STUDY ON THE EFFECT OF DIFFERENT SIZES AND THE QUALITY OF THE TIGER PRAWNS (*Penaeus Monodon)* DRIED USING FREEZE DRYER

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A thesis submitted in fulfillment
of the requirements for the award of the degree of
Bachelor of Chemical Engineering

Faculty of Chemical & Natural Resources Engineering
Universiti Malaysia Pahang

April 2009

DECLARATION

I declare that this thesis entitled "Study on the effect of different sizes and the quality of the tiger prawns (*Penaeus Monodon)* dried using freeze dryer" is the result of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree."

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Date	: 20 April 2009

DEDICATION

Special Dedication to my family members,

my friends, my fellow colleague

and all faculty members

For all your care, support and believe in me.

ACKNOWLEDGEMENT

I would like to forward my appreciation to my thesis supervisor, Prof. Madya Nordin Bin Endut and my panels Mr. Zukkifly Bin Jemaat and Madam Norashikin Binti Mat Zain for their guidance and support. I would also very thankful to my academic advisor, Madam Junhaslinda Binti Shariffuddin, for her support and believe in me during my studies.

I'm very thankful to Universiti Malaysia Pahang (UMP) for providing good facilities in the campus. To all the lecturer and teaching engineer in Faculty of Chemical & Natural Resources Engineering, a very big thanks you to all.

My sincere appreciation also extends to all my fellow colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Thank you for the time sacrificed to accompany me. And last but not least, I am grateful to all my family members.

ABSTRACT

This paper is consist the study of freeze dried tiger prawn (*Penaeus Monodon)* under vacuum condition at pressure 6.5 atm and temperature -40^{o}C with a different size of tiger prawns *(Penaeus Monodon)*. The drying process had been carried out for several days and it's depending on the size of tiger prawns. Weight of tiger prawn is taken every six hour to monitor the drying process. The drying process proceeds until it reached constant weight. The quality of freeze dried tiger prawn was compared base on different size during the drying process. For each size, calculation is made based on percentage weight loss and the rehydration potential. Sample A (3 cm) had a highest percentage weight loss and rehydration capability with a less of rehydration time compare to sample B (6cm) and sample C (12 cm). The small structure size of tiger prawns (*Penaeus Monodon)* can reduce the time of drying in freeze dryer. Freeze dried tiger prawns (*Penaeus Monodon)* could be stored without refrigeration or at room temperature. This will reduce the weight of packaging for product delivery and thus can reduce the cost. The taste of the freeze dried tiger prawn is also being judge with sensory evaluation. The sensory evaluation had been carried out by 12 respondents. The sensory evaluation had been carried out based on the appearance, aroma, texture, taste, and mouthfeel. From the evaluation, most of the respondents can accept the taste of freeze dried tiger prawn.

ABSTRAK

Kajian ini menunjukkan udang harimau sejuk kering (*Penaeus Monodon*) dalam keadaan vakum, pada tekanan 6.5 atm dan suhu -40 ^{o}C dengan saiz udang harimau yang berbeza. Proses pengeringan berlaku selama beberapa hari dan ianya bergantung pada saiz udang harimau. Udang harimau akan ditimbang berat setiap 6 jam untuk mengawal proses pengeringan. Proses pengeringan ini berterusan sehingga berat udang harimau menjadi tetap. Kualiti udang harimau sejuk kering dibandingkan dari segi perbezaan saiz semasa proses pengeringan. Untuk setiap saiz udang harimau, pengiraan diambil berdasarkan kadar peratusan kehilangan berat dan penyerapan air. Sampel A (3 cm) adalah sampel yang mempunyai kadar peratusan kehilangan berat dan kadar penyerapan semula air yang paling tinggi berbanding dengan sampel B (6cm) dan sampel C (12 cm).. Semakin kecil saiz udang harimau, masa yang diambil untuk disejukkeringan adalah semakin berkurangan. Peratus kehilangan berat udang harimau yang tinggi melalui proses sejukkering ini dapat mengurangkan berat untuk pembungkusan semasa proses penghantaran dan sekaligus ia dapat mengurangkan kos. Udang harimau sejuk kering ini juga boleh disimpan tanpa menggunakan peti sejuk atau disimpan pada suhu bilik. Rasa udang harimau yang disejukkeringkan juga dinilai dengan borang penilaian deria dimana hasil kajian ini telah dirasa dan dinilai oleh 12 orang panel. Borang penilaian deria dianalisis dari segi rupa,aroma,struktur, dan rasa. Hasil penilaian tersebut, kebanyakkan panel dapat menerima rasa udang harimau sejuk kering.

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LIST OF SYMBOLS

kg	-	kilogram
g	-	gram
s	-	second
° C	-	degree celcius
wt%	-	weight percentage
cm	-	sentimeter
%	-	percentage
mmHg	-	millimeter mercury
atm	-	atmospheric pressure
hr	-	hour
min	-	minute

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Through the passage of time, people have learned that water removal increases the storage stability of perishable products. Recent scientific studies have shown that water, as the dominant component of food, provides the critical environment factor necessary for the ubiquitous biological, biochemical and biophysical process that degrade foods and ultimately make them unfit for human consumption. Any reduction in water content that retards of inhibits such process will give a major contribution to food preservation.

Preserving biological products by reducing their water content can be achieved by several dehydration techniques. Among these methods, freeze drying is considered as the reference process for manufacturing high quality dehydrated products. That is due to the peculiar freeze drying condition: sublimation of ice coupled with a low process temperature. The main advantages of the process are the preservation of most of the initial raw material properties such as shape, appearance, taste, flavor, texture, biological activity, etc. and the high re-hydration capacity of the freeze dried products. Indeed, the use of freeze drying in food industries is restricted to high added value products such as coffee, teas, and ingredients for ready to eat foods (vegetable, pasta, meat, fish, shrimp, etc.), several aromatic herbs and specialty foods.

In this paper, the tiger prawns are chosen as a raw material for this experiment by using freeze dryer. The scientific name of tiger prawn is a *Penaeus Monodon*. *Penaeus Monodon* is a marine crustacean that is widely reared for food. *Penaeus Monodon* farming has been practiced for more than a century for food and the livelihood of coastal people in some Asian countries, such as Malaysia, Indonesia, the Philippines, Taiwan Province of China, Thailand and Vietnam. Its very rapid growth rates and its low requirement for protein make it an attractive species for aquaculture. *Penaeus Monodon* has a high demand from the international markets for example exports to Japan and US. But, the long lasting of the *Penaeus Monodon* will be around 2 - 3 months if put it into the freezer with packaging to exports to international market. That is the major problem whereby *Penaeus Monodon* is not preservable food and rotten faster.

By using the modern technique for food preservation like a freeze dryer, the long lasting of *Penaeus Monodon* will be increase and the quality of the *Penaeus Monodon* not rotten faster. This modern technique can solve the problem to exports the *Penaeus Monodon* to the international market.

It is well known that process may affect (partially or totally) the quality of a product. Indeed, various changes in physical, chemical and/or biological characteristics of foodstuffs may occur during processing, storage and distribution (Karrel, Buera, & Roos, 1993). These changes alter the physical aspect such as color and structure.

Freeze drying is an expensive process, and the cost might be reduced if processing time could be effectively shortened. It's also a very high energy consuming operation due to the necessity of freezing the fresh products, heating the frozen foods at low temperature to induce sublimation, condensing water vapor and lowering the total pressure of the dehydration chamber. Moreover, due to the necessity of operating under vacuum, freeze-dryers normally operate batch wise. Freeze drying in the food industry is limited only too high added value product, and that's why we choose the penaeus monodon as a sample for this experiment.

Vacuum freeze drying is the best method of water removal with final products of highest quality compared to other methods of food drying (Genin & Rene, 1995; Irzyniec, Klimczack & Michalowski, 1995). Freeze drying is based on the dehydration by sublimation of a frozen product. Due to the absence of liquid water and the low temperature required for the process, most of deterioration and microbiological reactions are stopped which gives a final products of excellent quality. The solid state of water during freeze drying protects the primary structure and the shape of the products with minimal reduction of volume. Despite of many advantages, freeze drying has always been recognized as the most expensive process for manufacturing a dehydrated product.

The aim for this paper is to compare the percentage weight loss, dehydration, texture, and the drying time with the different size of *Penaeus Monodon*, in order to see their applicability to high value foods.

1.2 Identification of Problem

Frozen foods retain fresh flavor and nutritional value, but require uniform, low temperature storage conditions. Dehydrated and canned foods are shelf-stable, but high-temperature processing can degrade flavor, texture and nutritional content. Freeze-drying combines the best of these processing methods. It preserves freshness, color and aroma similar to frozen food, while providing the shelf-stable convenience of canned or dehydrated food.

The *Penaeus Monodon* has a high demand to export to the international market. To solve this problem, we choose the equipment that is freeze dryer that can make the *Penaeus Monodon* have a long lasting around 2 - 3 months. Another problem that we can solve from this experiment is:

1. ***Taste fresh***. Freeze-dried foods, like frozen, retain virtually all their fresh-food taste and nutritional content. Freeze-drying removes the water, not the flavor.

2. ***Look fresh***. Freeze-dried foods maintain their original shape and texture, unlike dehydrated foods, which shrink and shrivel due to high-temperature processing. Freeze-drying removes water under low temperatures (typically a maximum of 37.8 to 54.4 degrees C), which keeps intact the moisture channels and food fibers. Just add water, and in minutes every fresh food detail returns.

3. ***Weigh less than fresh***. Freeze-dried foods have 98% of their water removed. This reduces the food's weight by about 90%.

4. ***Stay fresh***. Freeze-dried foods can be stored at room temperature, without deterioration or spoilage. This is because freeze-drying and packaging remove both water and oxygen - the two primary causes of food deterioration.

1.3 Statement of Objective

The objective of this research is to investigate:-

i) The effect of the weight loss and rehydration capability with the different size of *Penaeus Monodon*,

ii) The quality of the product dried such as taste after freeze dried, mouthfeel and texture of *Penaeus Monodon* will analysis with sensory evaluation.

1.4 Scope of Study

In this experiment, the objective is to study the effect of different temperature and weight loss on freeze drying, and the quality of the product dried of *Penaeus Monodon*. To achieve the objective, scopes have been identified in this research. The scopes of this research are listed as below:-:

1. Parameters evaluated

   - Percentage weight loss (g)
   - Product size of *Penaeus Monodon* (3 cm, 6 cm, and 12 cm)
   - Dehydration capability of *Penaeus Monodon*

2. Sensory Analysis

   - Appearance
   - Texture
   - Mouthfeel
   - Aroma
   - After taste

CHAPTER 2

LITERATURE REVIEW

2.1 Raw Material

Penaeus monodon (common names include *giant tiger prawn*, *black tiger prawn*, *leader prawn*, *sugpo* and *grass prawn*) is a marine crustacean that is widely reared for food. The natural distribution is Indo-West-Pacific, ranging from the eastern coast of Africa, the Arabian Peninsula, as far as South-east Asia, and the Sea of Japan. They can also be found in eastern Australia, and a small number have colonized the Mediterranean Sea via the Suez Canal.

Both sexes reach approximately 36 cm long, and females can weigh up to 650 g, making it the world's largest species of prawn. *P. monodon* is the most widely cultured prawn species in the world, although it is gradually losing ground to the whiteleg shrimp, *Litopenaeus vannamei*.

Also known as the black tiger shrimp, the shrimp is easily recognizable by the dark stripes on its shell. Of all shrimp, these are among the most widely distributed and marketed shrimp in the world.

The shrimp industry in Malaysia has developed rapidly since the early 1980s after the so-called successes experienced in neighbouring Thailand, Indonesia and Philippines. Malaysia, however, is not one of the major producers of cultured marine prawn in the world, as the area under marine prawn culture is about 5,100 hectares (2,627 hectares in 1995). Despite this, the Government of Malaysia is very proud to claim that the country's average production (metric tonnes per hectare) is the third highest in the world, after Taiwan and Thailand. And plans for intensification and expansion have been drawn up.

Based on the Food Production Action Plan (Fisheries Sector) that was formulated by the Fisheries Department, forecasted production of marine prawn (White Prawn, *Penaeus penicillatus* and Tiger Prawn, *Penaeus monodon*) in the year 2010 will be 129,100 metric tonnes. This amounts to a jump in production by about 13 times from the 1998 level of 9,835 metric tonnes.(Malaysia: Each prawn produced represents a teardrop)

Figure 2.1: Tiger prawns

As we can see, the increase demand for *Penaeus Monodon* in world markets has encourages many developing countries to enter into the practice of shrimp farming which has a significant impact on the world’s mangrove forests because of over production. That is the one of the reason why choose *Penaeus Monodon* as a raw material in this experiment.

2.2 Freeze Drying

Certain biological materials, pharmaceuticals, and foodstuffs, which may not be heated even to moderate temperatures in ordinary drying may be freeze dried. The substance to be dried is usually frozen. In freeze drying, the water or another solvent is removed as a vapor by sublimation from the frozen material in a vacuum chamber. After the solvent sublimes to a vapor, it is removed from the drying chamber where the drying process occurs.

As a rule, freeze drying produces the highest quality food product obtainable by any dying method. A prominent factor is the structure rigidity afforded by the frozen substance at the surface, where sublimation occurs. This rigidity to a large extent prevents collapse of the solid matrix remaining after drying. The result is a porous, no shrunken structure in the dried product that facilitates rapid and almost complete rehydration when water is added to the substance at a later time.

Freeze drying of food and biological materials also has the advantage of the little loss of flavor and aroma. The low processing temperatures, the relative absence of liquid water, and the rapid transition of any local region of the material being dried from a fully hydrated to a nearly completely dehydrated state minimize the degradative reactions that normally occur in ordinary drying process, such as nonenymatic browing, protein denaturation, and enzymatic reactions. In any food material some non frozen water, which is called *bound or sorbed water*, will almost unavoidably be present during freeze drying, but there is very often a rather sharp transition temperature for the still wet region during drying, below which the product quality improves markedly. This improvement shows that sufficient water is frozen to give the beneficial product characteristics of freeze drying.

However, freeze drying is an expensive form of dehydration for foods because of the slow drying rate and the use of vacuum. The cost of processing is offset to some extent by the absence of any need for refrigerated handling and storage.

Increasingly, freeze drying is used for dehydrating foods otherwise difficult to dry, such as coffee, onions, soups, and certain seafood and fruit. Freeze drying is also increasingly employed in the drying of pharmaceutical products. Many pharmaceutical products when they are in solution deactivate over a period of time; such pharmaceuticals can preserve their bioactivity by being lyophilized soon after their production so that their molecules are stabilized.

Systematic freeze drying is a procedure mainly applied to the following categories of material:

1. Nonliving matter, such as blood plasma, serum, hormone solutions, foodstuffs, pharmaceuticals (e.g: antibiotics), ceramics, superconducting materials, and materials of historical documents(e.g : archaeological wood)
2. Surgical transplants, which are made nonviable so that the host cells can grow on them as the skeleton, including arteries, bone, and skin
3. Living cells destined to remain viable for long periods of time, such as bacteria, yeasts, and viruses

Freeze drying requires very low pressures or high vacuum in order to produce a satisfactory drying rate. If the water was in a pure state, freeze drying at or near 0^oC at an absolute pressure of 4.58 mm Hg could be performed. But, since the water usually exists in a combined state or a solution, the material must be cooled below 0^oC to keep the water in the solid phase. Most freezes drying is done at -10^{o}C or lower at absolute pressures of about 2 mm Hg or less.

In short, freeze drying is a multiple operation in which the material to be stabilized is:

1. Frozen hard by low temperature cooling
2. Dried by direct sublimation of the frozen solvent and by desorption of the sorbed or bound solvent (non frozen solvent), generally under reduced pressure
3. Stored in the dry state under controlled condition (free of oxygen and water vapor and usually in airtight, opaque containers filled with inert dry gas)

Figure 2.2: Freeze dryer (Biotron/Cleanvac 8) for laboratory scale

If correctly processed, most products can be kept in such a way for an unlimited period of time while retaining all their initial physical, chemical, biological, and organoleptic properties, and remaining available at any time of immediate reconstitution. In most cases this is done by addition of the exact amount of solvent that has been extracted, thus giving to the reconstituted product a structure and appearance as a close as possible to the original material. However, in some instances, reconstitution can be monitored in order to yield more concentrated or dilute products by controlling the amount of solvent.

Vaccines and pharmaceutical materials are very often reconstituted in physiological solutions quite different from the original but best suited for intramuscular or intravenous injections. Freeze dried organisms, such as marine animals, plants or tissue extracts, can also be the starting point of an extraction process [5] using nonaqueous solvents with the purpose of isolating bioactive substances. Freeze drying allows dehydration of the systems without impairing their physiological activity so that they can be prepared for appropriate organic processing.

Another example is the freeze drying of nuclear wastes, which results in the manufacture of dry powders of medium radioactivity. Mixed with appropriate chemicals, they then can be fused into glass bricks or molded to provide low cost, high energy radiation sources.

The freeze drying method has also been in synthesis of superconducting materials, and produces homogeneous, submicron superconductor powder of high purity [4].

In the chemical industry, catalyzes, adsorbing filters and expended plastics can be used in the dry form and placed in the path of appropriate fluid or gases. Freeze dried dyes may also be dispersed in other media, such as oils and plastics.

2.2.1 Freeze Drying Process

Freeze drying is a process by which a solvent (usually water) is removed from a frozen foodstuff or a frozen solution by sublimation of the solvent and by desorption of the sorbed solvent (nonnfrozen solvent), generally under reduced pressure. The freeze drying separation method (process) involves the following three stages: (a) the freezing stage, (b) the primary drying stage, and (c) the secondary drying stage.

In the freezing stages, the foodstuff of solution to be processed is cooled down to a temperature at which all the material is in frozen state.

In the primary drying stages, the frozen solvent is removed by sublimation; this requires that the pressure of the system (freeze dryer) at which the product is being dried must be les than or near to the equilibrium vapor pressure of the frozen solvent. If, for instance, frozen pure water (ice) is processed, then sublimation of pure water at or near 0^oC and at an absolute pressure of 4.58 mm Hg could occur. But, since the water usually exits in a combined state (e.g : foodstuff) or a solution (e.g : pharmaceutical product), the material must be cooled below 0^oC to keep the water in the frozen state. For this reason, during the primary drying stage the temperatures of the frozen layer (see Figure xx) is most often at – 10 oC or lower at absolute pressure of about 2 mm Hg or less. As the solvent (ice) sublimes, the sublimation interface (plane of sublimation), which started at the outside surface (see figure 2.3), recedes, and a porous shell of dried material remains. The heat for the latent heat of sublimation (2840 kJ/kg ice) can be conducted through the layer of dried material and through the frozen layer, as shown in Figure 2.3.

The vaporized solvent (water) vapor is transported through the porous layer of dried material. During the primary drying stage, some of sorbed water (nonfrozen water) in the dried layer may be absorbed. The desorption process in the dried layer could affect the amount of heat that arrives at the sublimation interface and therefore it could affect the velocity of the moving sublimation front (interface). The time at which there is no more frozen layer (that is, there is no more sublimation interface) is taken to represent the end of the primary drying stage.

The secondary drying stage involves the removal of solvent (water) that did not freeze (this is termed sorbed or bound water). The secondary drying stage starts at the end of the primary drying stage, and the desorbed water vapor is transported through the pores of the material being dried.

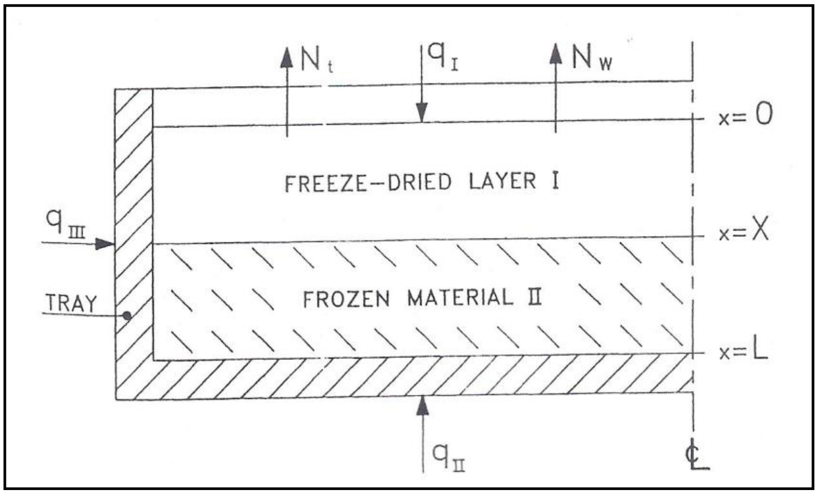

Figure 2.3: Diagram of a material on a tray during freeze drying. The variable X denotes the position of the sublimation interface (front) between the freeze-dried layer (layer *I*) and the frozen material (layer *II*)

2.2.2 Freezing Stage

The freezing stage represents the first separation step in the freeze drying process, and the performance of the overall freeze drying process depends significantly on this stage. The material system to be processed (e.g.: gel suspension, liquid solution, or foodstuff) is cooled down to a temperature (this temperature depends on the nature of the product) that is always below the solidification temperature of the material system. For instance, if the material to be freeze dried is a solution with equilibrium phase diagram that presents a eutectic point (e.g.: the solution of NACI and water presents a eutectic point at – 21.6^{o}C)