gel strength, expressible moisture, texture profile analyzer, scanning electron microscopy, Ca^{2+}-ATPase activity, differential scanning calorimetry, moisture content, pH, protein solubility, sulfhydryl content, sodium dodecyl sulfate polyacrylamide gel electrophoresis, and water holding capacity. Polydextrose was able to maintain a water-holding capacity of 77.0%, 98.6% whiteness, a folding test value of 100%, and a gel strength of 53.6% compared to its initial value during six months of frozen storage. Meanwhile, sucrose was able to maintain a water-holding capacity of 80.3%, 98.6% whiteness, a folding test value of 75%, and a gel strength of 56.8% compared to its initial value. Raw surimi (surimi without the addition of sugar and STPP) was only able to maintain a water-holding capacity of 62.2%, 98.7% whiteness, a folding test value of 75%, and a gel strength of 36.0% compared to its initial value. Based on the result in the first step, polydextrose showed as the potential cryoprotectant among the other sugars.

The second experiment investigated the changes of physicochemical properties of threadfin bream surimi with different levels of polydextrose (3%, 6%, 9% and 12%) during six months of frozen storage. The analyses included the measurement of Ca^{2+}-ATPase, sulfhydryl contents, protein solubility, sodium dodecyl sulfate polyacrylamide gel electrophoresis, differential scanning calorimetry and scanning electron microscopy. The Ca^{2+}-ATPase, sulfhydryl content and protein solubility levels added with 3%, 6%, 9% and 12% polydextrose were in the range of 151.8-421.1 μg Pi/mg protein/10 min, 5.0-14.4 mol SH/10^5 g protein, 22.1-69.3%, respectively, during six months of frozen storage. Differential scanning calorimetry showed decreases in thermal stabilization of myosin with regard to transition temperature. Analysis by scanning electron microscopy demonstrated that the number of pores formed increased after storage. This study recommended that surimi stored with 6% polydextrose as a cryoprotectant was able to maintain physicochemical properties of surimi better compared to raw surimi without addition of sugar and STPP and sucrose.

CHAPTER 1.

INTRODUCTION

1.1. Background

Surimi is concentrated myofibrillar proteins that have been blended with cryoprotectant for a longer frozen storage life (Park and Lin, 2005). The Japanese have been improving surimi technology for several hundred years. The development of the industry has recently been supported by an increase in the supply of raw materials, the development of new products, and the development of new technologies for manufacturing and preserving the products (Okada, 1992). Surimi is global in scope, with producing and consumption encompassing sites across Asia, America, and Europe (Mansfield, 2003).

Surimi can be produced from both marine and fresh-water fish, including both white-muscled and dark-muscled fish, such as alaska pollock, blue whiting, croaker, lizardfish, sardine, tilapia and bigeye snapper. Commonly, certain species are used due to their easy capture and low price. The use of alternative species in order to obtain surimi of good gel-forming ability is one of the aims of the fishing industry (Holmes et al., 1992).

Muscle protein is composed of sarcoplasmic protein, myofibrillar protein, and stroma. Myofibrillar protein covers 66-77% of the total protein in fish meat, and plays important role in coagulation and gel forming when fish meat is being processed (Suzuki, 1981). In particular, myofibrillar protein is the main factor affecting meat quality deterioration during frozen storage. Zayas (1997) suggested that the degree of protein denaturation and insolubilization during the freezing process and frozen storage are influenced by many factors, such as pretreatment before freezing, the degree of the autolytic process before freezing, the freezing rate, the freezing temperature, the storage temperature and time, as well as storage condition stability including temperature, thawing methods and thawing conditions.

The functional properties of surimi will be retained when cryoprotectant added into raw surimi (Okada, 1992). The commonly cryoprotectant used is incorporation of sucrose and sorbitol 1:1 with 0.3% sodioum tripolyphosphate added as synergist (Yoon and Lee, 1990; MacDonald and Lanier, 1991). However, the incorporation imparts sweet taste and high calorie value in surimi (Carvajal et al., 1999). Low sweetness sugar can be an alternative to overcome the problem. Many studies had been conducted about low sweetness sugar, such as trehalose on grass carp and tilapia surimi (Pan et al., 2010; Zhou et al., 2006), polydextrose and lactitol on rainbow trout actomyosin (Herrera and Mackie, 2004), palatinit on cod surimi (Sych et al., 1990a), and maltodextrin on Alaska Pollock surimi (Carvajal et al., 1999).

The study on some marine tropical fish had been conducted, such as croaker, lizardfish, threadfin bream, bigeye snapper that commonly used in Thailand for surimi production and mixed thorougly with 4% sucrose and 4% sorbitol.The results showed that lizardfish obtained the lowest properties on chemical and gel-forming ability during 25 weeks of frozen storage (Benjakul et al., 2005).

However, less study about cryoprotective effect of low sweetness sugar on marine tropical fish has been reported. The aim of this study was to investigate cryoprotective ability of low sweetness sugar on threadfin bream surimi during frozen storage and compare their cryoprotectiveness effect with sucrose. The benefits of this study are to produce surimi with low calorie content and less sweet taste, and to give a chance for another sugar to be applied as a cryoprotectant on surimi.

1.2. The objectives of this study:

1. To determine effect of different types of low sweetness sugar (lactitol, maltodextrin, palatinit, polydextrose, trehalose) on physicochemical properties of threadfin bream surimi during frozen storage.
2. To determine effect of polydextrose levels (3%, 6%, 9%, 12%) on physicochemical properties of threadfin bream surimi during frozen storage.

CHAPTER 2.

LITERATURE REVIEW

2.1. Surimi

2.1.1. Surimi Introduction

Surimi was a Japanese term which means the wet concentrate of the myofibrillar proteins of fish muscle that has been mechanically deboned, water-washed, mixed with cryoprotectant and frozen (Okada, 1992). Myofibrillar protein affects the quality surimi-based product that produced, such in gel strength and water holding capacity. Surimi is used as intermediate foodstuff with a long shelf life and high potential for various texturized product (Pan et al., 2010). In United Stated, surimi used to manufacture seafood analog products such as imitation crab, shrimp and lobster (Burden et al., 2004). Surimi is mainly produced from marine fish and white meat. At the present, Alaska Pollock (*Theragra chalcogramma*) is primary species supporting surimi industry. Due to excessive exploitation of Allaska Pollock, the catching of Alaska Pollock has been reduced in recent years. Another marine fish used as an alternative (Guenneugues and Morrisey, 2005) and also from fresh water fish (Pan et al., 2010).

The Asian surimi industry underwent a period rapid changed as the Republic of Korea, Thailand, New Zealand, and the United States were increasingly challenging Japan's position as the world's leading surimi producer. The appreciation of the yen and the Japanese exclusion from U.S. and Soviet walleye or Alaska Pollock resources, have caused Japanese production to decrease from its 1984 peak of 418,000 MT to 310,000 MT in 1989 and decreased to only 132,000 MT in 1994. Meanwhile, the output of the other four major producing countries had increased from about 26,000 MT to 260,000 MT during the same period. The Korean surimi industry shows the greates potential among the Asian surimi producers, with an output of 60,000 MT in 1989. During this period, Thai industries also had shown growth. The success of the Thai surimi industry stimulated developments of surimi production in other Southeast Asian countries such as Malaysia, Myanmar, Vietnam, and Indonesia. Figure 2.1 shows the percentage of surimi products in Southeast Asian countries in 2005. Thailand shows the largest surimi production and followed by Malaysia, Vietnam, Indonesia, and Myanmar, where the amount of surimi products are 145,000 MT, 95,300 MT, 64,000 MT, 8,000 MT, and 3,500 MT, respectively (SEAFDEC, 2007).

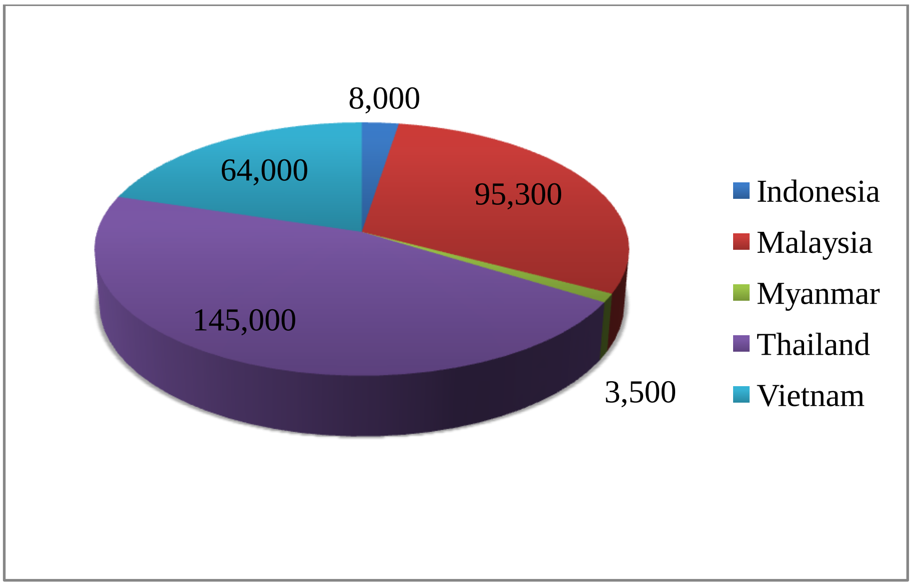

Figure 2.1. Percentage of surimi products in Southeast Asian Countries in 2005 (source: SEAFDEC, 2007)

Currently, 2-3 milion metric tones of fish from around the world, amounting to 2-3 percent of the world fisheries supply, are used for the production of surimi. The world will face a problem in availability of surimi raw material in the future and this will impact its price (SEAFDEC, 2009). To find out an alternative fish species as raw material in surimi industry will be a recommendation for the future sustainable development of the surimi industry.

2.1.2. Raw Material of Surimi

The fish normally used for making surimi are Alaska pollock or walleye pollock (*Theragra chalcogramma*), New Zealand hoki (*Macruronus novaezelandiae*), southern blue whiting (*Micromesistius australis*), and northern blue whiting (*Micromesistius poutassou*). In Asia, several species, such as the croaker (*Pennahai macrophthalmus*), lizardfish (*Sauruda micropectoralis*), barracuda (*Sphyraena* spp), hairtail (*Trichiurus* spp), atka mackerel (*Pleurogrammus azonus*), threadfin bream (*Nemipterus bleekeri*), and bigeye snapper (*Priacanthus tayenus*), are commonly used by shore-based surimi manufacturers (Park, 2005). Recently, beside marine fish, fresh water fish are also used in the manufacture of surimi, such as tilapia (*Sarotherodon nilotica*) (Zhou et al., 2006), grass carp (*Ctenopharyngodon idellus*) (Pan et al., 2010), catfish (Tadpitchayangkoon and Yongsawadigul, 2009; Kim et al., 1996; Kongpun, 1996). The abundance, accessibility, good gel strength, and subtle flavor and odor characteristics, make these species the optimal resources for surimi processing (Holmes et al., 1992).

2.1.2.1. Biology of Threadfin bream Surimi

According to Russell (1990), the classification of threadfin bream surimi are order: Perciformes, class: Actinopterygii, Family: Nemiptaridae, Genus: Nemipterus and Species: *Nemipterus* spp. The figure of threadfin bream is presented in Plate 2.1.Threadfin bream surimi had maximum length 21.0 cm (Paxton and Cohen, 1999) and the common length was 15.0 cm (Russell, 1999). The use of threadfin bream for surimi production has increased dramatically over the past decade, and will play a major role in surimi markets in the future. It has been proven that it can be used to make a high-quality surimi with good gel strength (Park, 2005).

Plate 2.1. Threadfin bream (*Nemipterus* spp.)

In Southeast Asian, sea areas of abundant stock (main spawning grounds) are Gulf of Thailand, Tonkin Bay, East coast of Peninsular Malaysia and North of Sulu Sea (SEAFDEC, 2007). These fish are benthic, inhabiting marine waters on sandy or muddy bottoms, usually at depths of 20 to 50 m, and feeding on small benthic invertebrates and small fish. Because of the white color, smooth texture, strong gel-forming ability, and easy processing, threadfin bream surimi is widely used as raw material for Japanese “kamaboko” and surimi-based crabstick or kani-kama (Park, 2005).

The Figure 2.2 showed the trend of threadfin bream landed in Southeast Asian countries. Thailand was the highest in landing threadfin bream as raw material for surimi although in 2002 it started to decrease. Indonesia in 2001 started to increase and followed by Malaysia and Philippines in 2003 and 2004, respectively, and there was no threadfin bream landing in Singapore (SEAFDEC, 2009).

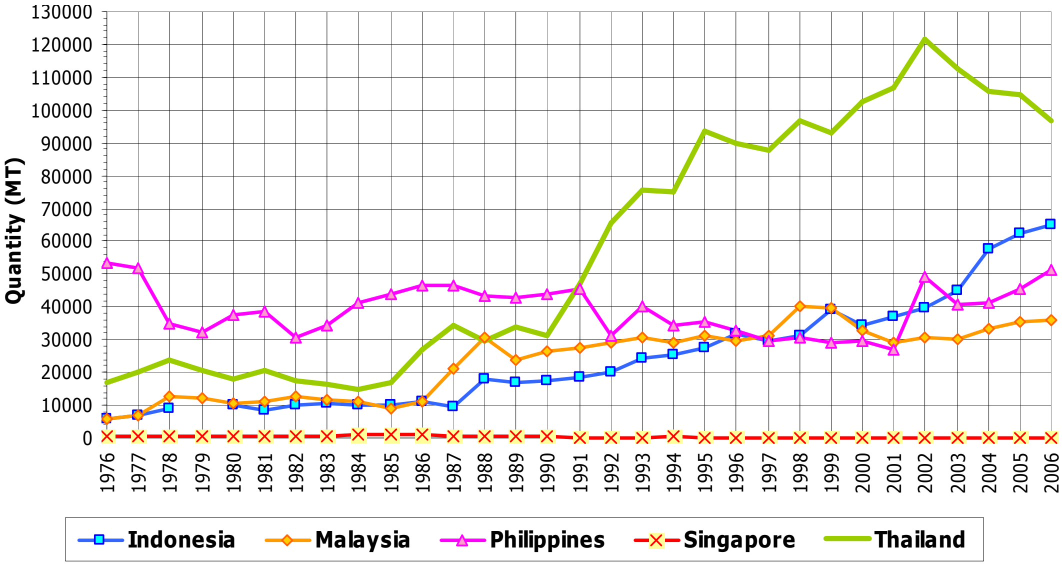

Figure 2.2. Trend of Nemipteridae landed in the Southeast Asian Countries (source: SEAFDEC, 2009)

2.1.3. Surimi Processing Technology

Surimi processing consists of several steps and a flow diagram of process for the manufacture of surimi is shown in Figure 2.3. The general steps are heading and gutting, cleaning and washing, deboning, fish meat, addition of cryoprotectant and freezing.

2.1.3.1. Heading, Gutting, Deboning and Mincing

Surimi manufacturing process starts from holding the fish and sorting by size and ends with freezing and frozen storage. There are two methods to prepare fish for the deboning. One is to remove head, gut and thoroughly clean the belly walls prior to deboning the carcass. The other is to fillet the fish and then debone the fillet containing skins and bones. Viscera must be removed because proteolitic enzyme in viscera can cause a severe shelf-life problem (Park et al., 1997). After heading and