UNIVERSITI PUTRA MALAYSIA

EVALUATION OF RHEOLOGICAL PROPERTIES AND QUALITY OF XYLITOL-SUBSTITUTED DADIH

NURFATIMAH BINTI MOHD THANI

EVALUATION OF RHEOLOGICAL PROPERTIES AND QUALITY OF XYLITOL-SUBSTITUTED *DADIH*

By

NURFATIMAH BINTI MOHD THANI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science.

May 2015

Specially dedicated to …
My loving parents…
My beloved husband…
My wonderful siblings…
My friends…
For their support and encouragements…

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the Degree of Master of Science

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Chairman : Assoc. Prof. Siti Mazlina Mustapa Kamal, PhD
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Dadih is a dairy based dessert made of milk, water, sugar, and agar that is popular especially among South East Asian people. It has sweet taste due to high sugar content in its formulation. An excessive sugar intake is harmful to human health, and it would be beneficial if conventional sugar is replaced by a sugar substitute. In order to produce a healthier *dadih*, xylitol that has less energy and possesses sweetening power comparable to sucrose, was used as sugar substitute. To produce a new product such as xylitol substituted *dadih*, it is crucial to evaluate the suitable range of process parameters with various xylitol compositions in properties and quality. In this study, the evaluated properties were in terms of mechanical (rheological and texture) and thermal properties. Safety (total plate count and water activity) and sensory analysis were measured to evaluate the *dadih* quality.

Thus, the first section of this current research was to investigate the effects of process conditions and xylitol concentrations in term of rheological and textural properties of *dadih*. Process conditions set up were cooking temperatures (85-95˚C) and cooking times (10-20 minutes) while the xylitol set up were at three levels of compositions (0%, 50%, and 100%). It was found that cooking temperature had the biggest impact on rheological and textural properties of *dadih.* All *dadih* samples showed an elastic characteristic (n'<1) with gel-like behavior where value of G' (storage modulus) was higher than G" (loss modulus). In general, the presence of xylitol in *dadih* contributed to softer texture compared to product that is made from sucrose. Thus, xylitol substituted *dadih* prepared at 85°C with cooking time 15 and 20 minutes have met the required texture in term of hardness and internal gel strength as the conventional *dadih*. The second section of this study focused on thermal and safety analysis of *dadih* prepared at temperature 85˚C with two points of cooking time (15 and 20 minutes). At both cooking time (15 or 20 minutes) as xylitol substitution increase, the onset temperature and enthalpy values were decreased, indicating a weaker structure of *dadih* with xylitol compared to sucrose. *Dadih* that was prepared with total xylitol (100%) exhibited the lowest onset temperature T_o (97.71±0.4˚C for 15 minutes and 99.85±0.18˚C for 20 minutes) and enthalpy values (2096.98±1.4 Jg^{-1} for 15 minutes and 2422.61±3.6 Jg^{-1} for 20 minutes). *Dadih* samples that demonstrated low values of onset temperature and melting enthalpy indicated that less energy was required to change the structure.

Safety analysis was done to predict the stability and product quality of xylitol substituted *dadih* by evaluating microbial growth throughout the storage period of 25 days. From total plate count (TPC) and water activity analysis, all samples was totally spoiled at Day 25 where it contained >300 organism per gram and achieved maximum water activity value, a_w (1). Spoilage of *dadih* with 100% xylitol was slightly prolonged, which was completely spoiled at Day 24 and 25, for 15 and 20 minutes cooking time respectively. However, *dadih* samples with total sucrose (0%) were observed to be spoiled earlier compared to the former, which was on Day 23. Extended shelf life and stability of *dadih* substituted xylitol might be due to natural characteristics of xylitol of having low water activity.

Last section of this research was to evaluate the sensory analysis of the *dadih*. Based on eight attributes of sensory analysis, *dadih* that was prepared at 15 minutes cooking time for both total sucrose (0%) and xylitol (100%) was more preferable compared to samples 20 minutes cooking time. However, there were no significant differences ($p > 0.05$) for overall acceptability of both samples with 0% and 100% xylitol prepared at 15 minutes cooking time. Based on sensory evaluation, the score for *dadih* with xylitol substitute was above 'slight like', which indicated a promising future to conventionally produce xylitol substitute *dadih*. Therefore, the outcome of this study has shown that xylitol is potentially to be utilize as sugar substitute for *dadih* production.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENILAIAN TERHADAP SIFAT-SIFAT REOLOGI DAN KUALITI UNTUK DADIH GANTIAN XILITOL

Oleh

NURFATIMAH BINTI MOHD THANI

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Pengerusi : Prof. Madya. Dr. Siti Mazlina Mustapa Kamal, PhD
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Dadih adalah satu pencuci mulut berasaskan tenusu yang diperbuat daripada susu, air, gula, dan agar dimana ianya popular terutamanya di kalangan orang Asia Tenggara. Ia mempunyai rasa yang manis kerana kandungan gula yang tinggi dalam perumusannya. Pengambilan gula yang berlebihan boleh memudaratkan kesihatan manusia, dan ia akan memberi manfaat jika gula konvensional digantikan dengan gantian gula. Dalam usaha untuk menghasilkan dadih yang lebih sihat, xilitol yang mempunyai tenaga yang kurang dan mempunyai kuasa pemanis setanding dengan sukrosa, telah digunakan sebagai gantian gula. Untuk menghasilkan produk baru seperti dadih gantian xilitol, ia adalah penting untuk menilai julat yang sesuai bagi parameter proses dengan kepelbagaian komposisi xilitol pada sifat-sifat dan kualitinya. Dalam kajian ini, sifat-sifat yang di nilai adalah dari segi sifat-sifat mekanikal (rheologi dan tekstur) dan termal. Analisa Keselamatan (jumlah hitungan koloni dan aktiviti air) dan analisa sensori juga di ukur untuk menilai kualiti dadih.

Oleh itu, bahagian pertama penyelidikan ini adalah untuk mengkaji kesan keadaan proses dan kepekatan xilitol dari segi sifat-sifat reologi dan tekstur terhadap dadih. Keadaan proses yang di tetapkan adalah suhu memasak (85-95˚C) dan masa memasak (10-20 minit) manakala xilitol ditetapkan pada tiga tahap komposisi (0 %, 50 %, dan 100%). Didapati bahawa suhu memasak mempunyai impak terbesar pada sifat-sifat reologi dan tekstur terhadap dadih. Semua sampel dadih menunjukkan ciri elastik (n ' < 1) dengan tingkah laku seperti gel di mana nilai G'(modulus simpanan) adalah lebih tinggi berbanding G''(modulus kehilangan). Secara umumnya, kehadiran xilitol dalam dadih menyumbang kepada tekstur yang lebih lembut berbanding dengan produk yang diperbuat daripada sukrosa. Oleh itu, dadih gantian xilitol yang disediakan pada 85°C dengan masa memasak 15 dan 20 minit, telah mempunyai tekstur yang diperlukan dari segi kekerasan dan kekuatan gel dalaman seperti dadih konvensional. Bahagian kedua kajian ini memberi tumpuan kepada analisa terma dan keselamatan dadih yang disediakan pada suhu 85˚C dengan dua tahap masa memasak (15 dan 20 minit). Pada kedua-dua tahap masa memasak (15 atau 20 minit) apabila penggantian xilitol meningkat, suhu permulaan dan nilai entalpi telah menurun, menunjukkan struktur dadih yang lebih lemah dengan penggantian xilitol berbanding sukrosa. Dadih yang telah disediakan dengan keseluruhan xilitol (100 %) menunjukkan nilai suhu permulaan (97.71±0.4˚C untuk 15 minit dan 99.85±0.18˚C untuk 20 minit) dan entalpi (2096.98±1.4 Jg^{-1} untuk 15 minit dan 2422.61±3.6 Jg^{-1} untuk 20 minit) yang paling

rendah. Sampel dadih yang mempunyai nilai suhu permulaan dan entalpi lebur yang rendah menunjukkan bahawa kurang tenaga diperlukan untuk mengubah strukturnya.

Analisa keselamatan telah dilakukan untuk meramalkan kestabilan dan kualiti produk dadih gantian xilitol dengan menilai pertumbuhan mikrob sepanjang tempoh penyimpanan iaitu selama 25 hari. Daripada analisis jumlah hitungan koloni (TPC) dan aktiviti air, semua sampel adalah rosak di hari ke-25 di mana ia mengandungi >300 organisma per gram dan mencapai nilai aktiviti air yang maksimum, $a_w(1)$. Masa untuk dadih dengan 100% xilitol untuk tidak rosak telah sedikit berpanjangan, di mana ia rosak sepenuhnya pada hari ke-24 dan ke-25, masing-masing pada masa memasak 15 dan 20 minit. Walaubagaimanapun, sampel dadih dengan total sukrosa (0 %) telah mengalami kerosakan lebih awal iaitu pada hari ke-23, berbanding dengan sampel yang digantikan dengan xilitol. Jangka hayat yang lebih panjang dan kestabilan dadih yang digantikan dengan xilitol mungkin disebabkan oleh sifat-sifat semula jadi xilitol yang mempunyai aktiviti air yang rendah.

Bahagian akhir kajian ini adalah untuk menilai analisis sensori dadih. Berdasarkan lapan sifat-sifat analisis sensori, dadih yang telah disediakan dengan masa memasak 15 minit untuk pengunaan total sukrosa (0 %) dan xilitol (100 %) adalah lebih lebih baik berbanding dengan sampel yang masa memasaknya 20 minit. Walau bagaimanapun, tidak terdapat perbezaan yang ketara ($p > 0.05$) bagi penerimaan keseluruhan kedua-dua sampel antara 0 % dan 100 % gantian xilitol yang disediakan pada 15 minit masa memasak. Berdasarkan penilaian sensori, skor bagi dadih dengan xilitol sebagai pengganti adalah melebihi 'suka sedikit', yang menunjukkan masa depan yang cerah bagi mengkomersilkan pengeluaran dadih gantian xilitol. Oleh yang demikian, hasil kajian mendapati xilitol mempunyai potensi untuk digunakan sebagai gantian gula di dalam penghasilan dadih.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

DSC	Differential Scanning Calorimetry
UHT	Ultra High Temperature
F&B	Food and Beverages
ε	normal strain
To	Onset Temperature
ΔH	Enthalpy
˚C	Celcius Degree
TPC	Total Plate Count
RH	Relative Humidity
a_w	Water activity
LVR	Linear Viscoelastic Region
G'	Storage Modulus
G"	Loss Modulus
K	Consistency coefficient
n	Flow Behaviour index
ω	Angular Frequency
R^2	Goodness of Fit
TFTC	Too Few To Count

CHAPTER 1

INTRODUCTION

1.1 Introduction

Dadih is a dairy based desert that has custard-like texture, sweet taste and sweet jellies appearance. It is a popular pudding among South East Asian people especially Malaysians. According to Yudoamijoyo *et al.* (1983) *dadih* was primarily introduced in West of Sumatera and Jambi where the initial method was done by using buffalo milk followed by fermentation in a bamboo container. In Malaysia, cow milk is more preferable to make *dadih*. Nowadays, *dadih* can simply be found at local supermarket with varieties of flavours such as chocolate, strawberry or other fruity flavours and colours, and demand for it is increasing due to its sweet, delicious taste.

The main components of *dadih* are milk, sugar, and agar. The preparation of *dadih* can be classified into three phases. The first phase is mixing *dadih* in liquid form with all ingredients. The mixture is then being heated during the second stage, to transform the *dadih* physical form from liquid to semi-liquid (more viscous), and during the final stage (third phase), the mixture is cooled down so it will turn into solid form. The second and third phases involve crystallization process due to the existence of starch and also coagulation of protein from milk. The crystallization process that occurs between chemical bonding of each element is mainly due to crystallization of protein.

Today, the demand on healthy food is increasing among consumers especially for food products with high nutritional values with less sugar or sugar-free. Due to this demand, many food manufacturers are willing to replace the use of sucrose in their products with substituted sugars. Several studies were done by replacing sucrose with substitute sugars partially or fully in food products, such as in chewing gum (Burt, 2006), jams (Basu *et al.* 2011; Hyvönen & Törmä, 1983), yoghurt (Hyvönen & Slotte, 1983), and cookies (Mushtaq *et al.* 2010; Winkelhausen *et al.* 2007). One of sugar substitues that is suitable to replace sugar in food is xylitol. Xylitol is a sugar alcohol that possesses sweetening power comparable to sucrose and can be replaced in 1:1 ratio. Xylitol can provide about 10 kJ/g energy which is 40% less energy than sucrose (Winkelhausen *et al.* 2007). Winkelhausen *et al.* (2007) stated that xylitol is suitable as sugar replacement for reduced energy food products as it contains less 25% energy compared to reference food. At equivalent concentration, xylitol has lower water activity that will improve product stability. Therefore, products containing xylitol has more microbial stability, thus longer shelf life (Parajo *et. al.* 1998). This study highlighted an improved *dadih* that used xylitol to replace sucrose.

1.2 Problem Statement

Nowadays, large population of Malaysians are facing obesity due to excessive intake of sugar and unhealthy diet. From the New Straits Times newspaper, the article with headline "Hilmi: We have 3M obese Malaysians" (Kaur, 2013), highlighted that Malaysia is leading in the prevalence of obesity among the Southeast Asian countries where almost one in two Malaysians are either overweight or obese, placing them at high risk for diabetes. Obesity caused by high sugar level may trigger many fatal diseases such as cardiovascular disease, hypertension, diabetes and others. Hence, there

are several ways to prevent the diseases from happening, such as by replacing sugar (sucrose) in the food products with substitute sugars.

One the potential substitute sugar is xylitol, which is a sugar polyalcohol that has been used in food processing, odontological, and pharmaceutical industries. It possesses a sweetening power comparable to sucrose (Russo, 1977). Due to its insulin independent properties, xylitol can be used by diabetic patients (Yilikari, 1979). Thus, xylitol can act as sugar replacement in various dairy food products such as *dadih*. Today, the Malaysian food market is flooded with multiplicity dairy products, and *dadih* is one of the most favourable. It is a traditional food generally consumed as dessert in the Peninsular Malaysia (Hamzah, 1983). However, to produce a new product with less sugar and calories such as xylitol substituted *dadih*, the information on suitable range of processing parameters are crucial as it will effected the properties and quality of *dadih*. Acceptability of customer to a new product is also important, thus sensory evaluation is needed in order to recognise the opinion of the potential customer. Thus, this study was conducted to improve conventional *dadih* using xylitol to replace sucrose to reduce the calorie content, as a way to promote a healthier version of *dadih.*

1.3 Objectives

Generally, this study was aimed to investigate the potential of utilizing xylitol as sugar substitute for *dadih* production. The specific objectives of this study are as below:

1. To investigate the effects of process parameters and xylitol concentrations in term of rheological and textural properties of *dadih*.
2. To analyze the thermal properties and safety analysis of *dadih* at different xylitol concentrations.
3. To evaluate sensory analysis on *dadih.*

1.4 Research scope

Experimental work of this project was carried out in three stages. The first stage was focused on obtaining a suitable range of process conditions for *dadih* preparation by substituting xylitol at different percentage of compositions. Throughout this stage, factors affecting the cooking process of *dadih* were determined, and numerous preliminary tests for every level of each factor were identified. Under the selected conditions, effects in term of the rheological and textural properties of *dadih* were studied.

Understanding the rheological behaviour changes during processing will help in designing a suitable process control for the production of xylitol substituted *dadih*. Thus, in this study the rheology properties of *dadih* were analysed using rheometer. Oscillatory test determined any variation within samples with different percentages of xylitol. Similar process conditions were used for texture properties of *dadih*. Texture analyser was used to analyse texture properties of *dadih* in term of hardness and internal gel strength.

While the second stage focused on analysing the thermal properties as well as safety analysis of *dadih* that prepared at various xylitol concentrations. For thermal analysis, effect of heat supplied on *dadih* was investigated by examining the onset temperature and enthalpy values. Whereas, *dadih* safety analysis were analysed through

microbiological test (using total plate count) and water activity analysis. Samples of various storage times were tested to determine the time taken for the product to spoil.

Final stage was focused on evaluating the sensory analysis of *dadih*. Equally important, sensory evaluation is one of the most important steps in food industry to determine new product acceptability. Due to this, *dadih* samples underwent sensory analysis by 40 untrained panellists. The total acceptability of the samples was analysed and panels' opinions towards *dadih* with xylitol were studied.

1.5 Thesis Structure

This thesis consists of five chapters. Chapter 1 or introductory chapter illustrates the importance of this research. The importance of xylitol as sugar substitute and introduction on *dadih* as Malaysia's famous dessert are discussed. Problem statements and the objectives of this study are also presented.

Chapter 2, which is literature review, evaluates the previous studies on xylitol and *dadih*. The importance and advantages of xylitol as sugar substitute are described. Moreover, theories and analysis in regard to formulation, production process, and gelation are assessed. The advantage of microbiological analysis towards the quality and stability of the products are highlighted too. Besides, sensory evaluation, which are some of the most important elements in food industry are discussed in this chapter.

Chapter 3 highlights general materials and methods used in this study, including xylitol, sucrose, and other ingredients used in *dadih* formulation. Furthermore, general analysis procedures of performance as well as preliminary tests conducted in this study are described, which is also included methodology of all analysis.

Chapter 4 elaborates results and explanations of the analysis, starting with physical analysis of *dadih* on rheology and texture analysis. Discussion on thermal properties where DSC analysis was used to determine the onset temperature as well as enthalpy value of every samples of *dadih* with different percentages of xylitol concentration is also included. In addition, this chapter also discusses about safety analysis of the product. Water activity test and total plate count test were done on each sample at different storage time. The *dadih* stability and safety were observed based on the shelf life of the product. Finally, this chapter also reports the overall acceptability of the products. Sensory analysis by 40 untrained panellists determined the satisfactoriness of selected samples containing different percentage of xylitol.

Chapter 5 provides a brief conclusion as well as recommendations for future work.

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