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OPTIMIZATION OF PROCESS CONDITIONS FOR PRODUCTION OF JAM FROM HONEYDEW (*CUCUMIS MELO I.)* SKIN

BY

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A dissertation submitted in fulfilment of the requirement for the degree of Master of Science (Biotechnology Engineering)

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ABSTRACT

Honeydew melon fruit (*Cucumis melo I*) is one of Malaysian's favourite fruit. This type of melon is rich in potassium, vitamin C and sodium. Almost 30 percent part from honeydew fruits are thrown away as waste, which leads to additional environmental problem. Nowadays, utilization of fruit or food waste into valuable products is becoming the main concern of research by the food scientists. This study has been divided into three parts, which were [1] pectin detection and jam making from melon pulp and melon skin, [2] optimization of product ingredients and [3] study of some physicochemical parameters. Alcohol precipitation has been used to detect the availability of the pectin in the fruit pulp and fruit skin before jam spread were produced from both parts. Pectin found in fruit skin was higher compared to fruit pulp, which were 0.503% and 0.088% respectively. In addition, jam spread of honeydew skin without additional commercial pectin received positive response from the sensory panelists. Thus fruit skin can be utilized to produce commercial pectin or jam spread. Later, optimization of the ingredients for jam spread of honeydew skin was conducted by using FCCCD under RSM. The independent variables were amount of sugar, amount of acid and amount of pectin. Twenty samples were evaluated by 20 trained students of IIUM in terms of appearance, aroma, taste/sweetness, texture and overall acceptability. The optimum formulation for jam spread of honeydew skin was 70% of sugar, 1.13% of pectin and 0.81% of acid. At the end of the study, moisture content and ash content were determined. Percentage of moisture and ash contain for sample with high sugar contain (64%) were 25.84% and 1.07%, respectively. While percentage of moisture and ash contain for sample with low sugar (58.63%) was 43.26% and 0.793%, respectively. Sample with more sugar can last until 6 month in the fridge. In contrast low sugar jam already yields a mould at the same time. The regression coefficient (R^2) came out from experimental and predicted result was 86.16%.

خلاصة البحـــث

الشمام من الفواكه المفضلة لدى الماليزيين. وهو من الفاكهة الغنية بالبوتاسيوم وفيتامين C والصوديوم و خالية من الكولسترول. يتم تقديم لب الشمام كالفواكه الطازجة بينما يتم التخلص من البذور والقشرة كالنفايات. ما يقارب من 30 في المائة من الشمام تطرح كنفايات وهو مما يؤدي الى اضافية المشكلات البيئية. والآن أصبح الانتفاع ببقايا أو نفايات الطعام شأن مهم للبحث عند علماء الغذاء لصناعة منتجات ذات قيمة إذ أنه يساعد في تخفيف كمية النفايات المتولدة وتنتج منتجات ذات مردود اقتصادي في النفس الوقت. مطابقا لهذا الاهتمام تكونت الفكرة في الانتفاع بقشر الشمام لإنتاج المربى حيث تقسم الدراسة الى ثلاثة أقسام وهي: استخلاص البيكتين وإنتاج المربى من اللب والقشر، وتحسين مكونات النتاج ودراسة لبعض المعالم الفيزيوكيميائية للمنتج. لقد استعمل ترسيب الكحول للتحقق من كمية البيكتين الموجود أصلاً في لب الفاكهة وقشرتها قبل تصنيع المربى منهما. كانت نسبة البيكتين المتوفرة في القشر أعلى من النسبة المتوفرة في اللب حيث النسبة 0.503% و 0.088% على التوالي. و بالاضافة، أن مربى قشر الشمام بغير اضافة البيكتين التجاري تأخذ الردود الايجابية من قبل خبراء التقييم. ومن ثم أمكن الاستفادة من قشرة الفاكهة لانتاج البيكتين التجاري والمربى. ثم تم لاحقا إجراء تحسين المكونات لمربى قشر الشمام باستخدام Face Centred Central Composite Design (FCCCD) تحت Response Surface Methodology (RSM). كانت المتغيرات المستقلة هي كمية السكر وكمية الحامض وكمية البيكتين. وقام عشرون من الطلاب المتدربين بالتقييم من خلال التذوق على عشرين من العينات من حيث المظهر و النكهة والحلاوة اوالطعم والقوام والقبولية عموما. كانت الصيغة الأمثل لمربى قشر الشمام هي 70% من السكر و 1.13% من البيكتين و 0.81% من الحامض. وفي نهاية الدراسة تم تحديد المحتوى الرطوبة و المحتوى الرماد. كانت الكمية العالية من السكر مسببة في انخفاض محتوى الرطوبة وامتداد فترة الصلاحية للمربى. إن الرماد يمثل المحتوى المعدني في الطعام و كانت النسبة المئوية للرماد في مربى قشر الشمام هي 1.07% و يعني من النسبة العالية من الرماد المزيد من المحتوى المعدني وبالتالي يعني أن المنتج ذا قيمة غذائية عالية. وكانت نتيجة المقارنة بين نتائج التجربة العملية والمتوقعة متقاربة حيث بلغت 86.16% .

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Biotechnology Engineering).

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Nurlina binti Yusof.

Signature …… Date ……..

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I would like to dedicate this thesis and everything I do to my beloved parents, Yusof bin Ismail and Hamidah binti Kamai.

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LIST OF ABBREVIATIONS

AHTN	Asean Harmonised Tariff Nomenclature
AOAC	Association of Official Analytical Chemists
CCD	Centered Composite Design
Cucumis melo I.	*Cucumis melo Inodorus*
DE	Degree of Esterification
FAMA	Federal Agriculture Marketing Authority
FCCCD	Faced Centred Central Composite Design
FDA	The Food and Drug Administration
g	Gram
IIUM	International Islamic University Malaysia
IPPA	International Pectin Procedures Association
JEFCA	Joint FAO/WHO Expert Committee on Food Additives
K	Potassium
kg	Kilogram
LM	Lower-methoxyl pectins
HM	High-methoxyl pectins
MOA	Ministry of Agriculture and Agro-Based Industry Malaysia.
MS	Malaysian Standards
Na	Sodium
PDK	*Perintah Duti Kastam* (Custom Duti Order)
RSM	Response Surface Methodology
RSQM	Response Surface Quadratic Model
USDA	United State Departments of Agriculture

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF RESEARCH

Food preservation is a technique of treating and handling food to slow down food spoilage (from microbes or physical and chemical change) and lengthen food shelf-life. This practice is applied all over the world (Rensselaer et al., 1919). Methods in preservation techniques include drying, smoking, chilling, and heating (Zeuthan et al., 2003). Compounds used in preservation are sodium (salt), sucrose or glucose (sugar), alcohol and acid (vinegar) (Madison, 2007). There are several examples of the foods that have been preserved such as *kimchi* (Korean fermented vegetable) (Price et al., 2002), *tempe* (fermented soy from Indonesia) (Bois et al., 2008), salted fish and sauerkraut (Chinese fermented cabbage) (Hunter, 2008). Conversion of fruit into jam spread is one of the most popular preservation practices in Europe (Flack, 1993).

Jam spread is a global food which originated from England. Some of the classic brands such as damsons and wild blackberry were first brought to the world during the colonial period of England and until now, these have maintained the taste and flavors (Saunder et al., 2010). When these jams are exported to other countries, its taste is slightly changed to suit their own countries savor. Malaysia also produces strawberry jam; orange jam; and blackberry jam, but with less sour taste than the original jam.

Jams are in demand around the world because they have a good taste, attractive color, simply available, nutritious, and easy to manufacture and have a long shelf life. There are four main components in jam making; fruit, sugar, pectin and acid (Smith et

al., 2003). In certain jam products, fruit dietary fibers (DF) are added to improve nutritious components and act as a thickener (Murray, 1977; Miguel et al., 1999; Miguel et al., 2000). Besides jam, there are two more gel products, which are jelly and marmalade. The main difference between them is the technique used to prepare and cook the fruit, and the texture of the final product (Saunder et al., 2010).

In preparing a jam spread, several important factors must be taken into account. One of which is the pectin content of the fruit. Pectin acts as a gelling agent that makes jam colloidal. Adding extra pectin to high-pectin fruit will make the jam harder while adding less pectin into low-pectin fruit will make the jam soft (Saunders et al., 2010). Thus it is really important to test pectin content in respective fruits. In addition, pectin is highly sensitive to temperature. High temperature or long exposure to the temperature will denature the pectin molecule and as a result, gel will become harder.

Initially fruit jams were produced from seasonal fruits. However nowadays, almost all types of fruits are made into jams because it lasts longer and can be eaten anytime. Besides using common fruits in jam making like strawberry, orange, black-currant and pineapple, other fruits such as apricot, plum and rhubarb also being used as different flavours of jams (http://www.barryfarm.com/jams.htm).

Honeydew is a seasonal fruit and is also known as winter melon because it grows during winter season in Europe (Grubben, 2004). The skin colour of immature honeydew is greenish white and becomes creamy yellow when it ripens. The flesh is light green or yellowish, thick, sweet, juicy and has a unique flavour (Stephens, 2009). Honeydew fruit is liked by Malaysian's due to its unique taste. It is presented as fruit salad, juice and also as a dessert (Abdullah, 2007). In 2011, Malaysia produced 310.7 metric ton of honeydew melon (*tembikai wangi*) with Johor as a primary manufacturer (DAPM, 2012).

Like other fruit, honeydew melon ripens quickly. According to United States Department of Agriculture (Buzby, 2009), about 25 percent of honeydew waste created in 2006, increase 3.7 percent from 2005 (20.9%). This amount includes the amount of damaged fruits due to weather and over-ripening. During honeydew fruit preparation, skin and seeds produced are considered as waste because these are not consumed by humans. For 1000 g of honeydew fruit, 60% is the fruit pulp, 30% is the skin and the remaining 10% is fruit seeds. Waste generated from honeydew fruit contributes to environmental problems.

Research about jam is seldom done in Malaysia. Even though jam is highly liked by Malaysians, not many studies have been done by Malaysians. Thus, this research will focus on optimization of jam production from honeydew skin. Several physical and chemical properties will be assessed.

1.2 PROBLEM STATEMENTS

Waste generated from honeydew skin is increasing due to boost production of honeydew crops (FAMA, 2005). It contributes to the environmental issues. Engineers and scientists nowadays are trying to find solutions to environmental problems. Thus the making of honeydew jam from the outer covering of honeydew fruit will be economical substrate for production, which will also solve the disposal of honeydew waste.

Jam is a world food. It can be seen in every corner of the world. Common fruit jams in the market are strawberry, mango, pineapple, orange and blueberry. However, there is no honeydew jam found in the market as of now. Until recently, research about jam only focused on the commercial fruit spread, especially on strawberry and berry fruit. Besides, not much research has been done for honeydew jam. Thus

optimizations of process condition are essential due to limited information on honeydew jam. This research focussed on the production of jam from honeydew melon skin.

Modern people began to give serious attention to their diet (Zeuthen et al., 2003). They are looking for healthy food yet delicious. Fruits are known sources of nutrition. It contains antioxidant compositions such as flavonoids, phenolics, vitamins and Carotenoids (Jongen, 2005), (Danijela, 2009). Some compounds of these antioxidant are able to increase Vitamin C activity, protecting the jam against oxidative degradation (Zeuthen et al., 2003) and also subtracting the possibility for many chronic diseases like cancer and cardiovascular illness (Jongen, 2005). Different fruits have a variety of nutritional compositions (Szeto et al., 2001). Honeydew fruits possess high amount of potassium (Lozano, 2006) which helps in reducing blood pressure (Insel, 2011). It also contains sodium and vitamin C. However when fruits are put under external pressures such as cooking, this will change the physiochemical properties of a fruit. Therefore few tests were conducted to evaluate the properties of jam from honeydew skin.

1.3 OBJECTIVES

The main objective of the study is to optimize the formulation (amount of sugar, acid and pectin) of jam making from honeydew skin. The research has been divided into three sub-objectives, which were:

- To quantify the amount of pectin for jam making from fruit pulp and fruit skin of honeydew.
- To optimize the process parameters (amount of sugar, acid and pectin) for production and quality improvement of honeydew jam from skin (skin part was selected based on excellent performance in objective 1).
- To study the physicochemical properties and stability of final product (jam from honeydew skin) during storage.

1.4 RESEARCH METHODOLOGY

This research is based on the laboratory-based experimental work. It began with the literature review and preparation of raw materials. Species of honeydew melon used in the research is *Cucumis melo. I.* The first sub-objective was to estimate the amount of pectin from various part of honeydew fruit. Pectin content was tested from fruit pulp and skin using alcohol precipitation methods. However, this method was performed only to detect the amount of pectin in the melon, not use the pectin extract in jam making. Commercial powdered pectin will be used in jam making. Later fruit pulp and inner skin were made into jam spread. For each part, two samples were prepared, one with additional of commercial pectin while the other sample free from commercial pectin. Sensory evaluation tests were conducted.

The second objective was to optimize the process conditions of honeydew skin jam. Parameters studied were quantity of pectin, acid and the amount of sugar added.

Experimental design used for optimization was Faced Centered Composite Design (FCCD) software. Five responses were recorded, which were aroma, appearance, taste, texture and overall acceptability. Finally, validation of process parameters was done to validate the parameters for jam production. The detailed methodology will be discussed in chapter three.

Percentage of ash and moisture content of the jam were tested using standard methods suggested by the Association of Official Analytical Chemis (AOAC).

1.5 RESEARCH SCOPE

The research focused on production of jam from honeydew skin. Three main ingredients in preparing jam; which were amount of pectin, amount of sugar and amount acid have been varied using Faced Centered Central Composite Design (FCCCD) under Response Surface Methodology (RSM). Response was based on sensory evaluation.

1.6 THESIS ORGANIZATION

Chapter 1 includes the introduction and background of the research. Chapter 2 provides a literature review of previous research related to this study. The detailed methodology will be discussed in Chapter 3 while results and discussions will be presented in Chapter 4. Chapter 5 concludes the research with some recommendations for future research on jam from honeydew skin.

CHAPTER TWO

LITERATURE RIVIEW

There are four subtopics related to the study, which will be discussed i.e. honeydew melon fruits, pectin, jam preservative and optimization process.

2.1 HONEYDEW MELON FRUIT (*CUCUMIS MELO INODORUS)*

The main focus of this research was the use of honeydew melon fruit in jam production. The main reason for choosing a honeydew melon in this research is because it is liked by most of the Malaysians as well as non-Malaysians (Abdullah, 2007). Honeydew melon also has been grown in Malaysia and become one of the fruits with high profitable value (FAMA, 2005). In addition, as the fruits are well known sources of nutrients, honeydew melon fruit is quite nutritious and is one of the healthiest foods (Lozano, 2006). Honeydew is also one quite inexpensive as a fresh fruit however its price increases when processed for consumption purpose (USDA, 2001).

2.1.1 Prologue of honeydew melon fruit

Honeydew melon fruit (*Cucumis melo I.)* is an American name for the 'White Antibes' cultivar which has been planted for many years in Southern France and Algeria. It belongs to *Cucumis melo* species under *Inodorus* group, which also includes *cantaloupe* and *casaba melon* (Stephans, 2009). Besides *Inodorus, cucumis melo* has several botanical subgroups such as *Cantaloupensis, Reticulatus, Conomon, Flexuosus, Chito and Dudaim* (Table 2.1). Honeydew fruit grows during winter in

Europe and is second largest winter melon fruit cultivated after a cantaloupe (Schultheis et al., 2002). Honeydew grows best in dry weather because they are easily exposed to fungal diseases which are enhanced through the moisture (Bertelsen et al., 1994).

The excellent taste of honeydew makes it highly prized as a dessert fruit. Like other melons from *Cucumis* family, honeydew fruits grow on climbing or trailing vines with round pointed or folded leaves and small yellow flowers (Figure 2.1). The melon is large (4 to 8 lbs.), slightly oval in shape, and generally very smooth with no netting or ribs. The rind is firm and ranges from creamy white when in an immature state to creamy yellow when ripe. The pulp is light green, thick, juicy, sweet and uniquely flavoured. The trunk does not separate from the fruit, and must be cut during harvesting (USDA, 1994). Figure 2.2 illustrates the *Cucumis melo I.* melon.

Table 2.1
Groups of *Cucumis melo* species (Jett, 2006)

Cucumis melo subgroup	**Cultivar examples**	**Fruit characteristics**
Cantaloupensis (true cantaloupe)	Prescott melon D'Alger Charentais	Smooth to warty fruit surface. Very aromatic. No netting. Fruits do not slip from vine when mature. Widely grown in Europe
Inodorus	Canary melon Casaba melon Crenshaw melon Honeydew melon	Not aromatic. Fruit does not slip from vine when mature. Flesh is usually green or white.
Reticulatus .	Muskmelons Persian melon Galia melon	Netted and aromatic fruit slips from the vine when mature
Conomon	Makuwa uri Chinese melon Sakata's sweet	No aroma. Fruit has crisp, white flesh. Widely grown in Asia.
Flexuosus	Armenian cucumber Snake melon	Elongated fruit with no aroma.