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ENZYMATIC HYDROLYSIS OF SAGO STARCH FOR THE PRODUCTION OF MALTODEXTRINS

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ENZYMATIC HYDROLYSIS OF SAGO STARCH FOR THE PRODUCTION OF MALTODEXTRINS

By
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Thesis Submitted in Fulfilment of the Requirements
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UPM

Specially for.....

My respected parents,

Ong,

sisters Daisy, Judy and Janet

Prof. Mahyuddin and Dr. Nasir

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LIST OF ABBREVIATIONS

BU	Brabender unit
°C	degree Centigrade
DE	Dextrose Equivalent
DP	Degree of Polymerisation
dsb	dry starch basis
gm	gram
hr	hour
M	Molar
min	minute(s)
mg	milligram
ml	millimeter
nm	nanometer
ppm	parts per million
u	micron
ul	microliter
um	micrometer
w/v	weight per volume
w/w	weight per weight
<	less than
%	percent

Abstract of the Thesis Presented to the Senate of
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ENZYMATIC HYDROLYSIS OF SAGO STARCH FOR THE PRODUCTION OF MALTODEXTRINS

BY

CH'NG YAN ENG

June, 1995

Chairman : Prof. Mohamed Mahyuddin Bin Mohd. Dahan, Ph.D.

Faculty : Food Science and Biotechnology

Maltodextrin is a partial starch hydrolysis product used widely in food. It has been produced from corn, tapioca and potato starches. This project was designed to study the production of maltodextrin from refined sago starch and to characterise the maltodextrins produced. The refined sago starch used was obtained from different sago factories and labelled as Bag A, B, C, D, E, F, G, H and I. Studies carried out showed that there were variations in the quality of the starch of different bags. The moisture content of the starch varied from 10.05 to 15.40% (w/w) while the ash and crude fibre contents were 0.110 to 0.930 % (w/w) and 0.040 to 0.560% (w/w) respectively. The sago starch showed greyish colour with Hunter Lab L values of 87.70 to 90.17 and pH values of 4.77 to 7.58. Particle size analysis showed that more than 99.3% (w/w) of the starch passed through the 125 um pore size sieve. The peak gelatinisation viscosity of the starch varied between 458 to 680 BU. The sago starch showed a common pasting temperature of 74°C and an

extremely low level of protein of less than 0.010% w/w. The measurement of the degree of starch damage showed that sago starch of Bags D, E, F and G were undamaged, while starch of the remaining bags had damage of up to 8% w/w. The undamaged sago starch was of two types: the high, and the low viscosity starch with peak gelatinisation viscosities of about 680 BU and 485 BU respectively. Enzymatic susceptibility studies showed that undamaged sago starch was relatively unsusceptible to alpha-amylases Termamyl 120L and BAN 240L. The degrees of hydrolysis achieved after prolonged incubation for 12 hours at 60°C were 8.6 to 12.1% w/w, and 1.8 to 2.3% w/w respectively. The raw damaged and the gelatinised undamaged sago starch had increased susceptibilities to these alpha-amylases. The degrees of hydrolysis were 17.5 to 22.1% w/w, and about 3.0% w/w respectively, for damaged starch, and 88.3% and 76.5% (w/w) respectively, for the gelatinised starch. Viscozyme 120L when used alone (at a dosage of 0.05% w/w) or in combination with either Termamyl 120L or BAN 240L (at a dosage of 0.10% w/w) had the ability of reducing the viscosity of gelatinised sago starch. It was unable to hydrolyse either the raw or gelatinised starch. Damaged sago starch when used for enzymatic hydrolysis (by Termamyl 120L) produced unstable low DE syrups which retrograded on cooling. Sago starch with high crude fibre content produced low DE syrups that were difficult to filter. Both Termamyl 120L and BAN 240L were found to be suitable for the production of maltodextrin from sago starch. A starch concentration of 20% (w/v) was suitable for hydrolysis at pH 5.5 to pH 6.5. Optimum Termamyl 120L dosages were 0.08 to 0.10% (w/w) for the production of DE 6 to 20 maltodextrins. A dosage of 0.04% (w/w) of BAN 240L was suitable for

producing DE 8 to 11 maltodextrins while 0.06% (w/w) and 0.08% (w/w) of the amylase were suitable for producing DE 12 to 15, and DE 16 to 20 maltodextrins respectively. Maltodextrins with similar DE value derived from Termamyl 120L and BAN 240L had different oligosaccharide profiles. The DE 10.0 maltodextrin (from Termamyl 120L hydrolysis) had predominant amount of maltoheptose, maltopentose and maltotriose with very low level of maltohexose. The DE 10.2 maltodextrin (from BAN 240L hydrolysis) had prominent amount of maltopentose and maltoheptose and a higher level of maltohexose than the aforementioned DE 10.0 maltodextrin. Maltodextrins produced from sago starch by using Termamyl 120L had much superior solution stability and solubility characteristics than those produced by using BAN 240L. The viscosity of solutions of maltodextrins produced were comparable to that reported for commercial Maltrin maltodextrins with similar DE value.

Abstrak tesis yang dikemukakan Kepada Senat
Universiti Pertanian Malaysia Sebagai Memenuhi Syarat
Keperluan Untuk Ijazah Master Sains

HYDROLYSIS ENZIMATIK KANJI SAGU UNTUK PENGHASILAN MALTODEKSTRIN

Oleh

CH'NG YAN ENG

June, 1995

Pengerusi : Prof. Mohamed Mahyuddin Bin Mohd. Dahan, Ph.D.

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Maltodekstrin adalah produk hasilan hidrolisis separa kanji yang digunakan secara meluas dalam makanan. Ia telah dihasilkan daripada kanji jangung, ubi kayu dan ubi kentang. Projek ini dijalankan untuk mengkaji penghasilan dan pencirian maltodekstrin daripada kanji sagu. Kanji sagu yang digunakan didapati daripada kilang yang berlainan dan dilabelkan sebagai Beg A, B, C, D, E, F, G, H dan I. Kajian yang dijalankan menunjukkan bahawa terdapat perbezaan pada kualiti kanji sagu tersebut. Kandungan airnya adalah di antara 10.05 hingga 15.40% (w/w). Kandungan abu dan fiber kasar dalam kanji sagu ialah masing-masingnya sebanyak 0.110 hingga 0.930% (w/w) dan 0.040 hingga 0.560% (w/w). Kanji sagu didapati berwarna kelabu dan bernilai L Hunter Lab sebanyak 87.70 hingga 90.17 L sementara nilai pH kanji berada di antara 4.77 hingga 7.58. Kajian saiz partikel menunjukkan bahawa lebih daripada 99.3% (w/w) kanji tersebut boleh melepasi penyaring bersaiz lubang sebesar 125 um. Kanji sagu didapati mempunyai kelikatan pengelatinan yang

berbeza-beza di antara 458 hingga 680 BU. Kandungan protinnya adalah sangat rendah sekitar < 0.010% w/w. Kanji sagu ini menunjukkan suhu 'pasting' serupa sebanyak 74°C. Kajian darjah kerosakkan kanji menunjukkan bahawa kanji sagu pada Beg D, E, F and G adalah sempurna tanpa kerosakkan granul, sementara kanji beg-beg lain mempunyai kerosakan setinggi 8% (w/w). Terdapat dua jenis kanji sagu tanpa kerosakkan berdasarkan nilai kelikatan pengelatinan tertingginya: iaitu kanji berkelikatan tinggi sebanyak 680 BU, dan kanji berkelikatan rendah sekadar 485 BU. Kajian enzimatik menunjukkan bahawa kanji sagu tanpa kerosakkan mempunyai kerintangan terhadap hidrolisis oleh alfa-amilase komersial Termamyl 120L dan BAN 240L. Pengeraman selama 12 jam pada 60°C menghasilkan darjah penghadaman sebanyak 8.6 hingga 12.1% (w/w), dan 1.8 hingga 2.3% (w/w). Kanji sagu dengan kerosakkan menunjukkan peningkatan darjah penghadaman sekitar 17.5 hingga 22.1% (w/w), dan 3.0% (w/w) masing-masingnya. Kanji sagu sempurna tergelatin mempunyai darjah penghadaman oleh kedua-dua amilase tersebut sebanyak 88.3% (w/w) dan 76.5% (w/w) masing-masingnya. Viscozyme 120L didapati berupaya menurunkan kelikatan pengelatinan tertinggi kanji sagu bila digunakan secara bersendirian (pada dos 0.05% w/w) atau bersama salah satu amilase tersebut (pada dos 0.10% w/w). Ia tidak berupaya menghidrolisiskan kanji sagu baik mentah mahupun yang tergelatin. Sirup bernilai DE rendah yang dihasilkan daripada kanji sagu yang rosak adalah tidak stabil dan mudah mengalami retrogradasi. Kanji sagu berkandungan fiber kasar yang tinggi menghasilkan sirup bernilai DE rendah yang sukar ditapis. Termamyl 120L dan BAN 240L didapati sesuai untuk penghasilan maltodekstrin dari kanji sagu. Kepekatan sluri kanji sebanyak 20% w/v and pH bernilai 5.5 hingga 6.5 adalah

CHAPTER 1

INTRODUCTION

Maltodextrin is a partial starch hydrolysis product widely used as bulking, bodying and thickening agents, spray drying and encapsulating aids, and fat replacers in many food systems and other applications (Meyer and Everett, 1972; Lloyd and Nelson, 1984; Blanchard, 1992a; Fullbrook, 1984; Alexander, 1992). Many types of maltodextrins have been produced from different starches with varying degree of hydrolysis measured in terms of dextrose equivalent value (DE) and through different manufacturing processes (Alexander, 1992; Katz, 1986; Lloyd and Nelson, 1984; Slott and Madsen, 1975, Coker and Venkatasubramaniam, 1984; Morehouse and Sander, 1987). All these offer a multitude of useful common functional properties. However, due to manufacturing variations, these maltodextrins have unique characteristic differences particularly in their oligosaccharide profiles (Alexander, 1992; Katz, 1986).

Maltodextrins have been produced mainly in America, Mexico, Europe and Australia from starches that represent cheap carbohydrate sources of these regions. These products are therefore mostly derived from corn, potato and tapioca starch (Alexander, 1992; Katz; 1986). Consequently, technical information regarding the manufacturing process and the various processing parameters are based on hydrolysis of these starches (Slott and Madsen, 1975; Coker and Venkatasubramaniam, 1984; Morehouse and Sander, 1987; Morehouse et al., 1972; Armbruster, 1981).

In Malaysia, maltodextrins are being imported for utilisation in the local food industries. Although there are no figures in the literature regarding the amount and type of maltodextrins being imported and consumed, the amount is assumed to be large as can be seen from the quantity of local products produced that contain maltodextrins as an ingredient. To date, there is no factory producing commercial maltodextrins for local utilisation or for export. Therefore, if maltodextrins can be manufactured using one of the local indigenous starches, this will not only save revenue but also diversify the utilisation of such starch and related industries apart from the possibility of exporting the maltodextrins produced. For these reasons, one such possible indigenous starch is sago starch of which Malaysia is the largest producer and exporter (Azudin and Lim, 1991).

The sago starch industry has improved tremendously with the production of better quality sago starch for utilisation in the food and biotechnological industries (Azudin and Lim, 1991; Zulpilip et al., 1991). Various starch hydrolysis products typically produced from corn starch have also been produced from sago starch (Azudin and Lim, 1991; Azudin and Ali, 1991; Zulpilip et al., 1991; Solichien, 1994; Pranamuda et al., 1994; Haska, 1994; Ghani et al., 1994). However, although the starch quality has improved greatly, the main problem of quality variation still persists (Azudin and Lim, 1991). This significantly affects its utilisation in a bioconversion process, like for example the production of maltodextrins where a rather constant starch quality is required (Katz, 1986).

At present there is no report on the suitability of sago starch of various quality for hydrolysis or bioconversion process. More importantly, there is no information available on the manufacture of maltodextrins from sago starch. Therefore, the objectives of this study are :

1. To characterise the quality of refined sago starch and to determine its suitability for enzymatic hydrolysis

2. To determine the optimum conditions for enzymatic hydrolysis of sago starch to maltodextrins

3. To characterise the maltodextrins (DE 10 and DE 19) produced

CHAPTER 2

LITERATURE REVIEW

Maltodextrins

Maltodextrin is defined as non-sweet, nutritive saccharide polymers that consist of D-glucose units linked primarily by alpha-1,4 glucosidic bonds having a dextrose equivalent (DE) value of less than 20. It is prepared as a white powder or concentrated solution by partial hydrolysis of starch with safe and suitable acids and/or enzymes. Maltodextrin is generally recognised as safe as a direct human food ingredient (Blanchard, 1992b; Long, 1985; Fullbrook, 1984; Lloyd and Nelson, 1984; Alexander, 1992; Katz, 1986; FDA CRF 184.1444). Typically, maltodextrins are used as bulking, bodying and thickening agents, spray drying and encapsulating aids, and fat replacers in many food systems and other applications (Meyer and Everett, 1972; Lloyd and Nelson, 1984; Blanchard, 1992b; Fullbrook, 1984; Alexander, 1992).

Although a wide variety of commercial maltodextrins made from corn, waxy corn, tapioca and potato starch is available, the information on acidic and/or enzymatic processes manufacturing them are rather limited (Alexander, 1992; Katz, 1986). Moreover, most of the limited information available regarding the production of these maltodextrins, particularly technical information, is derived from pilot-scale patented processes (Slott and Madsen, 1975; Morehouse and Sander, 1987, Coker and Venkatasubramaniam, 1984). This chapter presents and discusses, in general, various aspects of

maltodextrin, and in particular its enzymatic production, quality and characterisation. It also presents currently available information on sago starch.

Manufacturing Process

The industrial process of making maltodextrin (Figure 1) can basically be divided into five main stages which comprise of, starch gelatinisation, liquefaction, partial dextrinisation and stabilisation, refining and clarification, and finally spray drying (Alexander, 1992; Fullbrook, 1984). Native, ungelatinised starch is insoluble and relatively unsusceptible to hydrolysis (Swinkels, 1985). Gelatinisation, therefore, yields solubilised starch containing amylose and amylopectin molecules. This is thinned and hydrolysed during liquefaction, and dextrinisation stages to yield a stabilised low DE hydrolysate. It is then purified by refining to produce a concentrated maltodextrin solution or spraydried to give a white, dry maltodextrin powder (Alexander, 1992; Lloyd and Nelson, 1984).

Two main hydrolysis modes are utilised for the liquefaction, and dextrinisation stages (Lloyd and Nelson, 1984; Fullbrook, 1984; Blanchard, 1992b). Generally, total acidic hydrolysis previously used yields maltodextrins of poorer quality that haze easily (Lloyd and Nelson, 1984; Fullbrook, 1984; Schenck and Hebeda, 1992). Therefore, enzymatic hydrolysis with or without an initial acid hydrolysis stage is now more commonly employed (Armbruster and Harjes, 1971; Morehouse et al., 1972; Armbruster and Kooi, 1974; Alexander, 1992; Blanchard, 1992b). This mode which uses a thermal stable bacterial endo alpha-amylase has several advantages (Reilly, 1985; Teague

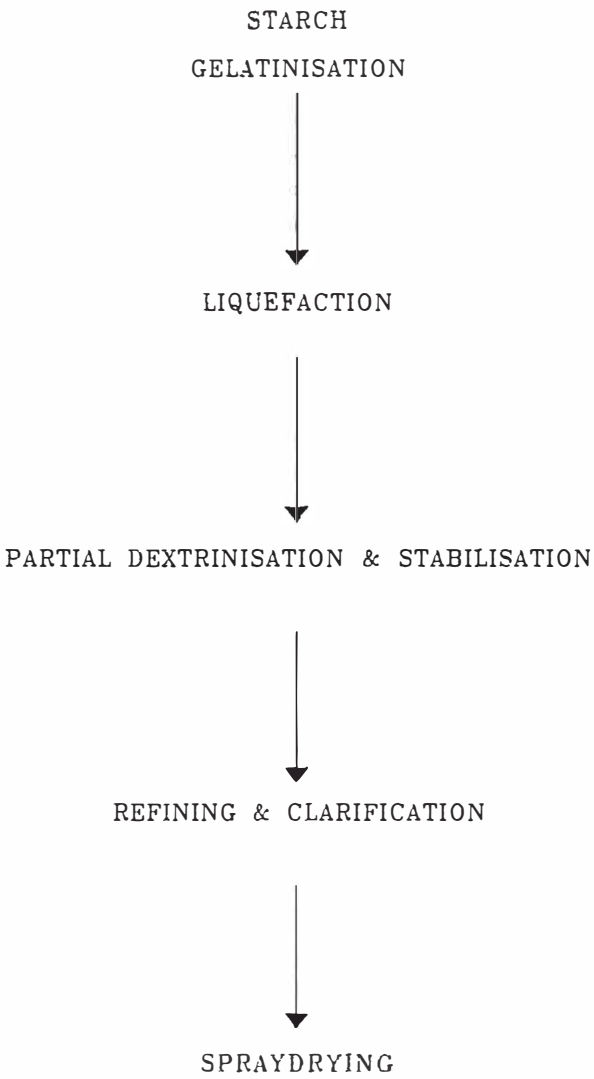

Figure 1. A Schematic Diagram of Stages of Maltodextrin Production