DEHYDRATED PITAYA (*Hylocereus undatus*) FRUIT CUBES CONTAINING IMMOBILIZED *Lactobacillus acidophilus* La-5 CELLS

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ABSTRACT

DEHYDRATED PITAYA (Hylocereus undatus) FRUIT CUBES CONTAINING IMMOBILIZED Lactobacillus acidophilus LA-5 CELLS

In this study, an attempt is made to combine the beneficial effects of Lactobacillus acidophilus La-5 with pitaya fruit (Hylocereus undatus) by applying the immobilization process. Pitaya fruit juice containing probiotic cells used as the immobilization medium. The viability of probiotic strains of Lactobacillus acidophilus La-5 during dehydration process and cold storage of the fruit cubes were studies. In order to increase stability and to assure fruit preservation, immobilized dragon fruit cubes were dehydrated using oven drying at two different temperatures (45°C and 50°C), freeze drying and sun drying. The freeze drying method resulted that the highest viability of probiotic cells on fruit cubes than other dehydration methods which decreased the cell population of 0.11 log cfu/g. The oven drying at temperature of 50°C reduced the population of L. acidophilus La-5 by four logarithmic cycles. However, oven drying at temperature of 45°C and sun drying reduced the probiotic cell viability less than one logarithmic cycle. The physical properties such as rehydration ratio and texture were carried out on the dragon fruit cubes. Sample of dried dragon fruit cubes were stored at 4°C up to 15 Days. During the storage condition, the cell numbers of probiotic on fruit cubes decreased less than one logarithmic cycle for all the dehydration methods which the viable cell content of final products was around $10^5$ to $10^6$ cfu/g and considered the proposed process as adequate to develop dehydrated products containing probiotic cells.
ABSTRAK

BUAH NAGA KERING YANG MENGANDUNGI SEL PEGUN LACTOBACILLUS ACIDOPHILUS LA-5

# LIST OF CONTENT

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE</td>
<td>I</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>ii</td>
</tr>
<tr>
<td>EXAMINER DECLARATION</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGMENT</td>
<td>iv</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>v</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>vi</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF TABLE</td>
<td>xi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>Xii</td>
</tr>
<tr>
<td>NOMENCLATURE</td>
<td>xiii</td>
</tr>
<tr>
<td>LIST OF APPENDIX</td>
<td>xiv</td>
</tr>
</tbody>
</table>

## CHAPTER 1: INTRODUCTION

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Background of Probiotic</td>
<td>1</td>
</tr>
<tr>
<td>2.1.1 Definition of Probiotic</td>
<td>6</td>
</tr>
<tr>
<td>2.1.2 Probiotic Cultures used in Food</td>
<td>6</td>
</tr>
<tr>
<td>2.1.2.1 General Characteristics</td>
<td>7</td>
</tr>
<tr>
<td>2.1.2.1 Technology Characteristics</td>
<td>8</td>
</tr>
<tr>
<td>2.1.2.3 Survival and Growth Characteristics</td>
<td>8</td>
</tr>
<tr>
<td>2.1.3 Criteria for Probiotic Selection</td>
<td>10</td>
</tr>
<tr>
<td>2.1.3.1 Acid and bile Tolerance</td>
<td>11</td>
</tr>
<tr>
<td>2.1.3.2 Adhesion Properties</td>
<td>14</td>
</tr>
<tr>
<td>2.1.3.3 Antagonistic properties</td>
<td>14</td>
</tr>
</tbody>
</table>
2.2 Cell Immobilization Supports and Techniques
   2.2.1 Immobilization on Solid Carrier Surfaces
   2.2.2 Entrapment within a Porous Matrix
   2.2.3 Cell Flocculation (aggregation)
   2.2.4 Mechanical Containment Behind a Barrier
   2.2.5 Desired Characteristic for Cell Immobilization
   2.2.6 Effects of Immobilization on Cell Characteristic
   2.2.7 Applications in Foods

2.3 Dragon Fruit (Pitaya)
   2.3.1 Types of Dragon Fruit
   2.3.2 Cultivation
   2.3.3 Harvesting and Post-harvesting Handling
   2.3.4 Pest and Disease

2.4 Dehydration of Food
   2.4.1 Oven-drying
   2.4.2 Natural Sun-drying
   2.4.3 Freeze-drying
   2.4.1.1 Microstructural and Macrostructural Changes
            2.4.1.1.1 Shrinkage
            2.4.1.2.1 Texture

CHAPTER 3: MATERIALS AND METHODS
3.1 Materials
3.2 Preparation Culture and Fruit Medium
3.3 Preliminary Growth Study 37
3.4 Cell Immobilization 37
3.5 Dehydration OF Fruit Cubes that Containing Probiotic Cells
   3.5.1 Oven-drying 38
   3.5.2 Sun-drying 39
   3.5.3 Freeze-drying 39
3.6 Physicochemical Analysis
   3.6.1 Moisture content 40
   3.6.2 Determination of pH value 41
   3.6.3 Determination of Titratable Acidity 41
   3.6.4 Determination of Soluble Solid Content 42
   3.6.5 Determination of Reducing Sugar 42
   3.6.6 Texture 43
3.7 Rehydration 44
3.8 Storage of Fruit Cubes 44
3.9 Enumeration of *L. acidophilus* La-5 44
   3.9.1 Preparation of Plates 45
   3.9.2 Culture Media 45
3.13 Analyses Statistic 46

CHAPTER 4: RESULTS AND DISCUSSION 47
4.1 Preliminary Growth Study 47
4.2 Effect of Cell Immobilization on the Growth of *L. acidophilus* La-5 50
   4.2.1 Fruit cubes added in fruit juices at the beginning of fermentation 50
   4.2.2 Fruit cubes added after dragon fruit juice ferment for 12 hours 52
4.3 Survival of probiotic cell on fruit cubes during dehydration process 55
4.4 The effect of dehydration process on fruit cubes 57
4.5 Physical properties of fruit cubes 60
  4.5.1 Texture properties of fruit cubes 60
  4.5.2 Rehydration properties of fruit cubes 62
4.6 Survival of *L. acidophilus* La-5 during storage 64

CHAPTER 5: CONCLUSION 67
REFERENCE 69
APPENDIX 79
LIST OF TABLE

<table>
<thead>
<tr>
<th>NO.</th>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Dragon fruit (<em>Hylocereus undatus</em>) nutritional information</td>
<td>28</td>
</tr>
<tr>
<td>4.1</td>
<td>Changes in pH, titratable acidity (TA; percentage lactic acid), °Brix and reducing sugar during fermentation of <em>L. acidophilus</em> La-5 in dragon fruit juice.</td>
<td>45</td>
</tr>
<tr>
<td>4.2</td>
<td>The changes of <em>L. acidophilus</em> La-5 viability on fruit cubes before and after freeze drying.</td>
<td>59</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>No.</th>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Survival of La-5 in dragon fruit juice during 36 hours of fermentation process at 37°C.</td>
<td>44</td>
</tr>
<tr>
<td>4.2</td>
<td>Survival of immobilized cell on fruit cubes and free cell in juices when the cubes were added at the beginning of fermentation.</td>
<td>46</td>
</tr>
<tr>
<td>4.3</td>
<td>Survival of <em>L. acidophilus</em> La-5 in fruit juices after 12 hours of fermentation process and survival of immobilized probiotic cell on fruit cubes.</td>
<td>48</td>
</tr>
<tr>
<td>4.4</td>
<td>Survival of <em>L. acidophilus</em> La-5 during dehydration in oven for two different temperatures (45°C &amp; 50°C) and sun drying.</td>
<td>50</td>
</tr>
<tr>
<td>4.5</td>
<td>Effect of dehydration method on moisture content for dragon fruit cubes.</td>
<td>51</td>
</tr>
<tr>
<td>4.6</td>
<td>Comparison of rate of weight loss of dragon fruit cubes by different dehydrated methods.</td>
<td>52</td>
</tr>
<tr>
<td>4.7</td>
<td>Texture properties of raw, after immobilization, dehydrated dragon fruit cubes.</td>
<td>54</td>
</tr>
<tr>
<td>4.8</td>
<td>Rehydration curve of oven dried at 45°C, oven dried at 50°C and sun drying fruit cubes at 25°C in sterilized distilled water.</td>
<td>55</td>
</tr>
<tr>
<td>4.9</td>
<td>Survival of <em>L. acidophilus</em> La-5 in dragon fruit cubes during 15 days of storage at 4°C.</td>
<td>56</td>
</tr>
<tr>
<td>Symbol</td>
<td>Definition</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
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<td>nm</td>
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<td>Weight/weight</td>
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</tr>
<tr>
<td>g</td>
<td>gram</td>
<td></td>
</tr>
<tr>
<td>( C )</td>
<td>Concentration</td>
<td></td>
</tr>
<tr>
<td>mL</td>
<td>Milliliter</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Appendix</td>
<td>Page</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>A.</td>
<td>Glucose solution standard curve</td>
<td>68</td>
</tr>
<tr>
<td>B.</td>
<td>Photo of fresh dragon fruit, dragon fruit cubes before immobilization and after dehydration process</td>
<td>69</td>
</tr>
<tr>
<td>C.</td>
<td>Output from one-way ANOVA for survival of probiotic cell and physicochemical properties in fruit juices</td>
<td>71</td>
</tr>
<tr>
<td>D.</td>
<td>Output from one-way ANOVA for survival of probiotic cell on fruit cubes and fruit juices during 24 hours of fermentation (fruit cubes added at the beginning of fermentation process)</td>
<td>72</td>
</tr>
<tr>
<td>E.</td>
<td>Output from one-way ANOVA for survival of probiotic cell on fruit cubes and fruit juices during fermentation (fruit cubes added after fruit juices ferment 12 hours)</td>
<td>73</td>
</tr>
<tr>
<td>F.</td>
<td>Output from one-way ANOVA for survival of probiotic and physicochemical properties during dehydration process</td>
<td>74</td>
</tr>
<tr>
<td>G.</td>
<td>Output from one-way ANOVA for survival of probiotic cells during storage of dragon fruit cubes</td>
<td>76</td>
</tr>
</tbody>
</table>
Nowadays, diet is perceived to be the most important factor contribution to human health. Production of foods fortified with functional properties that can promote human health is the key research priorities of food industries. The development of probiotics during the past decade has signaled an important advance in the food industry transferring towards the development of functional foods. Probiotic bacteria defined as “live microorganisms which confer a health benefit on the host when administrated in adequate amounts” (Picard et al., 2005). Probiotic bacteria for human nutrition usually belong to lactic acid bacteria or bifidobacteria groups. The beneficial effects of these strains on human health and well being are in experimental and clinical studies, has the potential to aid lactose digestion (Vesa et al., 1996), prevent traveler’s diarrhea (Boylston et al., 2004), improvement of gut health, lowering of blood cholesterol, improvement of the body’s natural defense mechanisms (Betoret et al., 2003), and enhance the activity of the immune system (Meydani & Ha, 2000).

Probiotic has been increasingly included into commercial dairy products in respond to consumer demand for healthy food. The growing demand for healthy foods is stimulating innovation and new products development in the food industry. Dairy products incorporating with probiotic bacteria, like fermented milks (Oliveira, et al., 2001), probiotic cheese (Bergamini et al., 2005), drinking and frozen yogurts (Doleyres & Lacroix, 2005) are well established in the market. With the market
success and the growing popularity of these fortified dairy foods, global food industry have begun researching on the possibility of probiotic enhanced line extensions which involved with the formulation of non-dairy probiotic foods such as cereal-based probiotic products and nonfermented frozen vegetarian dessert. It was also suggested that fruits could also serve as medium for functional ingredients like probiotics (Mattila-Sandholm et al., 2004).

Consumption of fresh fruits and vegetables has been associates with reduced risk of coronary heart disease (CHD), stroke and cancer (Wu et al., 2005). Polyphenolic compounds, widely distributed in higher plants, have been found to have potential health benefits that are believed to arise mainly from their antioxidant activity which play an important role in cancer chemo prevention and as anti-inflammatory agents (Liu et al., 2002). The fruit of *Hylocereus cacti*, known as strawberry pear, thang loy (Vietnamese), pitaya roja (Spanish), and la pitahaya rouge (French), grows on tropical climbing cacti, have recently drawn much attention of grower’s worldwide, not because of their red-purple color and economic value as food products, but also for their antioxidative activity from the betacyanin contents (Mizrahi et al., 1997). The skin of pitaya is covered with bracts, or “scales”—hence also named as dragon fruit.

The most popular species are *Hylocereus undatus*, a pitaya with a red skin and white flesh, and *Selenicereus megalanthus*, white fleshed but with a yellow skin and spines on the tubercles. Commercial pitaya plantings can be found in Vietnam, Taiwan (about 2000 acres), Central America, from Mexico and Texas to Peru and Argentina, Malaysia, and Israel. Vietnam is one of the main commercial producers of pitaya since it was introduced by the French 100 years ago. Production potential in
Taiwan was estimated at 14,700–24,500 pounds per acre (Zee et al., 2004). It is believed that there are only 10 to 15 hectares of dragon fruit planted commercially on the U.S. mainland which located in Southern California (Merten, 2002). In Nicaragua plantings yielded 10 tons to 12 tons per hectare in the fifth year (Jacob, 1999). In Malaysia, commercial cultivation of dragon fruit was initiated in Sitiawan, Kuala Pilah and Johor as early as 1999 (Anon, 2006).

Some technological advancement have been made achievable to alter the structural characteristics of fruit matrices by modifying food components in a controlled way, technologies such as cell immobilization or technology of vacuum impregnation are being used for the incorporation of probiotic cells into the structure of fruit and vegetables (Betoret et al., 2003). Cell immobilization has been suggested for various industrial applications compared to the free cell systems, because of its wide research interest and various advantages. Advantages of immobilized cell technology include prevention from washing-out during continuous cultures, reduction of susceptibility to contamination, continuous utilization, preventing of interfacial of secondary metabolites, and protection against turbulent and disadvantageous environments (Tsen et al., 2004).

Particles of various synthetic or natural materials, both organic and inorganic, are commonly used as supports for cell immobilization. In general, the supports used for cell immobilization in food production must be materials of food grade purity and also cheap and abundant. The used of fruits in developing such a biocatalyst was an obvious alternatives that has been used in several food-related industries. Apple, quince, and pear pieces, and grape skin have been already used successfully for immobilization of *Saccharomyces cerevisiae* yeast in both batch and continuous wine
making resulting in improves productivity and product aroma and taste (Kourkoutas et al., 2003). Immobilization on the supports modified cell metabolism resulting thus increased specific rates of substrate consumption and products formation (Mallouchos et al., 2002).

When the immobilized techniques successfully applied to fruit, the problem of preserve the quality of fruit before having by consumer may have been solved. Recently, new interest has arisen in the field of dehydration fruit products due to the demand for healthy and convenience meal that keep their original or functional properties. The purposes to dehydrate the fruit are to extend the shelf life of fruit products by reduction of the moisture content to a level which allows safe storage over an extended period (Riva et al., 2005). Also, it brings substantial reduction in weight and volume, minimizing packaging, storage and transportation costs. With air drying, a wide range of water and soluble solid contents in the final product could be achieved in order to prepare fruit ingredient with functional properties suitable for specific food systems.

Other dehydration methods such as freeze-drying also used as an effective method to preserved foods and avoid spoilage caused by microorganisms (George & Datta, 2002). It is considered to be a valuable process for products of high added value. Freeze-drying, although expensive, is the best method for drying foods with regards to its quality (Hammami et al., 1999). However, research on developing a dehydrated fruit product containing probiotic cells are very limited. Application of probiotic cultures in fruit cubes with dehydration treatment represents a great challenge to food industry. The viable cell content of the final products must be high enough (> 10^7 CFU/g) to consider the proposed process as adequate to develop
dehydrated fruits with probiotic effect after different dehydration methods and subsequent storage (Betoret et al., 2003).

Therefore, the aim of the study is to produce a novel dehydrated Dragon fruit (pitaya) cubes containing immobilized probiotic cells. This intended to determine the optimum processing parameters necessary to effectively incorporate the probiotic cells into the dragon fruit cubes and study the survival of immobilized probiotic with different dehydration treatment and storage periods.

1.2 OBJECTIVE

➢ To study the feasibility to immobilized probiotic cells into pitaya fruit cubes, aiming to develop a procedure to produce dehydrated fruit products immobilized with probiotic.
➢ Analyze the effect of dehydration condition on survival of probiotic cells.
➢ Study the viability of probiotic microorganisms in dehydrated product over a certain storage period.
2.1 Background on Probiotic

The consumption of live microbial food supplemented such as fermented milk products has a long history associated with beneficial health effects and probiotic cultures have a long associated with dairy food products. According to known scientists in early ages, such as Hippocrates and others considered the fermented milk not only used were often used therapeutically well before the existence of microorganisms recognized the use of microbes in food fermentation is one of the oldest methods to preserves food (Lourens-Hattingh and Viljoen, 2001).

At the beginning of the 20th century, the Russian scientist Elie Metchnikoff first give the scientific explanation for the beneficial effect of lactic acid bacteria present in fermented milk products which associated with longevity and good health. Metchnikoff reported that the lived longer of Bulgarians to their consumption of large amounts of fermented milk, called "yohourth". From Metchnikoff report stated that the lactic acid bacteria resulted in the elimination of putrefactive bacteria from gastrointestinal tract resulting in prolonged life (O'Sullivan et al., 1992). Almost at the same time, Tissier isolated bifidobacteria from the stools of breast-fed infants. He proposed that bifidobacteria might be effective in preventing infections in infants, since they were the predominant microflora in the intestinal of breast-fed infants (Ishibashi and Shimamura, 1993a).
Many excellent reviews have been published on the health benefits of probiotics throughout the century. The earlier studies dealt with the function of fermented milk in curing the intestinal infection. Recently, there are more studies focus on other aspects of health effects derived from probiotic, as well as the advances of technology to ensure survival of these bacteria in the gastrointestinal tract and the carrier food.

2.1.1 Definition of Probiotic

The term probiotic is derived from Greek and means “for life”, was first used to describe the growth-promoting factors produced by microorganisms that stimulate the growth of intestinal microflora (Scoot, 1999; Gomes and Malcata, 1999; Fook et al., 1999). However, the definition of probiotic was popularized by Fuller (1989) who described probiotic as live microbial feed supplements, exert the beneficial effects affect the animal microflora balance. Most recently, probiotic defined as microbial cell preparation or components of microbial cells that have a beneficial effect on health and well-being of the host. (Salminen et al., 1996). This definition includes either nonviable cells or parts of cells of probiotic, as well as certain fermented foods have been showed health effects.

In 2001, at an Expert Consultation meeting arranged by the World Health Organization and the Food and Agriculture Organization of the United Nations (FAO/WHO, 2001), redefined a simple and widely accepted definition of probiotic. They defined probiotic as live microorganisms which when administered in adequate amounts confer a health benefit on the host, again highlighting the important of viability in this most recent definition.
2.1.2 Probiotic Cultures used in Food

2.1.2.1 General Characteristics

Members are of the genus *Bifidobacterium* and *Lactobacillus* are widely used as probiotic microorganisms in functional foods. Many *Lactobacillus* or *Bifidobacterium* strain with nutritional benefits characteristics of probiotic bacteria are of human intestinal origin. The human origin probiotic bacteria are accepted generally that they are better suited to the physiological needs of the host and can easily colonize in human intestinal tract (Gomes and Malcata, 1999). However, *Bibifodobacteria* are the most important groups of intestinal organisms regarding human health. The main species of bifidobateria present in humans include *Bifidobacterium adolescentis*, *Bifidobacterium bifidum*, *Bifidobacterium infantis*, *Bifidobacterium breve*, and *Bifidobacterium longum* in the colon (Champagne and Gerner, 2005).

The most popular food delivery system for probiotic cultures divided into two categories, freshly fermented or unfermented dairy foods which include milk, yogurt, ice cream and frozen dessert (Gomes et al., 1995; Samona and Robinson, 1994; Corbo et al., 2001; Stanton et al., 1998). Recent studies showed that selected strain of bifidobacteria such as *Bifidobacteria longum*, *Bifidobacteria adolescentis* and *Bifidobacteria infantis* used as dietary adjuncts in dairy products which exhibit unique properties improve the products quality. Although dairy products classified as suitable food carrier for probiotic, there are numerous challenges to enable each strain within these species can meet the therapeutic minimum requirement after various processing condition.
The incorporation of bifidobacteria in fermented soy products has been recently studied for the of soy functional fermented foods. Numerous studies have been showed that bifidobacteria able to growth well in soymilk medium and can withstand the adverse conditions during the industrial processing or production (Kamaly, 1998; Tsangalis and Sha, 2004). Lactobacilli also become important as adjunct cultures in production of dairy functional probiotic foods (Klaenhammer, 1998). Lactobacillus probiotics in particular, are usually given GRAS status, since most are isolated either from traditional dairy products or the gastrointestinal tract of healthy individuals (Ishibashi and Shimamur, 1993b).

*Lactobacillus acidophilus* is the best known of the probiotic lactobacilli which is a natural inhabitant of mammalian gastrointestinal systems. The *Lactobacillus acidophilus* complex strains divided into six groups at the species level. Presently, *Lb. acidophilus*, *Lb. crispatus*, *Lb. amylovorus*, *Lb. gallinarum*, *Lb. gasseri*, and *Lb. johnsonii* have been proposed as valid species in the *L. acidophilus* group (Champagne and Gardner, 2005). It is difficult to evaluate the probiotic potential of these strains used in dairy products marketed as functional foods. Therefore, the selection of probiotic strain used in fermented dairy products is based on their overall effect towards human health.

It is estimated that there are 80 probiotic containing products in the world. In terms of consumer awareness, Japan, a leading country in manufacture, produces more than 50 different marketable dairy products containing viable cells. According to the literature, the market in Japan for probiotics and other functional foods is approximately $3.5 billion (Gomes and Malcata, 1999). Similar trends are observed in other development countries; more than 45 dairy plants in Europe currently


