



UNIVERSITI PUTRA MALAYSIA

**PHYSICO-CHEMICAL CHANGES IN SUGARCANE (*SACCHARUM
OFFICINARUM* VAR. YELLOW CANE) AND THE EXTRACTED JUICE
DURING DEVELOPMENT, MATURATION AND POSTHARVEST
TREATMENTS UPON STORAGE**

HANAN YASSIN M. QUDSIEH

FSMB 2001 27

**PHYSICO-CHEMICAL CHANGES IN SUGARCANE (*SACCHARUM
OFFICINARUM* VAR. *YELLOW CANE*) AND THE EXTRACTED JUICE
DURING DEVELOPMENT, MATURATION AND POSTHARVEST
TREATMENTS UPON STORAGE**

By

HANAN YASSIN M. QUDSIEH

**Thesis Submitted in Fulfilment of the Requirement for the
Degree of Master of Science in the Faculty of
Food Science and Biotechnology
Universiti Putra Malaysia**

May 2001



Especially dedicated to my beloved parents



Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master Science

PHYSICO-CHEMICAL CHANGES IN SUGARCANE (*SACCHARUM OFFICINARUM* VAR. *YELLOW CANE*) AND THE EXTRACTED JUICE DURING DEVELOPMENT, MATURATION AND POSTHARVEST TREATMENTS UPON STORAGE

By

HANAN YASSIN M. QUDSIEH

May 2001

Chairman: Assoc. Prof. Dr. Salmah binti Yusof

Faculty: Food Science and Biotechnology

A study was conducted to determine the physico-chemical changes between different portions (top, middle, and bottom) of sugarcane at different maturity stages (between 3 and 10 months from planting). The variety used was *Saccharum officinarum* var. *Yellow cane*. The parameters analysed were weight, diameter, yield, total colour of juice, total soluble solids (TSS), pH, titratable acidity, sugar content (sucrose, glucose, fructose), tannin, chlorophyll and polyphenol oxidase (PPO) activity. The weight, diameter, total soluble solids (TSS) and sucrose content increased significantly ($P < 0.01$) for sugarcane from all portions (top, middle and bottom) until the end of maturity stage. On the other hand, titratable acidity (TA) values, pH, juice yield, glucose, fructose contents, tannin, chlorophyll and PPO decreased significantly ($P < 0.01$) during maturity. Significant differences were also detected in all the parameters between the

different portions during maturity. Results obtained indicated that there were significant decreases ($P < 0.01$) in tannin and chlorophyll contents during maturity. Different parts of cane showed no significant difference ($P > 0.05$) in tannin and chlorophyll contents between the middle and the bottom portion. The top of the stem had lower ($P < 0.01$) concentration of chlorophyll and higher ($P < 0.01$) content of tannin. However, the top portion of the stem had the highest PPO activity ($P < 0.01$) compared with the middle and the bottom portion. PPO was high at early development stage and decreased during maturation then remained relatively constant at the end of the maturity stages. The colour of extracted juice was dark at early stages of maturity then turned to yellowish green during maturity. The overall colour change (ΔE) during maturity indicated that the colour of the middle and bottom portion were stable than the top portion. The middle and the bottom portions gave good quality juice compared to the top portion. The suitable harvesting stage was found to be between 7 and 8 months after planting.

Different postharvest treatments using liquid paraffin and semperfresh on sugarcane stems (with and without shoots) were carried out to extend the shelf life of sugarcane stems. The canes were stored at 10 ± 1 °C; 85-88% RH. Results indicated that there was significant difference ($P < 0.01$) in the physico-chemical characteristics of sugarcane juice when the canes were exposed to the different postharvest treatments during storage. The yield, L^* value, TSS, pH, sucrose content, chlorophyll and tannin content decreased during storage while

the TA, a^* value, b^* value and reducing sugar increased. Storage time had an effect on the juice quality and that effect was enhanced by waxing of canes. The application of wax on canes increased the shelf life of the canes and stabilized its juice quality. It can be concluded that the wax treatments was able to minimise and slow down the changes in the physical and chemical characteristics associated with juice quality. The canes could be stored up to 12 days at $10 \pm 1^\circ\text{C}$; 85-88% RH and produced a good quality juice. Significant difference ($P < 0.01$) was found between liquid paraffin and semperfesh. Nevertheless, the canes that were treated with liquid paraffin without shoot was generally associated with the highest percentage of good quality juice. Based on this study it is recommended that the best postharvest treatment for storage of sugarcane stems was by dipping the cut end in liquid paraffin wax and storing at $10 \pm 1^\circ\text{C}$; 85-88% RH.

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

PERUBAHAN-PERUBAHAN FIZIKO-KIMIA PADA TEBU (*SACCHARUM OFFICINARUM* VAR. *TEBU KUNING*) DAN JUS YANG DIEKSTRAK SEMASA PERTUMBUHAN, PROSES KEMATANGAN DAN PERLAKUAN LEPAS TUAI SEBELUM PENYIMPANAN

Oleh

HANAN YASSIN M. Qudsieh

Mai 2001

Pengerusi: Prof. Madya Dr. Salmah binti Yusof

Faculty: Sains Makanan dan Bioteknologi

Satu kajian telah dijalankan untuk menentukan perubahan-perubahan fiziko-kimia di antara bahagian tebu yang berlainan (atas, tengah dan bawah) pada peringkat kematangan yang berbeza (di antara 3 dan 10 bulan selepas penanaman). Kultivar yang telah digunakan ialah *Saccharum officinarum* var. tebu kuning. Parameter-parameter yang telah dianalisis adalah diameter, jus terekstrak, warna keseluruhan jus, jumlah pepejal terlarut (TSS), pH, keasidan titratan (TA), kandungan gula (sukrosa, glukosa, fruktosa), tannin, klorofil dan aktiviti polifenol oksidase (PPO). Berat, diameter, TSS dan kandungan sukrosa meningkat secara bererti ($p < 0.01$) untuk tebu dari semua bahagian (atas, tengah dan bawah) sehingga tamat peringkat kematangan. Manakala TA, pH, jumlah jus, kandungan glukosa, fruktosa, tannin, klorofil dan PPO didapati

berkurangan secara bererti ($p < 0.01$) semasa proses kematangan. Perbezaan-perbezaan bererti juga dapat dikesan dalam kesemua parameter di antara bahagian-bahagian tebu yang berbeza semasa kematangan. Terdapat pengurangan yang bererti ($p < 0.01$) dalam kandungan tannin dan klorofil semasa peringkat kematangan. Keputusan analisis pada bahagian-bahagian tebu yang berlainan juga menunjukkan bahawa tiada perubahan yang bererti ($p > 0.05$) dalam kandungan tannin dan klorofil di antara bahagian tengah dan bawah. Bahagian atas batang tebu mempunyai kepekatan klorofil yang lebih rendah ($p < 0.01$) dan kandungan tannin yang lebih tinggi ($p < 0.01$). Walau bagaimanapun, bahagian atas batang tebu mempunyai aktiviti PPO yang lebih tinggi ($p < 0.01$) berbanding dengan bahagian tengah dan bawah. Kandungan PPO didapati tinggi pada peringkat awal pertumbuhan dan menurun semasa proses kematangan kemudian berada pada tahap yang stabil di akhir peringkat kematangan. Warna jus yang diperolehi pada peringkat awal kematangan berwarna gelap, kemudiannya bertukar menjadi warna hijau kekuningan pada tahap kematangan. Perubahan warna keseluruhan (ΔE) semasa tahap kematangan menunjukkan bahawa warna jus yang diperolehi pada bahagian tengah dan bawah batang tebu lebih stabil daripada bahagian atas. Bahagian tengah dan bawah memberikan kualiti jus yang lebih baik berbanding dengan bahagian atas. Kajian ini menunjukkan bahawa peringkat penuaian tebu yang sesuai adalah di antara 7 dan 8 bulan selepas penanaman.

Rawatan lepastuai yang berlainan menggunakan cecair paraffin dan semperfresh ke atas batang tebu (dengan dan tanpa pucuk) telah dijalankan untuk memanjangkan jangka hayat tebu. Penyimpanan dilakukan pada suhu $10\pm 1^{\circ}\text{C}$; 85-88% kelembapan relatif. Keputusan menunjukkan bahawa terdapat perubahan secara bererti ($p < 0.01$) dalam ciri-ciri fiziko-kimia jus tebu apabila tebu didedahkan kepada rawatan lepastuai yang berlainan semasa penyimpanan. Jumlah hasil, nilai L^* , TSS, pH, kandungan sukrosa, klorofit dan tannin berkurangan semasa penyimpanan, manakala TA, nilai a^* dan b^* , gula penurun meningkat. Jangka masa penyimpanan didapati memberi kesan ke atas kualiti jus dan kesan ini telah ditingkatkan dengan proses melilinkan tebu. Kajian ini menunjukkan bahawa penggunaan lilin pada tebu telah dapat meningkatkan jangka hayat batang tebu dan kualiti jus yang diperolehi dapat distabilkan. Kesimpulannya, perawatan lilin telah dapat menurunkan kadar perlakuan perubahan ciri-ciri fizikal dan kimia yang berkaitan dengan kualiti jus. Tebu boleh disimpan sehingga 12 hari pada $10\pm 1^{\circ}\text{C}$; 85-88% kelembapan relatif dan mampu menghasilkan kualiti jus yang baik. Perbezaan yang bererti ($p < 0.01$) telah didapati di antara kesan cecair paraffin dan samperfresh. Walau bagaimanapun, perawatan tebu tanpa pucuk dengan menggunakan cecair paraffin telah menghasilkan jus yang berkualiti tinggi. Berdasarkan kajian ini, perawatan lepastuai yang terbaik bagi penyimpanan tebu adalah dengan mencelupkan tebu yang dipotong hujungnya dalam cecair paraffin dan disimpan pada $10\pm 1^{\circ}\text{C}$; dengan kelembapan relatif 85-88%.

ACKNOWLEDGEMENTS

I am grateful to be given an opportunity to express my profound thanks and appreciation to Associate Professor Dr. Salmah Yusof, the chairman of my supervisory committee for her keen interest, kind assistance, advice and encouragement by giving greater latitude of freedom in conducting this study as well as completion of this thesis. I would also like to extend my gratitude and thanks to the other members of the supervisory committee, Associate Professor Dr. Azizah Osman and Associate Professor Dr. Russly Abdul Rahman for their guidance, constructive criticism and comments in carrying out this study.

My sincere thanks are due to Universiti Putra Malaysia (UPM) for the financial support provided through IRPA fund for this research, which was awarded to Associate Professor Dr. Salmah Yusof. A special acknowledgement and sincere thanks to all the staff in the Faculty of Food Science and Biotechnology for their cooperation. My special appreciation is also extended to my colleague especially to the beverage lab members and Tan Chin Ping for the Bahasa Malaysia translation of the abstract. Thanks and appreciation also goes to my dear friends especially Abeer Sahtoot, Gabby Setioaty for their unfailing help, encouragement and motivation. My deepest thanks to my close friend Fadwa Gazy in Jordan who stood beside me all the time. I greatly appreciate her kindness and warm friendship. My deepest thanks and appreciation to Wael Mansi and his family my friend Hanan for their moral encouragements, motivation and care during the final period of my study. I would like to convey

my gratitude to my wonderful brother Isam who deserve special mention for his inspiration, support and company he has given me in completing this project.

Last but not least, I wish to express my appreciation to my beloved parents who are always beside me for their patience, unconditional love, inspiration and support whenever I need, to all my sisters and brothers for their care, encouragement and love which had been the biggest motivation for undertaking and completing this degree. Words can't express my warmest gratitude and special thanks to the memory of my grandma who shared and lived with me in all my way. Finally my thanks to any one who has helped in one way or another towards this degree. Thank Allah for giving me the patience and guidance with wisdom and strength for completing my study.



I certify that an Examination Committee met on 18th May 2001 to conduct the final examination of Hanan Yassin M. Qudsieh on her Master of Science thesis entitled "Physico-Chemical Changes in Sugarcane (*Saccharum Officinarum* Var. *Yellow Cane*) and the Extracted Juice during Development, Maturation and Postharvest Treatments Upon Storage" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommended that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Mohd. Yazid Abd, Ph.D.,
Associate Professor,
Food Technology Department,
Faculty of Food Science and Biotechnology
Universiti Putra Malaysia.
(Chairman)

Salmah Yusof, Ph.D.,
Associate Professor,
Food Technology Department,
Faculty of Food Science and Biotechnology,
Universiti Putra Malaysia.
(Member)

Azizah Osman, Ph.D.,
Associate Professor,
Food Science Department,
Faculty of Food Science and Biotechnology,
Universiti Putra Malaysia.
(Member)

Russly Abdul Rahman, Ph.D.,
Associate Professor,
Food Technology Department,
Faculty of Food Science and Biotechnology,
Universiti Putra Malaysia.
(Member)




AINI IDERIS, Ph.D.,
Professor /Dean of Graduate School,
Universiti Putra Malaysia.

Date: 26 MAY 2001




This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science.



AINI IDERIS, Ph.D.,
Professor /Dean of Graduate School,
Universiti Putra Malaysia.

Date: 14 JUN 2001

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.



Hanan Yassin M. Qudsieh,
Candidate.

Date:

TABLE OF CONTENTS

	Page
DEDICATION.....	2
ABSTRACT.....	3
ABSTRAK.....	6
ACKNOWLEDGEMENTS.....	9
APPROVAL SHEETS.....	11
DECLARATION.....	13
LIST OF TABLES.....	17
LIST OF FIGURES.....	19
LIST OF PLATES.....	22
LIST OF ABBREVIATION	23
 CHAPTER	
I INTRODUCTION.....	24
II REVIEW OF LITERATURE	
Sugarcane.....	28
Origin of Sugarcane.....	28
Sugarcane Varieties in Malaysia.....	29
Yellow Cane (Tebu Kuning)	30
Botany of Sugarcane <i>S. Officinarum</i>	30
Growth and Development	32
Growth Phases.....	32
Germination.....	32
Tillering Phase	33
Growth Stalk Phase.....	33
Cane Yield.....	33
Cane Ripening	34
Factors Affecting the Growth of Sugarcane.....	34
Composition of Sugarcane Juice.....	35
Carbohydrate (sugars and non sugars).....	35
Minerals and Constituents	38
Organic Acids.....	38
Protein.....	39
Nitrogen.....	39
Cellulose.....	39
Maturity and Ripening of Sugarcane.....	40
Harvesting and Handling	41
Postharvest Deterioration of sugarcane.....	42

Effect of Wax Application on the Storage Life.....	44
Physico-Chemical Changes in Sugarcane Juice.....	45
Colour.....	45
Viscosity.....	46
Sugar.....	46
Titratable Acidity and pH.....	47
Chlorophyll.....	47
Phenolic Compounds.....	48
Economic Potential.....	49
III PHYSICO-CHEMICAL CHANGES IN SUGARCANE (SACCHARUM OFFICINARUM VAR. YELLOW CANE) AND THE EXTRACTED JUICE DURING GROWTH, DEVELOPMENT AND MATURATION	
Introduction.....	51
Materials and Methods.....	52
Samples Source.....	52
Sampling.....	52
Extraction of Juice	53
Physical Analysis.....	53
Chemical Analysis.....	54
Determination of Total Soluble solids.....	54
Determination of Titratable Acidity.....	54
Determination of pH.....	55
Determination of Sugar content.....	55
Determination of Tannin Content.....	55
Determination of Chlorophyll.....	56
Assay of Polyphenol Oxidase Activity (PPO).....	57
Statistical Analysis.....	58
Results and Discussion.....	58
Physical Changes During Maturation.....	58
Weight and Diameter	58
Yield of Juice.....	60
Colour of Juice.....	61
Chemical Changes during Maturation.....	66
Total Soluble Solids.....	66
Titratable Acidity (TA).....	67
PH.....	69
Sugar Content.....	70
Tannin Content.....	74
Chlorophyll Content.....	77
Polyphenol Oxidase Activity.....	79
Conclusion	83

IV	EFFECT OF POSTHARVEST TREATMENTS ON PHYSICO-CHEMICAL CHANGES OF SUGARCANE JUICE (<i>SACCHARUM OFFICINARUM</i> VAR. <i>YELLOW CANE</i>) DURING STORAGE OF CANE	
	Introduction.....	85
	Materials and Methods.....	87
	Samples Source	87
	Sampling.....	87
	Extraction of Juice (perpetration of sugarcane juice).....	88
	Physical Analysis.....	88
	Chemical Analysis.....	89
	Statistical Analysis.....	89
	Results and Discussions.....	89
	Yield of Juice.....	89
	Colour of Juice.....	91
	Total Soluble Solids (TSS).....	96
	Titratable Acidity (TA).....	97
	pH.....	99
	Sugar Content.....	101
	Tannin Content.....	104
	Chlorophyll content.....	107
	Conclusion.....	110
V.	CONCLUSION AND RECOMMENDATION	
	Conclusion.....	111
	Recommendation for Further Study.....	112
	BIBLIOGRAPHY.....	114
	APPENDICES	
	A Methods of physico-chemical determinations.....	126
	B Additional tables	129
	C List of Plates.....	139
	VITA.....	142

LIST OF TABLES

Table		Page
1	Composition of sugarcane juice and juice solids.....	36
2	Mean Values and Standard Deviations (\pm) for Yield, Weight and Diameter of Yellow Cane during Development and Maturation.....	129
3	Mean Values and Standard Deviation (\pm) for Juice Colour (Hunter L^* value, a^* value, b^* value) of Yellow Cane During Development and Maturation.....	130
4	Mean Values and Standard Deviations (\pm) for Total Soluble Solids (TSS), Titratable Acidity (TA) and pH of Yellow cane Juice during Development and Maturation.....	131
5	Mean Values and Standard Deviations (\pm) for the Percentages of Fructose, Glucose and Sucrose of Yellow Cane Juice during Development and Maturation.....	132
6	Mean Values and Standard Deviation (\pm) for Tannin Content and Chlorophyll of Yellow Cane Juice During Development and Maturation.....	133
7	Mean Values and Standard Deviation (\pm) for polyphenol Oxidase Activity of Yellow Cane Juice During Development and Maturation.....	134
8	Mean Values and Standard Deviations (\pm) for Yield of juice, and Juice Colour (Hunter L^* value, a^* value, b^* value) of Yellow cane Juice during Storage.....	135
9	Mean Values and Standard Deviations (\pm) for Total Soluble Solids (TSS, Titratable Acidity and pH) of Yellow cane Juice during Storage.....	136
10	Mean Values and Standard Deviations (\pm) for Sugar Content (Fructose, Glucose and Sucrose) of Yellow cane Juice during Storage.....	137

11	Mean Values and Standard Deviations (\pm) for Tannin Content and Chlorophyll of Yellow cane Juice during Storage.....	138
----	---	-----

LIST OF FIGURES

Figure		Page
2.1	Composition of the stalk of the cane plant.....	31
3.1	Changes in stem weight of yellow cane from different portions harvested at different stages of maturity.....	59
3.2	Changes in stem diameter of yellow cane from different portions harvested at different stages of maturity.....	59
3.3	Changes in juice yield of yellow cane from different portions harvested at different stages of maturity.....	61
3.4	Changes in Hunter L^* values of yellow cane juice at different portions harvested at different maturity stages.....	62
3.5	Changes in Hunter a^* values of yellow cane juice at different portions harvested at different maturity stages.....	64
3.6	Changes in Hunter b^* values of yellow cane juice at different portions harvested at different maturity stages.....	64
3.7	Total colour change of cane juice extracted from different portions during maturity.....	65
3.8	The total soluble solid of yellow cane juice from different portion harvested at different stages of maturity.....	66
3.9	Titrateable acidity of yellow cane juice from different portion harvested at different stages of maturity.....	68
3.10	The pH changes in yellow cane juice from different portion harvested at different stages of maturity.....	69
3.11	Fructose content of yellow cane Juice harvested at different stages of maturity.....	71
3.12	Glucose content of yellow cane Juice harvested at different stages of maturity.....	73
3.13	Sucrose content of yellow cane Juice harvested at different stages of maturity.....	73

3.14	Changes in tannin content of yellow cane juice at different portions harvested at different stages of maturity.....	76
3.15	Changes in chlorophyll content of yellow cane juice at different portions harvested at different stages of maturity.....	78
3.16	Changes in polyphenol oxidase activities (using chlorogenic acid as substrate) of yellow cane juice at different portions harvested at different stages of maturity.....	80
3.17	Changes in polyphenol oxidase activities (using catechol as substrate) of yellow cane juice at different portions harvested at different stages of maturity.....	81
4.1	Effect of postharvest treatments on yield of yellow cane juice during storage.....	90
4.2	Effect of postharvest treatments on Hunter L^* value of yellow cane juice during storage.....	92
4.3	Effect of postharvest treatments on Hunter a^* value of yellow cane juice during storage.....	94
4.4	Effect of postharvest treatments on Hunter b^* value of yellow cane juice during storage.....	95
4.5	Effect of postharvest treatments on total soluble solids TSS of yellow cane juice during storage.....	97
4.6	Effect of postharvest treatments on titratable acidity TA of yellow cane juice during storage.....	99
4.7	Effect of postharvest treatments on pH of yellow cane juice during storage.....	100
4.8	Effect of postharvest treatments on fructose content of yellow cane juice during storage.....	102
4.9	Effect of postharvest treatments on glucose content of yellow cane juice during storage.....	103
4.10	Effect of postharvest treatments on sucrose content of yellow cane juice during storage.....	103

4.11	Effect of postharvest treatments on tannin content of yellow cane juice during storage.....	106
4.12	Effect of postharvest treatments on chlorophyll content of yellow cane juice during storage.....	108

LIST OF PLATES

Plate		Page
1	Sugarcane plant	139
2	Labelling of sugarcane stems in the farm	139
3	Colour of Juice obtained from different portions during maturation	140
4	Sugarcane stems without shoots before storage	140
5	Sugarcane stems with shoots before storage	141

LIST OF ABBREVIATION

ANOVA	Analysis of Variance
ΔE	Changes in colour
AOAC	Association of Official Analytical Chemists
M	Molar
μg	Micro gram
pH	Hydrogen ion concentration
SAS	Statistical Analysis System
PPO	Polyphenol Oxidase
r	Correlation coefficient

CHAPTER I

GENERAL INTRODUCTION

Sugarcane (*Saccharum spp.*) is an economically important crop world wide (Bucheli *et al.*, 1996). Among sugar production plants, sugarcane is responsible for about 60% of world's sugar production (Clements, 1980). Sugarcane (*Saccharum Officinarum*) has been grown in Malaysia since the 19th century mainly for sugar production (Tan, 1989). The total area planted with sugarcane was around 17,000 ha, confined mainly to areas in Kedah and Perlis where the climate is most suitable. Lately, the noble canes are also grown for fresh juice production and these occupy an even smaller land area, mainly in Negeri Sembilan and Selangor. Among the varieties grown, variety 'Tebu Kuning' or yellow cane is popular since it has a softer and less fibrous stem and produces abundant juice with distinct flavour (Siti and Baharuddin, 1994).

Fresh sugarcane juice is popular with high consumption and great demand through out Malaysia as a pleasing, sweet, thirst-quenching beverage and the juice is more appreciated by consumers due to its sensorial and nutritional characteristics. It is served fresh at many eateries from roadside stalls to high-class hotel restaurants. Due to its commercial importance, and the crop's ability to thrive well in Malaysia, it is envisaged that sugarcane juice production can become a profitable business provided efforts are made to preserve its fresh quality during storage (Yusof *et al.*, 2000).