

**APPLICATION OF HACCP PRINCIPLES
IN BLOCK ICE AND CRUSHED ICE MANUFACTURING**



**A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(FOOD AND NUTRITION FOR DEVELOPMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY**

2008

COPYRIGHT OF MAHIDOL UNIVERSITY

Copyright by Mahidol University

Thesis
Entitled

**APPLICATION OF HACCP PRINCIPLES
IN BLOCK ICE AND CRUSHED ICE MANUFACTURING**



Kukkanang Sirilaksanamon
.....
Miss Kukkanang Sirilaksanamon
Candidate

Visith Chavasit
.....
Assoc. Prof. Visith Chavasit,
Ph.D. (Food Science)
Major-Advisor

Pornrat Sinchaipanit
.....
Asst. Prof. Pornrat Sinchaipanit,
Ph.D. (Food Technology)
Co-Advisor

B. Mahaisavariya
.....
Prof. Banchong Mahaisavariya,
M.D.
Dean
Faculty of Graduate Studies

Anadi Nitithanyong
.....
Asst. Prof. Anadi Nitithanyong,
Ph.D. (Food Science)
Chair
Master of Science Programme
in Food and Nutrition for Development
Institute of Nutrition

Thesis
Entitled

**APPLICATION OF HACCP PRINCIPLES
IN BLOCK ICE AND CRUSHED ICE MANUFACTURING**

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science (Food and Nutrition for Development)
on

May 29, 2008



Kukkanang Sirilaksanamanon
Miss Kukkanang Sirilaksanamanon
Candidate

Tipvon Parinyasiri
Lect. Tipvon Parinyasiri,
Ph.D. (Food Science)
Chair

Visith Chavasit
Assoc. Prof. Visith Chavasit,
Ph.D. (Food Science)
Member

Pornrat Sinchaipanit
Asst. Prof. Pornrat Sinchaipanit,
Ph.D. (Food Technology)
Member

B. Mahaisavariya
Prof. Banchong Mahaisavariya,
M.D.
Dean
Faculty of Graduate Studies
Mahidol University

Visith Chavasit
Assoc. Prof. Visith Chavasit
Ph.D. (Food Science)
Director
Institute of Nutrition
Mahidol University

ACKNOWLEDGEMENT

This thesis can't be succeeded smoothly without grateful helps from many people. To my advisor, Associate Professor Dr. Visith Chavasit, I would like to express my special sincere gratitude and appreciation for his invaluable guidance, advice, kindness and encouragement throughout the study. All his kindness will be long remembered in my mind.

Really thankful to Dr. Tipvon Parinyasiri for her kindness in giving examination, very useful suggestions and budget that make my thesis complete. Including, obliged to Mr. Yuthana Norapoompipat for his constructive comments.

I would like to thank, staff members of the Food Microbiology Department of Institute of Nutrition, Mahidol University for their technical assistance.

Special thanks extend to the staffs of the Paitoon Ice Factory (1999) Company Limited, especially, Mr. Paitoon Pongnetwilai, for their excellent cooperation and supportive information, and convenience. Also, I am thankful to Patkol Public Company for their both basic and technical information in ice making.

I am grateful to all the lectures and staffs of Institute of Nutrition for their supportive and encouragement.

In particular, very special thanks go to my beloved friend, Ms. Phannakon Phithaksantayothin for sharing the very moments together, and her mental support, as well as, to Mr. Theerachai Wongmethinee, Ms. Supakorn Athikomnantha, Ms. Suwimol Tanghom and Ms. Juntima Photi for their numerous assistances.

Last of all, I would like to express my gratitude to my parents and family for their encouragement, love and spiritual support throughout my life.

Kukkanang Sirilaksanamanon

APPLICATION OF HACCP PRINCIPLES IN BLOCK ICE AND CRUSHED ICE MANUFACTURING

KUKKANANG SIRILAKSANAMANON 4837379 NUFN/M
M.Sc. (FOOD AND NUTRITION FOR DEVELOPMENT)

THESIS ADVISORS: VISITH CHAVASIT, Ph.D.,
PORN RAT SINCHAIPANIT, Ph.D.

ABSTRACT

Block ice production in Thailand began more than one century ago. Contamination from various types of pathogenic bacteria has always been found in crushed ice. This study aimed to develop practical preventive measures for reducing microbial and chemical contaminations of block and crushed ice by applying hazard analysis and critical control points (HACCP) principles. Information on production and distribution processes were gathered from 8 ice-making plants located in different provinces. Improper water disinfection and treatment systems were found in most plants, while the block ice making processes were similar. Samples including raw water, water used in the production, block ice, crushed ice and sacks for ice packing were analyzed for aerobic plate count and total coliforms by using plate count agar and Most Probable Number (MPN) method, respectively. Samples of block ice were analyzed for chromium content by Flame Atomic Absorption Spectrometry. Most samples were contaminated with aerobic bacteria and total coliforms at various levels. Yellow-stained ice was contaminated with chromium from anti-rusting agent at unacceptable level. Swab tests on floors, surfaces of equipment and worker's hand also indicated contamination of total coliforms. Effect of the freezing process (frozen within 48 h) on reducing microbial load was minor. Potential hazards identified were chemical and microbial contaminations of raw water, chromium contamination of block ice during production, and microbial contamination in sacks. Appropriate water treatment systems should be used in order to satisfy physical and chemical standards. The water should be disinfected with chlorine at 0.5 ppm, which would totally destroy coliforms (≤ 1.8 MPN/100ml). To prevent chemical hazard, maintenance of ice making equipments, especially ice can, should be performed regularly. Floors used for block ice transportation should be built with smooth, durable materials that are easy to clean and do not accumulate dirt. The used area should be restricted. In contrast to current practice, used sacks should be pre-washed with water before disinfection in at least 7 ppm chlorinated water for at least 5 min. Drying methods to prevent bacterial contamination of ice sacks were also tested. Sacks were tested under three drying conditions; without drying, drying for 1 h and drying for 4 h and three storage conditions; 0 h, 12 h and 24 h. Under most circumstances, drying for 1 and 4 h were the best while the length of storage did not matter. Taken as a whole, the new sack cleaning method is practical for ice manufacturing and improved the microbial quality of the sacks.

KEY WORDS: BLOCK ICE/ HACCP/ AEROBIC PLATE COUNT/ TOTAL COLIFORMS

89 pp.

การประยุกต์ใช้หลักการวิเคราะห์อันตรายและจุดวิกฤตที่ต้องควบคุมในการผลิตน้ำแข็งของและน้ำแข็งบด (APPLICATION OF HACCP PRINCIPLES IN BLOCK ICE AND CRUSHED ICE MANUFACTURING)

คัคนางค์ ศิริลักษณ์มานนท์ 4837379 NUFN/M

วท.ม. (อาหารและโภชนาการเพื่อการพัฒนา)

คณะกรรมการควบคุมวิทยานิพนธ์: วิสิฐ จะวะสิต , Ph.D., พรรรัตน์ สิ้นชัยพานิช, Ph.D.

บทคัดย่อ

การผลิตน้ำแข็งของในประเทศไทยได้เริ่มขึ้นเมื่อกว่าหนึ่งร้อยปีก่อน โดยส่วนใหญ่นำไปใช้เป็นน้ำแข็งบดสำหรับให้ความเย็นแก่เครื่องดื่มและอาหาร อย่างไรก็ตาม มีรายงานกล่าวถึงการพบการปนเปื้อนของจุลินทรีย์ก่อโรคหลายชนิดในน้ำแข็งบด งานวิจัยนี้จึงจัดทำขึ้นเพื่อพัฒนามาตรการป้องกันเพื่อลดการปนเปื้อนทางจุลินทรีย์และเคมีน้ำแข็งของและน้ำแข็งบดด้วยการประยุกต์ใช้หลักการ HACCP จากการสำรวจกระบวนการผลิตและการขนส่งของโรงงานน้ำแข็งจากหลายพื้นที่จำนวน 8 แห่งพบว่า โรงงานส่วนใหญ่มีระบบการฆ่าเชื้อในน้ำและการปรับสภาพน้ำไม่เหมาะสม ในขณะที่กระบวนการผลิตน้ำแข็งของในทุกรังมีลักษณะเหมือนกัน มีการวิเคราะห์ตัวอย่างน้ำดิบ น้ำที่ใช้ในการผลิต น้ำแข็งของ น้ำแข็งบด และกระสอบสำหรับบรรจุน้ำแข็งโดยวิเคราะห์ปริมาณจุลินทรีย์ทั้งหมด ด้วยวิธี Pour plate technique และโคลิฟอร์มทั้งหมด ด้วยวิธีเอ็มพีเอ็นตามลำดับ สำหรับตัวอย่างน้ำแข็งของจะนำไปตรวจหาปริมาณโครเมียมด้วยวิธี Flame Atomic Absorption Spectrometry ตัวอย่างส่วนใหญ่ปนเปื้อนจากจุลินทรีย์ทั้งหมดและโคลิฟอร์มทั้งหมดที่ $1.6 \times 10^2 - 1.6 \times 10^4$ ซีเอฟยู/มล. และ $2 - >1600$ เอ็มพีเอ็น/ 100 มล. ตามลำดับ น้ำแข็งของที่มีสีเหลืองพบการปนเปื้อนของโครเมียมจากสารกันสนิมที่สูงกว่ากฎหมายกำหนด การทดสอบความสะอาดของลานเทของ พื้นผิวของอุปกรณ์และมือของพนักงานแสดงถึงการปนเปื้อนของโคลิฟอร์มที่ $<6.1 - 188.9$ เอ็มพีเอ็น/พื้นที่ 10.16 ซม^2 จากการศึกษาพบว่า กระบวนการแช่แข็ง (ภายใน 48 ชม.) มีผลต่อการลดจำนวนจุลินทรีย์ในปริมาณต่ำ ดังนั้นอันตรายที่ต้องควบคุม ได้แก่ อันตรายจากการปนเปื้อนของสารเคมีและจุลินทรีย์ในน้ำดิบ การปนเปื้อนของโครเมียมในน้ำแข็งของระหว่างการผลิต และการปนเปื้อนของจุลินทรีย์ในกระสอบ ด้านคุณภาพน้ำควมมีที่ปรับปรุงคุณภาพน้ำอย่างเหมาะสมเพื่อให้ น้ำที่ใช้ผลิตน้ำแข็งผ่านเกณฑ์มาตรฐานทั้งทางกายภาพและเคมี โดยเฉพาะการฆ่าเชื้อด้วยคลอรีนให้มีความเข้มข้นของคลอรีนคงเหลือ 0.5 พีพีเอ็ม ซึ่งจะสามารถทำลายโคลิฟอร์มได้ทั้งหมด (≤ 1.8 เอ็มพีเอ็น/100 มล.) มาตรการป้องกันอันตรายเคมีคือการดูแลของน้ำแข็งอย่างสม่ำเสมอ พื้นที่ใช้สำหรับเคลื่อนย้ายน้ำแข็งของควรสร้างด้วยวัสดุพื้นเรียบ ทนทานทำความสะอาดง่าย และไม่เป็นที่สะสมสิ่งสกปรก รวมทั้งควรกำหนดให้เป็นพื้นที่ควบคุม จุลินทรีย์ทั้งหมดและโคลิฟอร์มทั้งหมดสามารถปนเปื้อนจากกระสอบที่สกปรกสู่น้ำแข็งที่สัมผัสกับผิวกระสอบได้ถึง 2.1×10^5 ซีเอฟยู/มล. และ >20845 เอ็มพีเอ็น/ 100 มล. ตามลำดับ การทำความสะอาดกระสอบที่ใช้แล้วอย่างมีประสิทธิภาพได้แก่ ล้างกระสอบที่สกปรกด้วยน้ำสะอาดก่อนการฆ่าเชื้อด้วยการแช่กระสอบลงในน้ำผสมคลอรีนที่ความเข้มข้น >7 พีพีเอ็ม เป็นเวลา >5 นาที กระสอบที่ทำความสะอาดแล้วถูกทำให้แห้งในสภาวะต่างๆ ได้แก่ ไม่ตาก ดากที่ 1 ชม (ตากแบบไม่แห้งสนิท) และ 4 ชม (ตากแบบแห้งสนิท) คุณภาพทางจุลินทรีย์ของกระสอบที่ความสะอาดที่ไม่ตากและตากไว้ 4 ชม. ไม่เปลี่ยนแปลงหลังจากเก็บไว้เป็นเวลาถึง 24 ชม. (โคลิฟอร์มทั้งหมด ≤ 2 เอ็มพีเอ็น/ 100 มล.) หลังจากนัามาตรการป้องกันที่พัฒนาขึ้นไปใช้จริงที่โรงงานพบว่า ทำให้คุณภาพทางจุลินทรีย์ของกระสอบน้ำแข็งดีขึ้น $> 90\%$ ซึ่งทำให้เป็นวิธีที่สามารถจริงได้กับผู้ผลิตน้ำแข็งของ

CONTENTS

	Page
ACKNOWLEDGEMENTS	iii
ABSTRACT	iv
LIST OF TABLES	x
LIST OF FIGURES	xii
LIST OF ABBREVIATIONS	xiii
CHAPTER	
I INTRODUCTION	1
II OBJECTIVES	3
III LITERATURE REVIEW	4
3.1 Definition of block and crushed ice	4
3.2 Block and crushed ice production	4
3.2.1 Water Source	4
3.2.2 Water treatment	6
3.2.3 Processing of block and crushed ice	11
3.3 Quality Assurance	12
3.3.1 Good Manufacturing Practice	13
3.3.2 Hazard Analysis and Critical Control Points	14
3.4 GMP in block ice and crushed ice manufacturing	15
3.4.1 Building interior	16
3.4.2 Program equipment	16
3.4.3 Sanitation and cleaning program	16
3.4.4 Personal practices	17
3.4.5 Personal training	18
3.5 Hazards in block ice and crushed ice manufacturing	19

CONTENTS (cont.)

CHAPTER	Page
3.5.1 Hazards from microbial contamination	19
3.5.2 Hazard from Chemical contamination	20
3.6 Related research about ice quality	21
IV MATERIALS AND METHODS	27
4.1 Production process evaluation	27
4.2 Microbial assessment: Case study at Paitoon Ice Factory (1999) Co., Ltd.	27
4.3 Analysis of hazards during production and distribution processes	28
4.4 Evaluation of potential hazards	28
4.4.1 Effect of freezing temperature on reducing microbial risk	28
4.4.2 Contamination of chromium in ice	28
4.4.3 Sack cleanliness	28
4.5 Development of preventive measures	29
4.5.1 Water chlorination on microbial quality of ice	29
4.5.2 Sack cleaning	29
4.6 Test for the practicality of the developed measures	31
4.7 Method of analysis	31
4.7.1 Sampling procedures	31
4.7.2 Analysis	32
V RESULT	34
5.1 Production process of block and crushed ice	34
5.1.1 MODULE 1: Water treatment	34
5.1.2 MODULE 2: Block ice making	37
5.1.3 MODULE 3: Ice crushing and distribution	38

CONTENTS (cont.)

CHAPTER	Page
5.2 Microbial assessment:	39
Case study at Paitoon Ice Factory (1999) Co., Ltd.	
5.2.1 Water, ice and packaging	39
5.2.2 Equipment surface and worker's hand	40
5.3 Analysis of hazards during production and distribution processes	40
5.3.1 Water treatment	40
5.3.2 Block ice making	41
5.3.3 Sack used for distribution	41
5.4 Evaluation of potential hazards	42
5.4.1 Effect of freezing temperature on reducing microbial risk	42
5.4.2 Chromium contamination in block ice	43
5.4.3 Sack cleanliness	43
5.3.4 Microbial contamination in water of thawing tank of the block ice factory.	44
5.5 Development of preventive measures	44
5.5.1 Water chlorination on microbial quality of ice	44
5.5.2 Sack cleaning	45
a. Effect of pre-washing sack with water before soaking in chlorinated water on microbial quality	45
b. Appropriate chlorine concentration and soaking period for reducing microbial risk in sack	45
c. Appropriate drying and storage condition of washed sacks	47
5.6 Test for the practicality of the developed measures	48
5.6.1 Sack cleaning	48

CONTENTS (cont.)

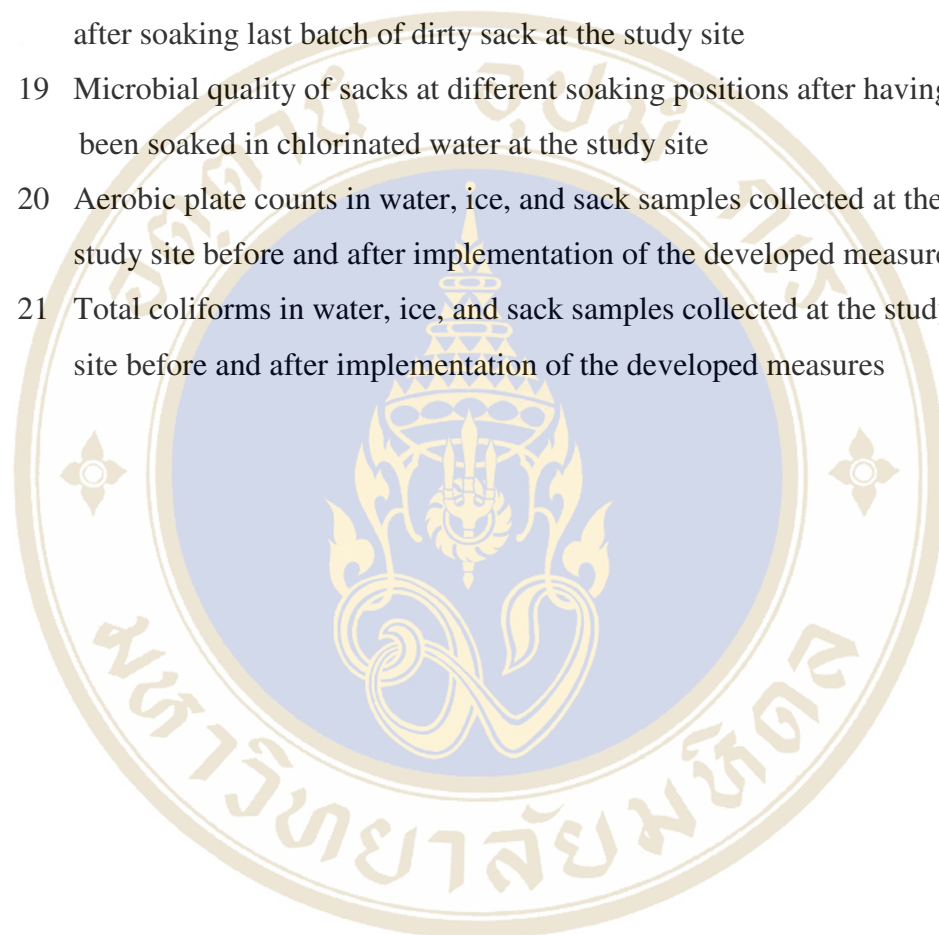
CHAPTER	Page
5.6.2 Verification of developed measures	50
VI DISCUSSION	52
6.1 Water treatment process	52
6.2 Block ice making	52
6.3 Ice crushing and distribution	53
6.4 Sack cleanliness	54
6.5 Additional requirement	54
VII CONCLUSION	55
REFERENCES	57
APPENDIX	63
BIOGRAPHY	89

LIST OF TABLES

Table	Page
1 Main water treatment unit process	9
2 Water source and water treatment and its improper practices of surveyed block ice plants	35
3 Microbial qualities of water, ice, and sack samples collected at the study site	40
4 Total coliforms of equipment surface and worker's hand by swab test	40
5 Problems found during water treatment process	41
6 Problems found during block ice production	42
7 Problems found ice distribution	42
8 Microbial quality of samples before and after freezing at -15°C for 2 d	42
9 Microbial quality of simulated ice sample during storage at -5°C	43
10 Chromium content in yellow stained block ice as compared to the normal block ice	43
11 Evaluation of microbial risk in ice contaminated from sack	44
12 Microbial qualities of water at the factory before and after implementing chlorination	44
13 Microbial qualities of sacks soaked in chlorinated water with and without pre-washing with water	45
14 Microbial qualities of sacks soaked in chlorinated water at various Concentrations	46
15 Microbial qualities of sacks soaked in 10 ppm of chlorinated water at different soaking periods	47
16 Residual chlorine concentration of chlorinated water after each use for sack soaking	47
17 Microbial quality of sacks after being dried and stored at different periods	49

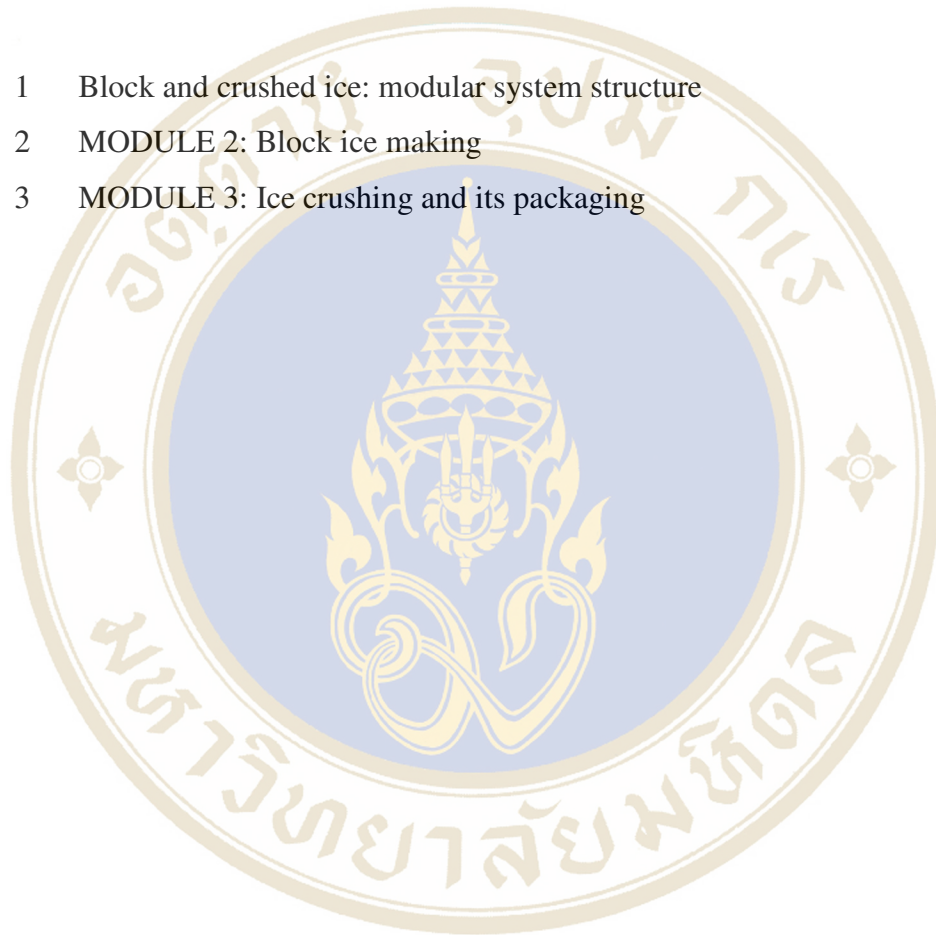
LIST OF TABLES (cont.)

Table		Page
18	Residual chlorine concentration in chlorinated water before and after soaking last batch of dirty sack at the study site	48
19	Microbial quality of sacks at different soaking positions after having been soaked in chlorinated water at the study site	50
20	Aerobic plate counts in water, ice, and sack samples collected at the study site before and after implementation of the developed measures	51
21	Total coliforms in water, ice, and sack samples collected at the study site before and after implementation of the developed measures	52

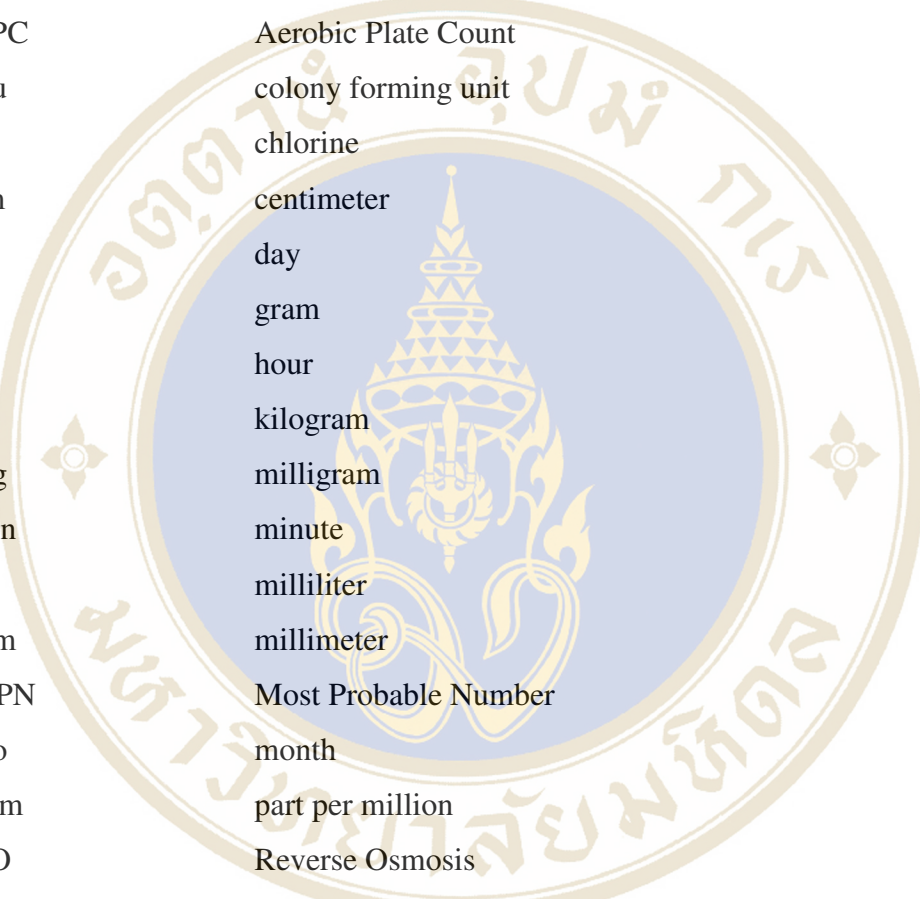


LIST OF FIGURES

Figure	Page
1 Block and crushed ice: modular system structure	34
2 MODULE 2: Block ice making	37
3 MODULE 3: Ice crushing and its packaging	39



LIST OF ABBREVIATIONS



°C	degree Celsius
APC	Aerobic Plate Count
cfu	colony forming unit
cl	chlorine
cm	centimeter
d	day
g	gram
h	hour
kg	kilogram
mg	milligram
min	minute
ml	milliliter
mm	millimeter
MPN	Most Probable Number
mo	month
ppm	part per million
RO	Reverse Osmosis
sq cm	square centimeter
PAC	Poly Aluminium Chloride
Thai FDA	Thailand's Food and Drug Administration

CHAPTER I

INTRODUCTION

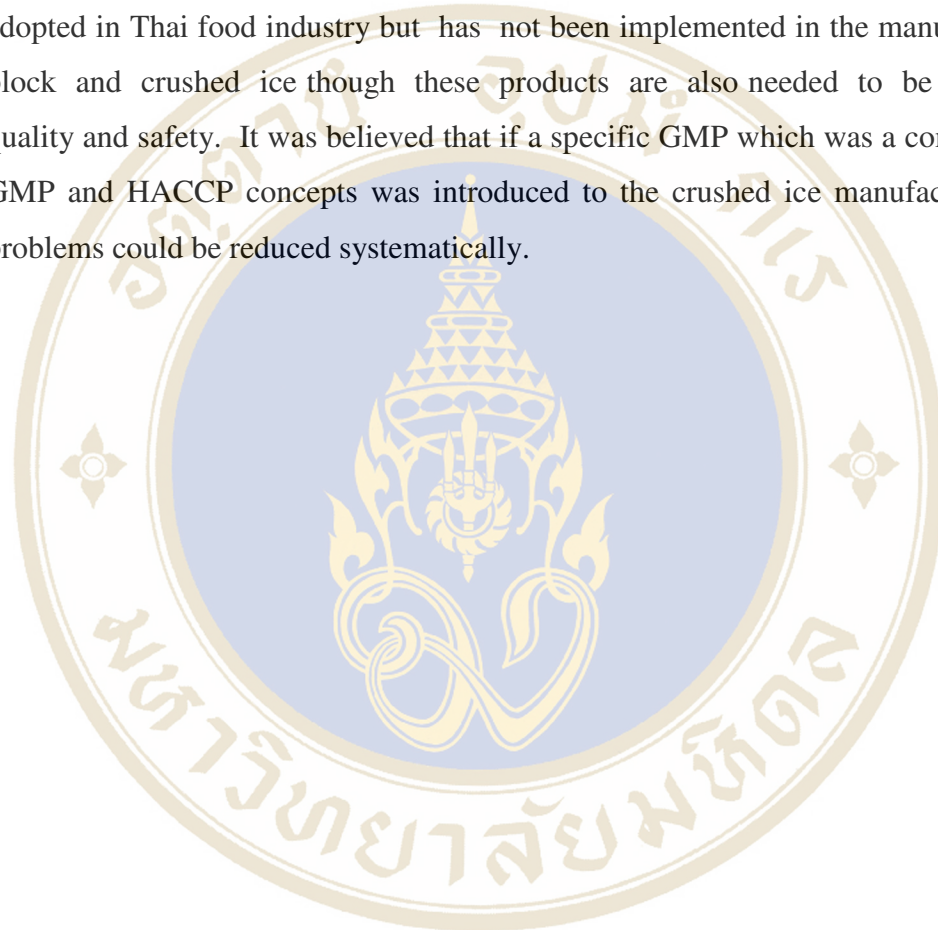
Crushed ice has been used for cooling drinks and foods in all parts of the world for centuries. As compared to tube ice, crushed ice provides better sensory acceptability and cold transfer due to smaller particle. Production cost of crushed ice is also lower than tube ice. Crushed ice is therefore preferred for better sensory characteristic and lower price. Since crushed ice is made by disintegrating block ice, which is produced by using older technology in open area. Crushed ice is always found to be contaminated and unacceptable in term of hygiene. Contamination can occur in various production steps e.g. water source, poor machinery and improper handling. Block ice can be contaminated with pathogenic microorganisms where contaminated water source is used in its production or during handling.

Many studies of the Department of Medical Sciences, Ministry of Public Health indicated that crushed ice samples in the market were contaminated with *Escherichia coli*, *Salmonella* spp. *Vibrio cholerae* non O1/non O139 and *Staphylococcus aureus* (1). Outbreaks of gastroenteritis due to contaminated ice have been reported in the many provinces of Thailand and other parts of the world. *E. coli*, coliforms and a variety of microorganisms normally present in ice indicating either poor quality of source water used or a lack of hygiene in production or handling, or both. Besides, crushed ice can be polluted by chemicals used in water treatment, ice processing, and sanitizing of ice bag. Consumption of contaminated ice not only causes health problems to consumers but also has impact on economics and country's reputation.

By law, factors involved in the production are controlled by General Good Manufacturing Practices (GMP), which is mentioned in the notifications no. 193 B.E.2543 and no.239 B.E.2544 Re: Production Processes, Equipments and food storages (APPENDIX). By following the concept of General GMP, ice producers might not be able to efficiently improve qualities of their products since the concept

was designed for controlling various kinds of food products. In order to follow whole GMP concept, producers might need to invest more on infrastructure, which might still not guarantee for product safety.

At the present, HACCP program is used worldwide in many food industries to ensure the safety of products. This program becomes more widely adopted in Thai food industry but has not been implemented in the manufacturing of block and crushed ice though these products are also needed to be sure of its quality and safety. It was believed that if a specific GMP which was a combination of GMP and HACCP concepts was introduced to the crushed ice manufacturing, such problems could be reduced systematically.



CHAPTER II

OBJECTIVES

General Objectives:

To develop practical preventive measures for reducing contaminations in the block ice and crushed ice manufacturing by applying HACCP principles.

Specific objectives:

1. To study production processes of block and crushed ices
2. To analyze the physical, chemical, and microbial hazards at each step of block and crushed ice production
3. To develop preventive measures in order to ensure the safety of ice
4. To evaluate on practicality of the developed measures

CHAPTER III

LITERATURE REVIEW

3.1 Definition of block and crushed ice

3.1.1 Ice (2)

Ice is water that passed the freezing process which can be divided into two types depending on the manufacturing process which are block ice and tube ice.

3.1.2 Block ice (2)

Block ice is made by freezing in brine tank and is generally 11”x22”x60” sized and 150-kilogram weigh. Block ice can be classified into two types:

- 1.1 Edible ice: The used water for ice must meet the standard according to Notification of the Ministry of Public Health Re: Drinking Water in Sealed Container No.61 B.E.2521 and No.135 B.E.2536. The ice is normally clear by using the air blower in the blocking process.
- 1.2 Non-edible ice: The ice in this type is generally used for refrigerating seafood or fishery products. The manufacturing process is similar to the consumable ice making but the air blower is not employed.

3.1.3 Crushed ice

Crushed ice is the ice that crushed from block ice by the ice crushing machine. Crushed ice is normally used for refrigerating foods and cooling drinks.

3.2. Block and crushed ice production

3.2.1 Water Source

Major source of water for ice manufacturing are surface water, groundwater and municipal tap water. Surface water includes fresh water available in natural lakes, rivers and streams. Groundwater includes water obtained from wells,

springs, and infiltration galleries. The quality of water varies considerably and is, in most cases, dependent upon area in which it is found.

3.2.1.1 Surface water

Surface water can be defined as the water open to the atmosphere such as streams, rivers, lakes, ponds, and reservoirs (3). The amount and characteristic of constituents in surface water derive from many different sources. Surface water may contain silts and suspended sediments, dissolved organic matter from topsoil, bacteria disease germs from sewage, chemical impurities from industrial wastes and fertilizers and toxic materials from agricultural uses (4,5).

The extent to which faecal bacteria, viruses, and parasites are removed by properly designed and operated equipment for flocculation, coagulation, sedimentation, and rapid filtration is equivalent to that achieved by slow sand filtration.

Additional treatment, such as ozonation, will have a considerable disinfecting action besides converting part of the total organic carbon into a biodegradable form. If it is followed by activated carbon treatment or the biological filtration stage, some of the biodegradable organic carbon will be removed by microbial activity, thus reducing the potential for aftergrowth of nuisance bacteria in distribution networks (6).

3.2.1.2 Groundwater

Groundwater can be defines as waters such as spring water, artesian water and well water originating from subsurface aquifers (3). In general, groundwater has always been considered to be a high quality source of water for potable, agricultural and industrial uses (7). However, groundwater supplies are used only by smaller communities because the limited quantity that can be obtained from an aquifer (8).

Groundwater extracted from well protected aquifers is usually free from pathogenic microorganisms, and the distribution of such groundwater without treatment is common practice in many countries. However, the catchment area must be protected by effective regulatory measures and the distribution system adequately protected against secondary contamination of the drinking-water. If the water, in its

passage from source to consumer, cannot be protected at all times, disinfection and the maintenance of adequate chlorine residuals are imperative (6).

3.2.1.3 Tap water

Tap water is part of indoor plumbing, which became available in the late 19th century and common in the mid-20th century. The provision of tap water requires a massive infrastructure of piping, pumps, and water purification works. Tap water may contain various types of natural but relatively harmless contaminants such as scaling agents like calcium carbonate in hard water and metal ions such as magnesium and iron, and odoriferous gases such as hydrogen sulfide.

3.2.2 Water treatment

Water treatment process in ice plants depends on the quality of the raw water source. The good quality of treated water used is needed to produce ice products. The principle objective of water treatment is to make the quality of water meet the drinking water standard described in the Notification of the Ministry of Public Health No.78 B.E.2527 because there has been no specific regulation for ice manufacturing up to now. A range of unit process that usually used in series of water treatment was shown in table 1.

The fundamental purpose of water treatment is to protect the consumer from pathogens and from impurities in the water that may be injurious to human health or aesthetically unpleasant. Where appropriate, treatment should also remove impurities which, although not harmful to human health, may make the water unappealing, damage pipes, plant or other items with which the water may come into contact, or render operation more difficult or costly (6). These purposes are achieved, by introducing successive barriers, such as coagulation, sedimentation, filtration and advanced treatments, to remove pathogens and impurities. The final barrier is often disinfection (6).

For block and crushed ice manufacturing, the water treatment steps that mostly used are coagulation, flocculation, sedimentation, filtration, and reverse osmosis. Moreover, Using chlorine and ultraviolet radiation are normally found in the disinfection steps.

3.2.2.1 Water storage (6)

The storage of water in reservoirs creates favorable conditions for the self-purification of the stored water, but may also cause undesirable changes in water quality. The benefits of storage include the provision of a continuous supply of water, reduction in turbidity, reduction in pathogens through the action of sun-light and sedimentation, dilution of undesirable substances that may accidentally enter the intake, and oxidation of impurities. It also provides a buffer should pollution occur in the river. Undesirable conditions created by birds and animals, evaporation, and the leaching of iron and manganese from soils and rocks.

Reservoirs should either be constructed in series or designed to prevent short-circuiting, since this will enhance removal of pathogens and self-purification. The benefits of reservoir storage are greatest in the summer and when residence periods are about 3-4 weeks.

3.2.2.2 Prechlorination (6)

Prechlorination to breakpoint has been widely used as an alternative to storage for water derived from lowland rivers and is also used when stored water contains much planktonic life. Its purpose is to reduce counts of faecal bacteria and pathogens, destroy animal life and algae, and oxidize ammonical nitrogen, iron, and manganese, thereby assisting in their removal. The combined and free chlorine which remains effectively discourages microbial activities, such as protozoal predation and nitrification, as well as microbial growth during subsequent filtration. When used to disinfect raw water, the oxidative effect of chlorine and even more ozone will result in the partial conversion of total organic carbon into biodegradable organic carbon.

3.2.2.3 Coagulation and flocculation

Coagulation involves the addition of coagulants to the water at a specific concentration about 30-100 ppm to neutralize the charges on particles by a reaction of the coagulant with alkalinity in the water to produce an insoluble metal hydroxide precipitate which enmeshes the colloid particles (9).

Flocculation is the second stage of the formation of settleable particles from destabilized colloidal particles. It is obtained by gentle and prolonged mixing.

During this mixing, the particles will aggregate into larger particles that enough to settle rapidly and may be removed from suspension by filtration (10, 11). Detention time of 30-60 minutes is generally adequate to produce a floc that will settle within a reasonable time (12).

3.2.2.4 Sedimentation

The purpose of sedimentation is to permit settleable floc to be deposited and thus reduce the concentration of suspended solids that must be removed by filters (13). The factors that influence sedimentation include the size, shape, and weight of the floc, viscosity and hence the temperature of the water, the detention time, the number, depth, and areas of the basins, the surface overflow rate, the velocity of the flow, and the inlet and outlet design (6).

These processes (coagulation, flocculation, and sedimentation) can bring about major reductions in turbidity and in counts of protozoa, bacteria, and viruses (14).

3.2.2.5 Filtration

After clarification, the water only contains fine solids and soluble material. Filtration is required to remove this residual material. There are two types of filter used in water treatment i.e. rapid and slow sand filters. Rapid sand filter medium are silica sand, crushed anthracite coal, granular activated carbon, and garnet or limonite (10, 12, 15).

Typically, rapid sand filters consist of 0.4-1.2 m of sand, usually of an effective size of 0.5-1.0 mm, supported by gravel and underdrains. In recent years, single-medium filters have often been replaced by dual-medium or multimedia ones. During filtration, residual particles of floc not removed by sedimentation are trapped in the interstices of the bed, and may induce further flocculation of particles. A limited amount of biological activity may also occur, if it is not suppressed by prechlorination or by high flow rates. Both sand and mixed media filters are normally cleaned by reversal of flow through the bed (backwashing). Backwash water is either discharged to the sewer or drying beds or recycled after removal of sludge.

The performance of rapid filters in removing microorganisms and turbidity varies over the duration of the run between backwashing. Immediately after backwashing, performance is poor, until the bed has compacted. In some plants, water is filtered and diverted for recycling for 15-30 min at the start of each filter run.

Table 1 Main water treatment unit process (9)

Treatment Category	Unit process
Intake	
Pre-treatment	Coarse screening Pumping Storage Fine screening Equalization Neutralization Aeration
Primary treatment	Chemical pre-treatment Coagulation Flocculation Sedimentation
Secondary treatment	Rapid sand filtration Slow sand filtration
Disinfection	Chlorination Ozone process Use of ultraviolet radiation
Advance treatment	Iron and Manganese removal Softening Ion-exchange Adsorption Chemical oxidation

3.2.2.6 Reversed Osmosis

Reverse Osmosis is the most common process for reducing the salinity of brackish groundwater. It is a process which uses a membrane under pressure to separate relatively pure water (or other solvent) from a less pure solution. When two aqueous solutions of different concentrations are separated by a semi-permeable membrane, water passes through the membrane in the direction of the more concentrated solution as a result of osmotic pressure.

Water molecules can form hydrogen bonds in the Reverse Osmosis membrane and fit into the membrane matrix. The water molecules that enter the membrane by hydrogen bonding can be pushed through under pressure. Most organic substances with a molecular weight over 100 are sieved out, i.e., oils, pyrogens and particulates including bacteria and viruses (16).

3.2.2.7 Disinfection

Disinfection is considered to be the primary mechanism for the inactivation/ destruction of pathogenic organisms to prevent the spread of waterborne diseases. It is important that water be adequately treated prior to effective disinfection (17). Although the above processes can efficiently remove microorganisms, the finished water may still contain pathogens which need to be removed or destroyed. However, in practice it is impossible to sterilize water. So, the water is disinfected rather than sterilized by disinfection methods such as chlorination, ozonation, or ultraviolet radiation to ensure the safe level of pathogens (10). There are several methods of treatment of water to kill living organisms, particularly pathogenic bacteria; the application of chlorine or chlorine compounds is the most common. Less frequently used methods include the use of ultraviolet light, ozone, or silver ions.

a. Chlorination

Among various types of disinfectants, chlorine is the most widely used because it is easy to handle, relatively inexpensive, and leaves residual in water that continues to destroy pathogens after water travels through distribution system. Several chlorine-containing compounds such as chlorine dioxide, sodium hypochlorite and calcium hypochlorite are available for disinfection (10, 18).

Since chlorine is a strong oxidizing agent, it can react with inorganic reducing substances and convert to inert or less active forms. The quantity of the chlorine used is referred to as chlorine demand. For chlorination, chlorine is added continuously into water to the point or dosage of breakpoint chlorination whereby all of the chlorine demand had been satisfied and all of the ammonia had been oxidized, which leave a free residual of chlorine for disinfection (19, 21).

b. Ultraviolet radiation

An Ultraviolet (UV) disinfection system transfers electromagnetic energy from a mercury arc lamp to an organism's genetic material (DNA and RNA). When UV radiation penetrates the cell wall of an organism, it destroys the cell's ability to reproduce. UV radiation, generated by an electrical discharge through mercury vapor, penetrates the genetic material of microorganisms and retards their ability to reproduce. The effectiveness of a UV disinfection system depends on the characteristics of the water, the intensity of UV radiation, the amount of time the microorganisms are exposed to the radiation, and the reactor configuration (17).

3.2.3 Processing of block and crushed ice

Overall, after water passes through water treatment units, treated water will be added into ice cans and frozen to make block ice. The block ice will be cut into small pieces and ground. The final ice product is called crushed ice.

3.2.3.1 Equipment for block ice manufacturing (21):

Block ice is the ice that passed the freezing steps within the ice cans by heat exchange between the refrigerant in the brine tank and the water in cans. The ice blocking apparatus are consisted of 3 main parts:

- 1) Ice making unit
 - 1.1 Brine tank
 - 1.2 Ice can
 - 1.3 Can lifting frame
 - 1.4 Agitator
 - 1.5 Tank insulation

- 1.6 Tank cover
- 1.7 Aeration system
- 2) Transferring
 - 2.1 Overhead traveling crane
 - 2.2 Thawing tank
 - 2.3 Can filling tank
- 3) Cooling system
 - 3.1 Compressor
 - 3.2 Accumulator
 - 3.3 Evaporator coil
 - 3.4 Condenser
 - 3.5 Receiver
 - 3.6 Cooling tower
 - 3.7 Valve
 - 3.8 Control equipment

3.2.3.2 Block ice manufacturing (21)

After water treatment process, treated water is pumped into ice can and frozen in the brine tank. As cold brine is circulated in the tank, ice is gradually formed in the can. After 24-48 hours, ice will be removed from the can. At this step, the ice is called block ice.

3.2.3.3 Ice crushing and distribution

After removing ice from ice cans, block ice is transferred manually to the transporting platform. Then it is cut by the ice cutter and crushed by the ice crusher. Normally, crushed ice is collected and kept in ice containers such as sacks or other insulated plastic buckets. In some plants, the bulk of crushed ice is transported to retail business by vehicles of the manufacturers themselves. Some, the bulk is sold to the wholesalers and transported by their own vehicles to the retailers.

3.3 Quality Assurance

Several quality food systems have been implemented to ensure the safety of the products such as quality control, quality assurance, good manufacturing practice, and hazard analysis and critical control point. The term Quality Control (QC) is used to encompass all those controllable factors that determined the quality of the product up to the point when it arrived in the hands of the consumers (22). It includes the organization, carrying out and documentation of sampling and testing for compliance with specifications, examination of process control data, and the provision of rapid information and advice leading to corrective action when necessary. Later, the term Quality Assurance (QA) became so popular that it virtually superseded QC in the jargon of most companies. The aim of QA is to ensure that a product as closely as possible and consistently to that standard at all times (23).

3.3.1 Good Manufacturing Practice (24)

Good manufacturing practice or GMP is considered as a part of a food and drink control operation aimed to ensuring that products are consistently manufactured to a quality appropriate to their intended use. It is thus concerned with both manufacturing operation and quality control/quality assurance system. Both these components must be well designed and effectively implemented.

GMP is that part of an integrated food control operation. It is made up of two complementary components that interact with each other, the manufacturing operation itself, and the system/procedures that control it. According to the Codex Alimentarius guidelines, depending on the nature of the operations and the risks associated with them, premises, equipment and facilities should be located, designed and constructed to ensure minimal contamination, appropriate maintenance, cleaning, and disinfection and to minimize air-borne contamination. Surfaces and materials, in particular those in contact with food, are to be nontoxic in intended use and, where necessary, suitably durable and easy to maintain and clean. Suitable facilities must be available for temperature control. Humidity and other controls are needed and effective protection against pest access and harborage. A well established GMP will also include control procedures with adequate laboratory facilities, qualified quality control.

In Thailand, Office of Food and Drug Administration, Ministry of Public Health is the institute where responsible for GMP regulations. In early period, they promoted these regulations to food manufacturers by volunteering. Later, in July 2004, the Office of Food and Drug Administration, Ministry of Public Health has promulgated the Notification No.193 B.E.2543 and No.239 B.E.2544 Re: Production Processes, Production Equipments and Food Storages for enforcing 54 types of food products, including ice, to follow the GMP regulations (25, APPENDIX A).

GMP requirement in Thai-GMP Law consists of 6 requirements which are:

1. Location and manufacturing buildings; i.e. environmental management both internal and external of the plant area.
2. Tools, machineries and production equipments; i.e. design and arrangement of equipments
3. Control of production process; i.e. controlling of raw material, processing procedure, recording and reporting
4. Sanitation (Sanitary facilities); i.e. available toilets, hand washing basins and other sanitary facilities.
5. Cleaning and maintenances; i.e. management of processing area, machines and production equipments, both before and after production
6. Personnel and hygiene workers; i.e. good hygiene of people who work in the processing area and people who is not relevant to production that enters the area.

3.3.2 Hazard Analysis and Critical Control Point

HACCP is an acronym used to describe the Hazard Analysis and Critical Control Point system. The HACCP concept is a systematic approach to food safety management based on recognized principles which aim to identify the hazards that are likely to occur at any stage in the food supply chain and put into place controls that will prevent them from happening. This ensures that food safety is managed effectively and reduces reliance on the traditional methods of inspection and testing (26).

The HACCP concept is a systematic approach to the identification and assessment of the risk of biological, chemical, and physical hazards from a particular

food production process or practice and the control of those hazards. HACCP is a preventive strategy for food safety. Under it, the food producer develops a plan that anticipates and identifies the points in the production process where a failure would likely result in a food hazard being created or allowed to persist. These points are referred to as critical control points (CCP's). Under HACCP, identified CCP's are systematically monitored to ensure that critical limits (CL's) are not exceeded, and records are kept of that monitoring. Corrective actions are taken when control of a CCP is lost, including proper disposition of the food produced during that period, and these actions are documented. The effectiveness of HACCP is also systematically verified by the processor (24).

3.3.2.1 Hazard Analysis (26)

Hazard analysis is the part of HACCP study where the team looks at each step of the process, identifies the hazards likely to be present, evaluates their significance and ensures that adequate measures for their control are in place.

a. Biological hazards

These occur in the form of pathogenic micro-organisms and they present the biggest danger to consumers in many product groups. Pathogenic micro-organisms exert their effect either directly through growing in or contaminating food products and being ingested, or indirectly by forming toxins.

b. Chemical hazards

Chemical contamination of foodstuffs can occur via the ingredients, at the time of their production or during distribution/ storage and the effect on the consumer can be long term, short term or teratogenic.

c. Physical hazards

These are foreign bodies or matter that can contaminate a foodstuff at anytime during production. They are only significant safety hazards if they are likely to cause injury or a health risk to the consumer; otherwise they should be considered in terms of quality, wholesomeness or legality and manage through hygiene and quality prerequisite control programmes.

3.4 GMP in block ice and crushed ice manufacturing

The covered GMP requirements to be implemented in block ice and crushed ice manufacturing according to the Notification No.193 B.E.2543 included Building interior, program equipment, practice in sanitation and cleaning program, personal practices, and personal training.

3.4.1 Building interior (27)

3.4.1.1 Glass

Glass or glass-like materials such as breakable plastic in food plants can be sources of physical hazards and should not be used in processing areas where there is a likelihood of breakage that will result in contamination of product. If these materials must be used, they must be adequately protected from breakage. Overhead light bulbs should be protected from breakage.

3.4.1.2 Floor

The surface of the floors, especially the block ice transferring area, should be even with the appropriate slope for water to be drained at the designated outlets. Floor surfaces should be impervious, durable and free of cracks to facilitate cleaning. For the floor of old-style ice plant which was made of wood, the cleaning program must be addressed appropriately to prevent the microbial accumulation.

3.4.2 Program equipment (27)

The ice-contact surfaces of equipment should be made of nontoxic material and should not be corroded or damaged in any way of during normal operations, or when in contact with cleaning materials. The seams on food contact surfaces should be smooth so as to prevent accumulation of product and to facilitate cleaning and sanitizing.

3.4.3 Sanitation and cleaning program (27)

3.4.3.1 Equipment

For block ice plant, the equipments used are open-system so all of them can be clean handily. For utensils and ice contact services, ice tongs, axes, all

containers and all ice contact surfaces should be cleaned and sanitized as it becomes necessary.

3.4.3.2 Cleaning and sanitizing personnel

Persons who are assigned cleaning and sanitizing tasks should be trained in the safe use of the cleaning and sanitizing chemicals, such as sodium hypochlorite or calcium chlorite, and their proper handling, identification and storage. They should be provided with the directions for use, including the appropriate usage concentration or dilution for ice-contact surfaces, and instructions for removal of residue of these chemicals from these surfaces. The effectiveness of the cleaning and sanitizing activities for removal of contamination should be verified. This should be done by microbiological swab tests, by visual inspection if cleaned equipment and areas, and by observing employees who carry out the cleaning and sanitizing activities.

3.4.4 Personal practices (27)

3.4.4.1 Personal hygiene

In order to protect against contamination of products, ice plant employees are required to maintain satisfactory personal grooming and cleanliness and to practice good personal hygiene habits during all food handling operations. This includes general cleanliness of clothing and body, including hair and fingernails. Employees should refrain from placing fingers in mouth, nose or ears, and from eating, chewing, spitting, and smoking during food handling operations, and avoid coughing and sneezing over unprotected products, food-contact surfaces, or food processing equipment. For garments or work-wear, employee should wear the uniforms or outer garments provided for their works. Uniforms should be clean at the start of work and changed when they become dirty. The glove are required to be worn during work, they should always clean and sanitary, and should be changed if they become torn.

Personal items: Employees should refrain from keeping in their possession any personal items which could be a potential source of contamination.

3.4.4.2 Hand-washing

In order to protect hands from being a source of contamination, ice plant employees should wash, sanitize if necessary, and dry their hands at the designated hand-washing stations when their hands become dirty. Employees should

wash their hands before start of work, when re-entering their work area, after a visit to the toilet, after coughing and sneezing into their hands, or after any other situation that will cause the hands to become dirty and be a source of contamination or cross-contamination.

3.4.4.3 Visitors and noncompany personnel

The access of visitors and noncompany personnel to an ice plant should be controlled to avoid potential source of contamination. This control should apply to family members of employees, noncompany personnel working on the premises, suppliers, customers, government inspectors, auditors and individuals from educational and other institutions on organized visits and plant tours. These individuals should be required to follow the same personal practices of the regular employees of an ice plant.

3.4.5 Personal training (27)

3.4.5.1 Food Safety Training:

All food plant employees, including temporary employees, should be trained in the basic food safety principles and practices that are required to prevent contamination and cross-contamination of foods. This training should cover hygienic food handling practices, personal hygiene requirements, and the dangers associated with poor personal hygiene and unsanitary personnel practices in a food plant. In addition, personnel who have the responsibility to monitor the adequacy of food safety practices of food plants should have the necessary training and experience to recognize and identify food hazards and situations that have the potential to lead to contamination or cross-contamination of foods. This includes the training if supervisory personnel to recognize injuries or infectious illnesses among plant employees. The food safety training needs of employees in food plants should be reviewed periodically, and if necessary, additional training is provided to employees, there should be an evaluation to determine that the training is understood and could be put into practice by the employees.

3.4.5.2 Technical training

Employees, whose tasks involve operation, maintenance, cleaning of ice processing equipment, and sanitation and cleaning activities, should be provided

with the relevant technical training that is required to carry out their specific tasks so that all food safety requirements are met. The technical training needs of employees should be reviewed periodically, and if necessary, additional or refresher technical training should be provided. Technical training should also include on-the-job training and evaluation to ensure that employees understand the training and perform their tasks based on the training.

3.5 Hazards in block and crushed ice manufacturing (25)

Ice can be contaminated from environment in most steps of manufacturing process. Manufacturer must consider in safety of ice and produce ice safety without any hazards. Physical hazards found in the ice can be broken pieces of glass from light, woods from the ice can lid, platform, and transporting area. Chemical hazards include pesticide residue, lubricant, grease, motor oil, ammonia and anti-rusting agent. Microbial hazard, which is noticeably the most effective, is contamination from *Escherichia coli*, *Clostridium perfringens*, *Bacillus cereus*, and *Staphylococcus aureus*.

3.5.1 Hazards from microbial contamination

As reported from many surveys, coliforms and pathogens such as *Escherichia coli*, *Staphylococcus aureus*, *Clostridium perfringens*, *Salmonella spp.* and *Vibrio cholerae* were found in crushed ice samples. Microbial contamination are associated with both quality and safety properties. Natural water contains not only their natural flora but also microorganism from soil, animal and/or sewage (21). Microbiological parameters are indicators of potential water-borne diseases and, in general, are limited to bacteria, viruses, and pathogenic protozoa. Water contaminated with human feces of carriers or patients may introduce a variety of intestinal pathogens which may cause diseases varying in severity from mild gastroenteritis to severe and sometimes fatality (28).

a. Indicator organisms of fecal pollution

For fecal pollution, Coliform organisms or total coliforms, the most widely indicator, have long been recognized as a suitable microbial indicator of drinking water quality, largely because these organism organisms are easy to detect

and enumerate in water. They include *Escherichia coli*, *Citrobacter*, *Enterobacter*, and *Klebsiella* species. Coliform bacteria should not be detected in treated water (32).

Two basic methods are used for the detection of coliform organisms in water: the multiple-tube fermentation technique and the membrane-filter technique. The definition of coliform group when operating with the fermentation technique is all facultative anaerobic, gram-negative, non-spore forming, rod-shaped bacteria that ferment lactose with gas and acid formation within 48 h at 35°C. The result is reported in terms of the Most Probable Number (MPN) of organisms present. When the membrane-filter technique is used, the coliform group is defined as many facultative anaerobic, gram-negative, non-spore forming, rod-shaped bacteria that develop red colonies with a metallic (golden) sheen within 24 h at 35°C on an endo-type medium containing lactose (30). However, coliform organisms do not appear to be a good indicator for viruses and protozoa (10, 31).

b. Indicator organisms of water quality

Colony counts and microorganisms have been used to assess the hygienic quality of drinking water. However, there are not essential for the routine monitoring of hygienic quality. They are of value in certain circumstances in giving an indication of the general cleanliness of the distribution system and in assessing the quality of bottled water (29).

Colony counts or total plate counts may be used to assess the general bacterial content of water. They represent the microorganisms that are able to form visible colonies in nutrient media under specified culture conditions. The high variation of bacterial concentration from 100-600 colonies per ml is still classified as potable when total coliforms were negative. So the test of colony counts has been suggested to use in conjunction with the total coliforms test (31).

3.5.2 Hazard from Chemical contamination

In food processing operations, some chemical compounds that are not permitted substances in food are used during certain operations and care must be taken to prevent unintentional contamination. These substances include chemical compounds used for cleaning and sanitizing food contact surfaces of processing,

handling, and storage equipment, and for lubricating certain part of food processing equipment. (32)

According to the information from the block ice machine supplier, the anti-rusting agent, sodium dichromate dihydrate, is generally added into the brine tank in order to protect the ice can from erosion.

Normally, chromium and its salts are used in the leather tanning industry, the manufacture of catalysts, pigments and paints, fungicides, the ceramic and glass industry, and in photography, and for chrome alloy and chromium metal production, chrome plating, and corrosion control (6).

As cited in Material Safety Data Sheet, sodium dichromate dihydrate or sodium bichromate dihydrate ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$) is reddish to bright orange crystals and very soluble. Sodium dichromate dihydrate, itself, is toxic to human including carcinogenicity, reproductive and developmental toxicity, neurotoxicity and acute toxicity (32).

Moreover, dichromate ($\text{Cr}_2\text{O}_7^{2-}$) is one form of the Chromium (VI). From the biological point of view, hexavalent chromium itself is of particular importance because of its toxicity due to its oxidizing properties. Intakes of 1-2 grams/day can cause kidney and liver necrosis (33). For its carcinogenicity, the International Agency for Research on Cancer (IARC) has classified chromium (VI) in Group 1 which means carcinogenic to humans (6).

The allowable of dichromate or chromium (VI) content of Thai regulation has not been established. However, the allowable total chromium content in water used in ice manufacturing, according to the notification No.78 by the Thailand's Ministry of Health, is 0.05 mg/l (APPENDIX A).

3.6 Related research about ice quality

The study of bacteriological quality of ice factories, distributing agent and retail shop by Areeraj W. (34) showed that the quality of heterotroph and fecal streptococcus in retail shops were more than in the distributing agents, the quality of fecal coliforms and *Staphylococcus aureus* were not different in both places. The study also showed that the quality of ice samples from the factories have higher bacteriological quality than those from the distributing agents and retail shops. The

bacterial contamination of ice occurred through the unsanitary transportation procedures including the unsanitary handling and storing ice in the container with other foods before consumption.

Malasao S. et al. (35) reported that 9 surveyed samples in Bangkok were failed to meet the microbiological requirements. It was explained that 9 crushed ice samples were contaminated by *Escherichia coli* and *Staphylococcus aureus*.

Bangtrakulnont A. (1) studied the microbiological quality of ice for refrigerating foods in Dusit and Pra-nakorn provinces in Bangkok. The results showed that 21% of samples were contaminated by *E. coli*. Moreover, pathogenic bacteria such as *Salmonella* spp. (13%) *Vibrio cholerae* non O1/non O139 (11%) and *Staphylococcus aureus* (23%) were found in ice samples.

Nongharnpitak P. (36) studied the quality of cube ice in plastic baggage at Khon Kaen Municipality in Thailand. The 36 samples were analyzed in three dimension; physical chemical and biological characteristic. It was found that physical characteristic of cube ice had met the standard in terms of turbidity and pH from 83.33% of samples. Also chemical characteristic in the cube ice such as total solids, iron, chloride, fluoride, nitrate, and total hardness of all the samples had met the standard requirement. However, it was found that 91.67% of cube ice samples had not met the microbial quality standard of standard plate count. Moreover, of all samples had not passed the total coliform bacteria and fecal coliform bacteria requirements.

Silawan S et al. (27) reported the inspection of coliform bacteria contamination in drinking water plants and ice plants in Nakhon Ratchasima, Chaiyaphum, Buri Rum and Surin. 32 randomly sampled plants from 82 overall drinking water plants and ice plants, which were 21 drinking water plants and 11 ice plants, were analyzed. The study included collecting samples, interviewing, and observation of workers' practice. The results showed a high level of coliform bacteria contamination in every production step. The causes of contamination included improper use of chlorine, no checking of residual chlorine in treated water, the storage tank of treated water was not covered and inappropriate practice of workers.

In 2004, 51 samples of both crushed and tube ice were collected from slums in Bangkaen district, Bangkok by the Ministry of Public Health. It was found that 50

samples (98%) contaminated with coliform bacteria (37). Later, crushed ice samples obtained from market retailers in Bangkok metropolitan were analyzed by the national food institute (36). It was found that all samples were failed to meet the microbiological requirements for ice because they contained *Escherichia coli* and coliforms.

Wilson et al. (37) studied the Microbiological quality of ice in hospital and community in Ireland. The survey was undertaken in response to a report of a clinical infection which had been related to an ice-making machine on a hospital ward. A detailed study of the ice microflora of 27 ice-making machines was performed. In a subsequent survey, ice samples (N = 194) from establishments such as bars and hotels were examined for bacterial indicators of hygiene. Samples from hospital ice-making machines yielded low numbers of a wide range of potentially opportunistic microorganisms, many of environmental rather than clinical origin. For ice sampled in the community, the total aerobic plate count (TAPC) at 37 degrees C for 95% of the samples was < 500 cfu/ml, and at 22 degrees C 75% had < 500 cfu/ml. Examination for coliforms showed that 69% of samples contained no coliforms, but 20% contained > 100 coliforms/100 ml. *Escherichia coli* were detected in three samples but in very low numbers. This report investigates the relevance of ice machines to the control of hospital infection, the hygiene of ice in the community, discusses the microbiological quality of ice and proposes possible guidelines.

In 2002, the survey of Microbiological quality of Ice for Cooling Drinks was carried out in Ireland by 1st Quarter National Microbiological Survey (38). The samples were 97% ice from ice machine, any premises serving drinks cooled by the addition of ice. It was found that *Escherichia coli* and coliforms were absent in 95% and 70.5% of all samples respectively. And the type of storage had a significant effect on the microbiological results. It was recommended that manufacturer' instructions relating to the maintenance, storage, cleaning and situation of ice machines should be followed. Ice machine manufacturers should assess the results of this survey and prepare guidance on best practice. Moreover, where possible, ice should be stored in the storage bin of the ice machine. If ice buckets are used, they should be maintained in a hygienic condition and melt-water should not be present. Also, all staff should

have basic training in food hygiene and safety. And, food safety management system based on the principles of HACCP should be implemented.

Gordon Nichols et al. (39) studied the Microbiological Quality of Ice Used to Cool Drinks and Ready-to-Eat Food from Retail and Catering Premises in the United Kingdom. A survey of 4,346 samples of ice from retail and catering premises examined 3,528 samples (81%) used to cool drinks and 144 samples (3%) from food displays. For 674 samples (15%), the origin was not recorded. Most samples of ice used to cool drinks or ready-to-eat food on displays did not contain coliforms, *Escherichia coli*, or enterococci. Of the ice used to cool drinks, 9% contained coliforms, 1% *E. coli*, and 1% enterococci in excess of 10^2 CFU/100 ml, and 11% had an aerobic plate count at 37°C in excess of 10^3 CFU/ml. The microbiological quality of ice used to cool drinks was poorer when melt water was present in the ice buckets. Ice used in food displays was more contaminated than ice used to cool drinks, with 23% containing coliforms, 5% *E. coli*, and 8% enterococci at 10^2 CFU/100 ml or more. 29% percent of samples had an aerobic plate count greater than 10^3 CFU/ml. Ice that had been used to cool shellfish was of a lower microbiological quality than samples used to cool ready-to-eat fish, salads, or dairy produce. Samples of ice produced in commercial production facilities were of higher microbiological quality than samples of ice that were not. The microbiological quality of ice was dependent on the type of use, the type of premises, and the type and place of production. Although most ice samples were of acceptable microbiological quality, evidence from this study suggests that the microbiological quality of ice prepared and used at certain premises in the UK is a cause for concern.

Rosa et al. (40) conducted the study of Drinking Ice as a Vector for Gastrointestinal Disease. The survey confirmed that ice can be a vector for gastrointestinal disease, its quality reflecting the water from which it was made. High levels of organisms which indicate hygiene failure, as well as fecal contamination and/or the presence of pathogenic bacteria, viruses, protozoa or cryptosporidia have been found. While potable water is the minimum water quality required for ice production, good hygienic practices are needed for the production and handling of ice.

In Brazil, Falcão et al. (41) studied the Microbiological quality of ice used to refrigerate foods. The survey revealed that ice used for human consumption or to

refrigerate foods can be contaminated with pathogenic microorganisms and may become a vehicle for human infection. Results suggested poor hygienic conditions of ice production due to the presence of indicator micro-organisms. Fifty strains of *E. coli* of different serotypes, as well as one *Y. enterocolitica* biotype 1, serogroup O:5, 27 and phage type Xz (Ye 1/O5,27/Xz) and one *Salmonella Enteritidis* phage type 1 (PT1) were isolated. *Aeromonas spp.*, *Shigella spp.* and *V. cholerae* were not detected. The presence of high numbers of coliforms, heterotrophic indicator micro-organisms and pathogenic strains suggested that commercial ice and ice used to refrigerate fish and seafood may represent a potential hazard to the consumer in our community.

In summer 2002, a survey to assess the microbiological quality of ice served in drinks at food premises in the Brisbane North side area (42) was conducted by Environmental Health Services Brisbane North side Public Health Unit (BNPHU). A total of 57 samples were obtained from 30 randomly selected premises (i.e. restaurants, hotels, fast food outlets and a cinema). Overall 11 samples (19%), obtained from 8 of the 30 premises included in the survey, failed to meet the microbiological requirements for potable water set by the National Health and Medical Research Council (NH&MRC) Australian Drinking Water Guidelines 1996 (ADWG). Ice samples obtained from the retail storage contained more coliforms (35%) than ice from the bulk supply (7%). 4 samples (7%) contained a high standard plate count. No samples were reported containing *Escherichia coli*. It is suggested that good hygienic practices are needed for the production and safe handling of ice within premises. And it can be achieved by improving awareness of the potential for ice to become contaminated with food borne pathogens, advising of practical measures and continuous assessing the level of compliance within food premises.

In 2005, a survey to assess the microbiological quality of edible ice from ice manufacturing plants and retail businesses (e.g. hotels, Chinese restaurants, fast food shops, etc.) in Hong Kong was undertaken (43). A total of 89 samples from retail businesses and 12 samples from ice manufacturing plants were analyzed for aerobic colony counts (ACC), coliforms and *E. coli*. *E. coli*, the indicator organism for fecal contamination, was not detected in all samples. All the 12 samples taken directly from the ice manufacturing plants met the microbiological criteria used in the study. Of the 89 samples from retail businesses, 8 (9%) and 3 (3%) samples exceeded the criteria for

coliform (i.e. < 100 cfu per 100ml) and ACC (i.e. <1,000 cfu per ml) used in this study respectively. Coliforms and ACC are indicators for hygienic practices and do not represent food hazard directly. In the retail sector, ice can be produced on premises or supplied by manufacturing plants. Although packaged ice sampled from manufacturing plants was shown to have satisfactory quality, significantly higher percentages of those sourced from manufacturing plants but sampled from retail outlets had higher coliform counts and ACC. The reason for this phenomenon might be that the surface of ice bags had been contaminated during transportation and storage. The contaminated surface might subsequently contaminate the ice during opening and emptying of the ice bags. Overall, this survey showed that the microbiological quality of ice samples was satisfactory and the likelihood of enteric infection through the consumption of ice from food retail businesses was low. Recommendations and advice were given to food premises on the improvement of hygienic quality of ice intended for human consumption.

Agbeje L et al. (44) found that the surveyed ice samples for cool drinks and foods in Nigeria were contaminated by *Pediococcus cerevisiae*, *Bacillus subtilis*, *Streptococcus pyogenes*, *Bacillus firmus*, *Pseudomonas aeruginosa*, *Streptococcus equi*, *Staphylococcus epidermidis*, and *Micrococcus luteus*. They also suggested that the HACCP should be established to ensure the microbiological safety of ice.

CHAPTER IV

MATERIALS AND METHODS

4.1 Production process evaluation

The basic information of block and crushed ice manufacturing was gathered from the ice machine supplier, Patkol Public Company plants. Then, technical problems in the production of block ice were obtained from the surveys at the following factories.

1. Paitoon Ice Factory (1999) Company Limited

Address: Amphur Sampran, Nakhon-Pathom

2. Iyara-Sainoi Company Limited,

Address: Amphur Sainoi, Nontha-buri

3. Wangsala Ice Factory Limited Partnership

Address: Amphur Tha-muang, Kanchanaburi

4. Somchai Ice Factory:

Address: Amphur Mueng, Khonkaen

5. Saha Namkhaeng Trang Limited Partnership

Address: Amphur Mueng, Trang

6. Tiso Company Limited

Address: Amphur Mueng, Phuket

7. Tha-Chine Ice Factory Company Limited

Address: Amphur Mueng, Phuket

8. Sam-kong Ice Factory Limited Partnership

Address: Amphur Mueng, Phuket

4.2 Microbial assessment: case study at Paitoon Ice Factory (1999) Co., Ltd.

Water, ice and packaging samples were collected and swab test on ice-contacting surfaces were performed to evaluate the microbial quality in order to identify the problems during block ice and crushed ice manufacturing.

4.3 Analysis of hazards during production and distribution processes

Flow diagram for production and distribution processes of block and crushed ice was developed and analyzed for potential hazards. Analysis of the potential hazards was performed by applying principle of Hazard Analysis and Critical Control Points (HACCP). Furthermore, microbial and chemical analyses were also performed in order to verify the potential hazards.

4.4 Evaluation of potential hazards

Potential hazards were identified at certain production steps, which led to certain research questions that needed to be tested by the following experiments.

4.4.1 Effect of freezing temperature on reducing microbial risk

Water samples were prepared by mixing ditch water with deionized water at dilution factors of 1:100 and 1:5000. Initial loads of aerobic bacteria and coliforms were analyzed. Then 350 ml of each water sample was packed in polyethylene bag and heat-sealed. The bag was then placed in the insulated stainless steel tray to prolong the freezing rate. The experimental design aimed to simulate the production process of block ice at the factory, which water becomes frozen at about 48 h. Ice was then kept in freezer of refrigerator at -5°C for 2 d. Ice samples were collected to analyze aerobic plate count and total coliforms at 0th, 1st and 2nd day. Six sets of water were prepared for this experiment.

4.4.2 Contamination of chromium in ice

Chromium from anti-rusting agent could cause chemical hazard. Part of ice that was found to be stained with yellow color was collected and analyzed for residual chromium, as compared with normal ice.

4.4.3 Sack cleanliness

Sack size 48×81 sq cm was a receptacle for crushed ice during distribution. Cleanliness of the sacks was therefore an important factor for microbial contamination to the product. In this study, simulation of sack handling process at Paitoon Ice Factory was performed and evaluated for the potential in causing microbial

contamination. Sacks that were routinely used at the factory were sampled. Five pieces of sack size 1 sq in were cut from different positions of a sack by using aseptic technique, and then put into 250 ml sterilized phosphate buffer to evaluate for both aerobic plate count and total coliforms.

4.5 Development of preventive measures

According to the survey results and research questions, preventive measures were developed to assure the quality of block and crushed ice production and distribution. The developed measures were verified by microbial analyses and should be later transferable to the producers.

4.5.1 Water chlorination on microbial quality of ice

Statuses of water used for block ice making at Paitoon Ice Factory (1999) Co., Ltd. were obtained by interviewing involved staffs. Then, water samples were taken for analyzing residual chlorine and microbial quality. The factory staff was advised to add chlorine based on the Thai FDA's recommendation for treating raw water in bottled water production. After the implementation, water again was sampled and tested for the same qualities.

4.5.2 Sack cleaning

The cleaning process was developed based on normal practice of the factory, which had been observed during the survey. The process was developed in laboratory, which simulated sacks were made from the factory's sacks at much smaller size (16×24 sq cm). In each experiment, all of the sack samples were firstly soaked in ditch water for 1 h that so called "dirty sack", and tested for aerobic plate count and total coliforms. Then, certain processes were verified including (i) pre-washing in water before soaking in chlorinated water, (ii) appropriate chlorine concentration for sack soaking, (iii) appropriate sack soaking period in chlorinated water, and (iv) appropriate drying and storage conditions.

a. Effect of washing sack with water before soaking in chlorinated water on microbial quality of sack

In each experiment, after soaking sacks in dirty water, all of them were divided into 2 parts. For the first part, sacks were washed with tap water before soaking in the chlorinated water. The second part was soaked in the chlorinated water without washing. The chlorine concentration used was 10 ppm, measured by CHLORINE 200™ and the sacks had to be fully soaked for 20 min. Raw sack, washed sack and disinfected sack of both groups were analyzed for aerobic plate count and total coliforms.

b. Appropriate chlorine concentrations and soaking period for reducing microbial risk in sack

Dirty sacks were first pre-washed if needed based on the result from 4.4.2a, soaked in chlorinated water of concentrations 0.25, 1, 4, 7, and 10 ppm of residual chlorine for 20 min. As the efficient chlorine concentration was obtained by considering at result of microbial analyses, the value would be used as the minimum concentration of chlorine that should be maintained. Then, the study on minimum soaking period was performed with the minimum concentration of chlorine by varying soaking periods at 0, 5, 10, and 15 min.

At the factory, chlorinated water for cleaning sacks must be used continuously for about 12 h, which could normally cover up to 2000 sacks. Therefore, appropriate initial concentration of chlorine in chlorinated water must be high enough to retain minimum effective concentration after 12 h or being used for cleaning 2000 sacks. The initial chlorine concentration used in this experiment was approximately 100 ppm. Then, certain numbers of sack were soaked in the prepared chlorinated water at the ratio of 200 sacks per 350 l for certain period of time (evaluated from appropriate soaking period); the soaking cycle kept going until the concentration of chlorine reached the minimum effective concentration.

c. Appropriate drying and storage condition of washed sacks

By using the evaluated appropriate chlorine concentration and soaking period, dirty sacks were washed and stacked in the way that was practiced at the factory. The stacked sacks were left in air for 0, 1 and 4 h and then kept in new plastic bags at room temperature for 0, 12 and 24 h. The mentioned design was to simulate

practice at the factory that normally either left the sack for drying outside or kept the wet ones inside truck for day.

4.6 Test for the practicality of the developed measures

The developed preventive measure was tested for their practicality at Paitoon Ice Factory (1999) Co., Ltd. for 2 mo. During the testing period, verification was performed by using results from microbial analyses.

4.7 Method of analysis

4.7.1 Sampling procedures

a. Water

Water samples for microbial examination were collected in the 250 ml sterilized Duran™ glass bottles with plastic caps that had been cleaned and rinsed carefully. The volume of sample should be sufficient to carry out the tests required, preferably not less than 150 ml for microbial analysis and not less than 500 ml for chemical determination. Tap water was sampled after the tap was flame sterilized after being sprayed with 70% ethanol. During sample collection, the sampling bottle was filled carefully leaving air space in the container at least 2.5 cm to facilitate mixing by shaking before examination.

b. Ice

Ice samples were collected in presterilized plastic bag. Hand of operator and equipment were sprayed with 70% ethanol before used for collecting the samples.

c. Swab test

Swab tests were performed on specific areas of equipment surfaces that normally contacted with ice, hands of operator, distributing areas such as platform for laying and moving block ice, and pallet used for laying crushed ice sack. The cotton swab and screw capped test tube, which contained 10 ml of buffer solution, were sterilized. The swab head was moistened with buffer solution and then, rubbed over the target area. The target area was 50 sq cm which the sterilized stainless steel frame

was applied. To swab on equipment surfaces, the swab must not touch any portion of tube. The swab was returned into the buffer solution and rinsed briefly in the solution. The rinsed solution was used for the determination of total coliforms.

4.7.2 Analysis

4.7.2.1 Chemical analysis

a. Chlorine

Residual chlorine in the water samples was determined by spectrometry method using CHLORINE SERIES 200™. The range of the test was 0.0-6.0 mg/l.

b. Total chromium

Total chromium determination was applied by flame atomic absorption spectrophotometry (45).

4.7.2.2 Microbial analysis

a. Aerobic Plate Count (46)

The sample was prepared by making the dilution so that the total number of colonies on a plate would be within reliable countable range i.e. 25-250. The sample volume of 1.0 ml was added into a sterile petri dish and poured with medium. The poured plated was incubated at 35°C for 48±2 h. Number of bacteria was reported as colony forming units per milliliter (cfu/ml).

b. Total coliforms (47)

The five-tube fermentation technique was used as the method for coliform bacteria detection in presumptive and confirmed phases.

Lauryl tryptose broth was used as a media in the presumptive test. Two sets of five and ten tubes with inverted vials were prepared for double-strength and single strength broth, respectively. Five tubes of the double-strength broth were added with 10 ml of sample. For ten tubes of single-strength broth, five tubes were added with 1.0 ml and another five tubes were inoculated with 0.1 ml of sample. The inoculated tubes were incubated at 35°C. After 24±2 h, all tubes were examined for

growth, gas, and acidic reaction. If no gas and acidic reaction were observed, the tube was reincubated and reexamined till at the end of 48 ± 2 h.

Brilliant green bile broth fermentation tubes were used as a media in confirm test. A loopful of positive presumptive tubes which showed growth, any amount of gas, or acidic reaction within 24 ± 2 h or 48 ± 2 h was transferred to the fermentation tube containing brilliant green bile broth. Inoculated tube was incubated at 35 ± 0.5 °C. Formation of gas in any amount in the inverted vial of the brilliant green bile broth fermentation tube at any time within 48 ± 2 h constitutes a positive confirm test. Result from the confirm test was used for estimating the number of microorganism in terms of the Most Probable Number (MPN) per 100 ml of the sample (MPN/100 ml).

For swab test, three-tube fermentation technique was used in presumptive and confirmed phrases of total coliforms.

CHAPTER IV

RESULTS

5.1 Production process of block and crushed ice

From our survey, the production process consisted of 3 modules which were water treatment, block ice making, and ice crushing and its distribution (as shown in Figure 1). Within each module, there were certain differences among factories.

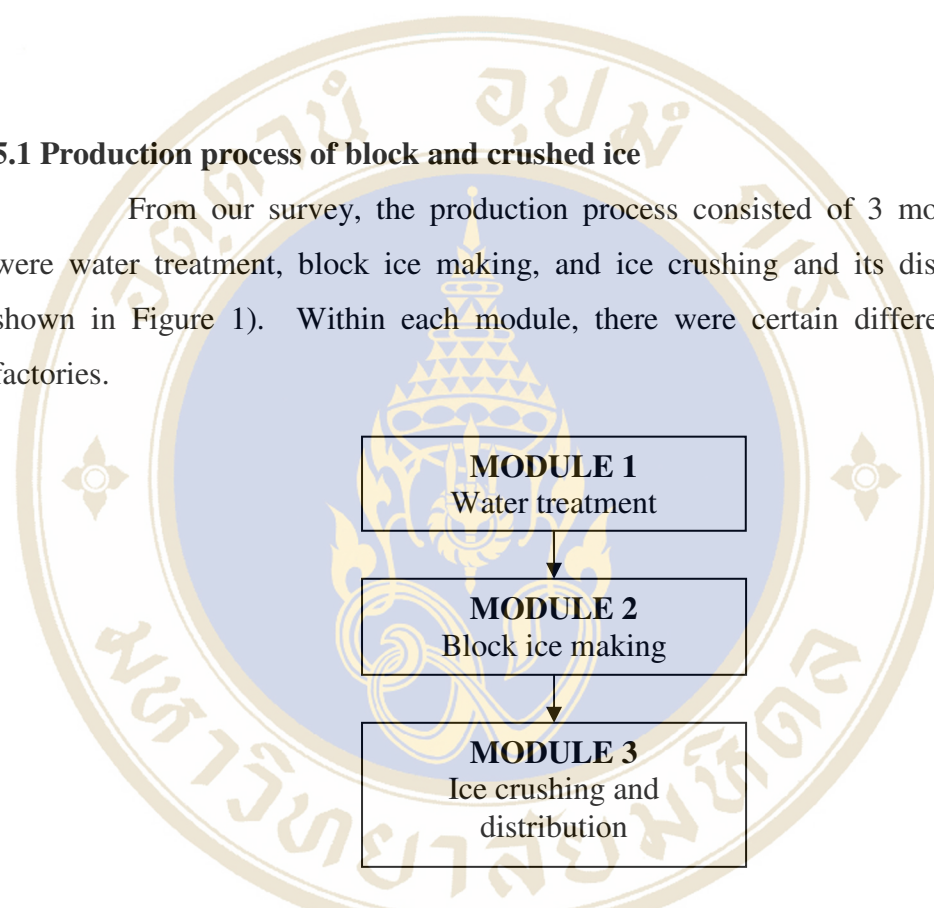


Figure 1 Block and crushed ice: modular system structure

5.1.1 MODULE 1: Water treatment

Various sources of water with different treatment methods were found (Table 2). Surface water from different sources i.e. river water, man-made soiled pond water, ditch water from mining, canal were either treated by the factories or by the municipal as tap water. Different methods for treatment were found and in fact not consistently practiced. In addition, groundwater was also used in some factories with different treatment processes, as well.

Table 2 Water source and water treatment and its improper practices of surveyed block ice plants

Plants	Location	Water source	Water treatment	Improper handling
Plant 1	Nakhon-pathom	groundwater	Chlorination → Filtration (Sand → Anthracite → Activated carbon) → RO system → Chlorination	- inadequate added chlorine content - unsuitable sequence of water treatment facilities (filtration after RO)
Plant 2	Nonthaburi	surface water	Chlorination → Sedimentation by PAC → Filtration (Sand → Activated carbon) → RO system → Cationic exchange resin → Chlorination	- uncovered treated water tank
Plant 3	Kanchanaburi	surface water	Chlorination → Sedimentation by alum → Filtration (Anthracite → Activated carbon → Cation Resin) → Filtration (Activated carbon → Cationic exchange resin)	- uncovered raw water tank
Plant 4	Khonkaen	municipal tap water	Chlorination → Filtration (Manganese sand → activated carbon → Cationic exchange Resin)	- uncertain concentration of chlorine added - improper use of chlorine - not functioning resin

Table 2 (cont') Water source and water treatment and its improper practices of surveyed block ice plants

Plants	Location	Water source	Water treatment	Improper handling
Plant 5	Phuket	surface water	Filtration (Sand → Anthracite → Activated carbon) → Chlorination	- raw water was stored in an open tank. - uncovered treated water tank.
Plant 6	Phuket	municipal tap water	-	- no water treatment was applied.
Plant 7	Phuket	groundwater	Chlorination → Filtration (Anthracite → Activated carbon → Cation resin) → Filtration (Activated carbon → Cation resin)	- uncertain concentration of chlorine added - improper preparation of chlorine - inefficient resin
Plant 8	Trang	surface water	Filtration (Sand → Anthracite → Activated carbon) → Chlorination → Sedimentation → Filtration (Sand → Anthracite → Activated carbon)	- uncertain concentration of chlorine added - improper preparation of chlorine - inefficient resin

5.1.2 MODULE 2: Block ice making

The processes for making block ice were found to be similar in all factories that had been surveyed (as shown in Figure 2). After water treatment process, treated water was automatically pumped into ice can, and then the can was moved on lifting crane and submerged into cold brine pond. Ice can was made from zinc galvanized iron, which was found to be corrosive in some plants. The brine pond

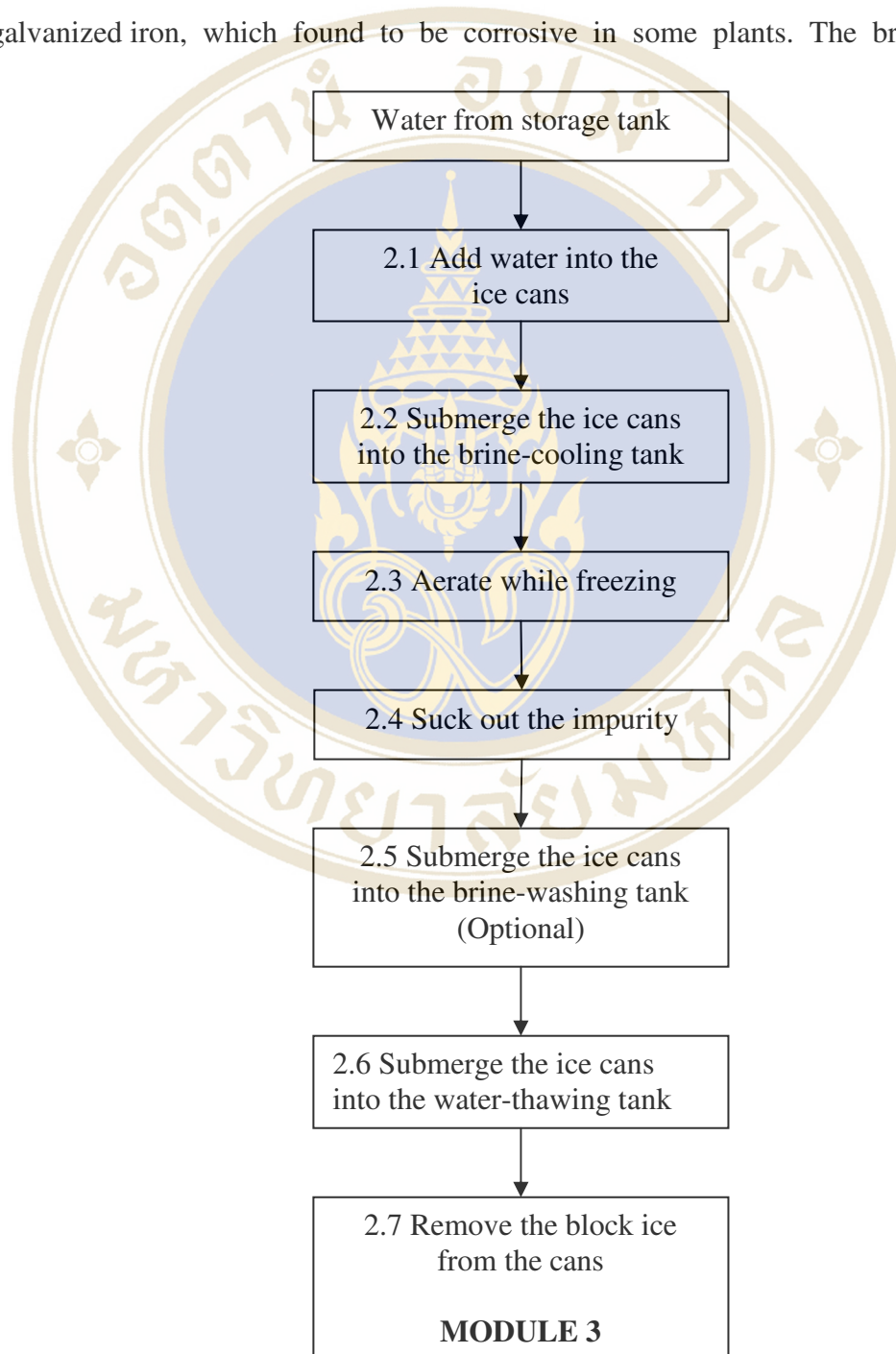


Figure 2 MODULE 2: Block ice making

was filled with 18-22 degree Baume brine of -12°C and anti-rusting agent, sodium dichromate dihydrate. Brine pond was made from cement and the area around was laid with wood. As cold brine was circulated in the tank by the central agitator, ice was gradually formed in the ice can. During ice formation, filtered air was blown into unformed ice (ice center) via stainless steel tube in order to make the ice clear. Meanwhile, impurity was also sucked out from the ice center, as well. Freezing process normally took about 24-28 h. The formed ice was removed from can after the can was lifted up from the pond and submerged in thawing pond that filled with water. Then, the block ice was then slid on floor to platform.

5.1.3 MODULE 3: Ice crushing and distribution

As shown in Figure 3, before crushing, block ice needed to be cut into smaller chunk, Ice crushing machine was made either from iron or stainless steel. Most of ice crushing machine were found to be rusty. Crushed ice was normally packed by hand in woven polypropylene sack for distribution. In some plants where there was excessive production, the block ice was stored at -3 to -5°C in a cool room before being crushed or distributed. Sack size was 19-inch wide and 32-inch long and used for packing 20 kg of crushed ice. Sack used for packing that belonged to either factory or customer was reusable, which mostly cleaned with water before using. The ice-filled sack was loaded on either open or close insulated truck for distribution.

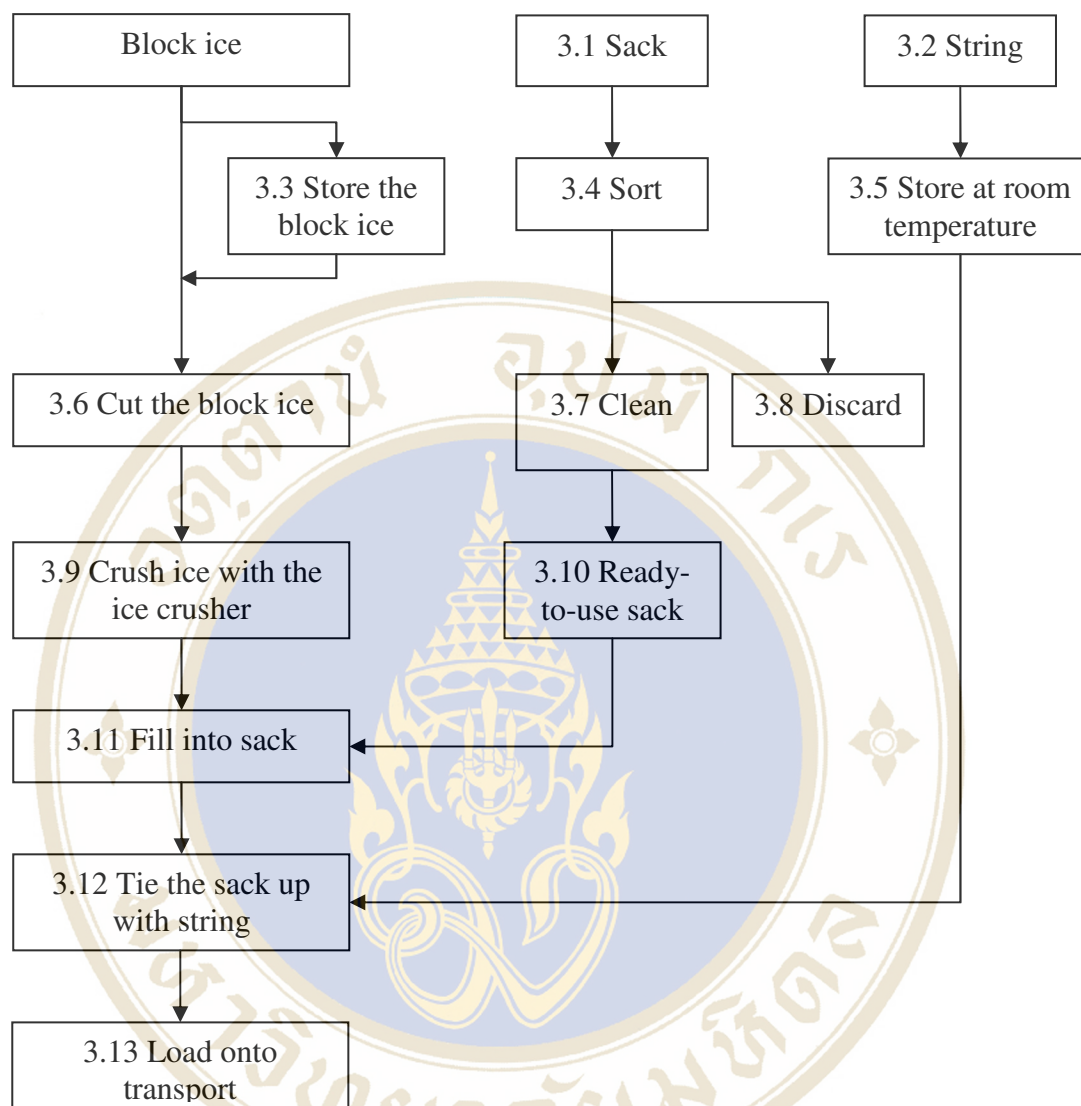


Figure 3 MODULE 3: Ice crushing and its packaging

5.2 Microbial assessment: case study at Paitoon Ice-Factory Co., Ltd.

5.2.1 Water, ice and packaging

Table 3 indicates microbial quality of waters, ices and sacks collected from the studied plant. High contaminations of aerobic bacteria and coliform were found in both raw and treated waters. Contamination was also found in ice which the more processes it passed, the higher microbial contamination it was.

Table 3 Microbial qualities of water, ice, and sack samples collected at the study site

Samples	Aerobic Plate Count ¹	Total Coliforms ²
Groundwater	1.0×10^4	350
Groundwater (soft)	3.6×10^2	23
Groundwater (RO)	<25	2
Treated water	1.2×10^3	130
Block ice	1.6×10^2	13
Crushed ice	7.1×10^3	240
Sack	1.6×10^4	>1600

¹ APC in water and ice samples reported as cfu/ml and APC in sack sample reported as cfu/sack.

² Total coliforms in water and ice samples reported as MPN/100ml and Total coliforms in sack sample reported as MPN/sack.

5.2.2 Equipment surface and worker's hand

Coliforms found on food-contacting surfaces during processing and handling including platforms that were lowly and highly used during block ice removal, ice crushing machine and worker's hands were shown in Table 4. The highly used area had higher number of coliforms than the low used area. Ice crushing machine was not the cause for coliform contamination. While, small number of coliforms was found in the gloved hand of worker.

Table 4 Total coliforms of equipment surface and worker's hand by swab test

Sample	Total Coliforms (MPN/10.16 cm) ^{1,2}
Platform (low usage)	15.0
Platform (high usage)	188.9
Ice crusher (inlet)	<6.1
Ice crusher (outlet)	<6.1
Hand of worker (gloved)	6.1

¹ Transformed from per 50 cm² into 10.16 cm²

² Standard of Department of Medical Science = 500 MPN/10.16 cm²

5.3 Analysis of hazards during production and distribution processes

5.3.1 Water treatment

Table 5 indicates that both microbial and chemical contamination could potentially be hazards during water treatment process. Most factories did not have the raw water analyzed before setting up the water treatment system. Unprotected storages of raw and treated water as well as inappropriate water treatment system could primarily cause chemical and microbial hazards. Lacking of knowledge in water disinfection, necessary equipments in the right sequence of installation and storages of raw and treated waters were critical factors for block ice quality.

Table 5 Problems found during water treatment process

Material/ Process steps	Problems
Raw water	<ol style="list-style-type: none"> 1. No data on raw water's qualities 2. Improper storage condition
Water treatment system	<ol style="list-style-type: none"> 1. No disinfection 2. Improper sequence of water treatment equipments 3. Non-functioned water treatment units 4. No quality assurance plan
Storage	<ol style="list-style-type: none"> 1. Unprotected and dirty conditions

5.3.2 Block ice making

During block ice making, several equipments which normally need regular maintenance were involved. Contamination of non-food grade lubricant could occur during operation as presented in Table 6. While, contamination from anti-rusting agent due to leaked can could be a chemical hazard since ice was used as solid, therefore small contamination could be at high dosage as it was served in small serving size. Water used for thawing and removing ice from the can normally was re-used, which could cause post-process contamination.

5.3.3 Sack used for distribution

Table 7 shows problems found during ice distribution. Dirty sack could be cause of contamination in the crushed ice. Sack-contacting ice could be heavy contaminated with microorganism since crushed ice was served as solid. Even, small amount of ice in small serving size could be microbial hazard.

Table 6 Problems found during block ice production

Material/ Process steps	Problems
Ice forming	Use of leaked ice can caused contamination of anti-rusting agent into block ice
Thawing	Dirty water used for thawing ice caused microbial contamination onto the block ice

Table 7 Problems found during ice distribution

Material/ Process steps	Problems
Sack	Accumulation and contamination

5.4 Evaluation of potential hazards

5.4.1 Effect of freezing temperature on reducing microbial risk

Table 8 shows that freezing temperature could very much affect microbial quality of water in terms of APC and total coliforms, especially at high initial loads of the microorganisms. At the lower initial load of coliforms, the reduction rate became lower. However, the reduction rates were not so consistent and mostly were less than 1 log cycle. And none of the case could totally reduce coliforms. During 2 d storage, APC and total coliforms tended to be lower but not much at the lower initial load of the microorganisms. After storage, it was not possible to totally reduce coliforms, as well (Table 9).

Table 8 Microbial quality of samples before and after freezing at -15°C for 2 d

Test	APC (cfu/ml)			Total coliforms (MPN/100ml)		
	Water	Block ice	% Reduction	Water	Block ice	% Reduction
1	2.0×10^4	2.3×10^3	88.4	>1600	430	>73.1
2	1.1×10^4	1.6×10^3	85.9	>1600	49	>96.9
3	1.4×10^4	5.4×10^2	61.4	1600	350	78.1
4	<25	<25	*	4.5	4	11.1
5	<25	<25	*	4.5	2	55.6
6	3.3×10^1	<25	>24.2	4	2	50.0

Table 9 Microbial quality of simulated ice sample during storage at -5°C

Test	APC (cfu/ml)			Total coliforms (MPN/100ml)		
	Day 0	Day 1	Day 2	Day 0	Day 1	Day 2
1	2.3×10^3	1.3×10^3	9.7×10^2	430	79	120
2	1.6×10^3	1.3×10^3	4.3×10^2	49	23	31
3	5.4×10^2	2.5×10^2	2.8×10^2	350	23	130
4	<25	<25	<25	3.7	2	3.7
5	<25	<25	<25	2	1.8	2
6	<25	<25	<25	1.8	<1.8	<1.8

5.4.2 Chromium contamination in block ice

A sample from the survey that obtained from a leaked ice can appeared yellow color inside the block ice. It was suspected that the yellow color was due to contamination of the anti-rusting agent, sodium dichromate dihydrate, in salt brine. The yellow part inside the block ice contained certain amount of chromium, which was not found in normal block ice (Table 10).

Table 10 Chromium content in yellow stained block ice as compared to the normal block ice.

Sample	Characteristic of melted ice	Total Chromium content (mg/l)
Block ice 1	Colorless clear liquid	Not detected
Block ice 2	Yellow clear liquid with brown precipitate	0.237

5.4.3 Sack cleanliness

From the calculation of microbial counts in 1 sack of 20 kg capacity, it resulted in a high contamination of both aerobic plate count and total coliforms as shown in Table 11. However, they became higher as the contamination of ice that contacted with sack was considered.

Table 11 Evaluation of microbial risk in ice contaminated from sack

Parameter	Content in packed ice ¹	Content in sack-contacted ice ²
Aerobic plate count (cfu/ml)	4.4×10^4	1.9×10^5
Total coliforms (MPN/100ml)	>4378	>19780

¹ Aerobic plate count and total coliforms in 1 sack sized 19x32 in were 8.8×10^8 cfu and 875520 MPN, respectively.

² One sack contained of 20 kg crushed ice.

³ There were 4.2 kg of crushed ice contacted on surfaces of sack.

5.3.4 Microbial contamination in water of thawing tank of the block ice factory.

From the survey, it was found that water used for thawing block ice was from natural sources without proper treatment such as from ditch, mining canal. Certain number of total coliforms was found in the water samples (110 cfu/100ml) (48).

5.5 Development of preventive measures

5.5.1 Water chlorination on microbial quality of ice

After the studied factory had been advised on the correct way of water chlorination, the microbial quality of the water became better. Total coliforms could be totally eliminated (Table 12).

Table 12 Microbial qualities of water at the factory before and after implementing chlorination

Parameter	Before chlorination	After chlorination implementation		
	1 st survey	2 nd survey	3 rd survey	4 th survey
APC (cfu/ml)	1.2×10^3	<25	5.2×10^1	3.0×10^1
Total coliforms (MPN/100ml)	130	<1.8	<1.8	1.8

5.5.2 Sack cleaning

a. Effect of pre-washing sack with water before soaking in chlorinated water on microbial quality

Table 13 indicates that washing sacks with water before soaking in chlorinated water could improve the microbial quality. The numbers of both APC and coliform bacteria considerably decreased after the sack was washed with water before soaking in the chlorinated water. Therefore, it was recommended to wash the sacks with clean water before disinfecting in chlorinated water.

Table 13 Microbial qualities of sacks soaked in chlorinated water with and without pre-washing with water

Test	Parameter	Dirty sack	No pre-washing	Pre-washing with water	
			Cl-cleaned sack	Washed sack	Cl-cleaned sack
1.	APC ¹	1.7×10 ⁴	6.6×10 ³	1.1×10 ⁴	3.4×10 ¹
	TC ²	920	17	49	2
2.	APC ¹	1.8×10 ⁴	4.6×10 ³	2.2×10 ⁴	<25
	TC ²	>1600	1600	>1600	<1.8
3.	APC ¹	1.8×10 ⁴	2.3×10 ³	1.4×10 ⁴	3.6×10 ¹
	TC ²	>1600	920	1600	<1.8
4.	APC ¹	3.8×10 ⁴	3.4×10 ⁴	1.5×10 ⁴	<25
	TC ²	>1600	69	1600	1.8

¹ Aerobic plate count reported as cfu/ml

² Total coliforms reported as MPN/100ml

b. Appropriate chlorine concentration and soaking period for reducing microbial risk in sack

b.1 Appropriate chlorine concentration

At lower chlorine concentrations i.e. 1-4 ppm (chlorine concentration in municipal tap water), it was not high enough to destroy coliforms on the sack. Minimum chlorine concentration that could effectively reduce total coliforms was at 7 ppm (Table 14). The chlorine concentration needed to be up to 10 ppm in order to totally destroy both APC and total coliforms.

Table 14 Microbial qualities of sacks soaked in chlorinated water at various concentrations

Test	Parameter	Dirty sack	Residual chlorine concentration (ppm)				
			0.25	1	4	7	10
1	APC ¹	2.1×10 ⁴	3.8×10 ³	6.4×10 ³	3.4×10 ¹	5.2×10 ¹	<25
	TC ²	>1600	920	350	23	<1.8	<1.8
2	APC ¹	1.4×10 ⁴	2.0×10 ³	5.8×10 ³	7.9×10 ¹	<25	3.6×10 ¹
	TC ²	>1600	920	350	4.5	<1.8	<1.8
3	APC ¹	3.8×10 ⁴	2.4×10 ⁴	1.2×10 ³	8.5×10 ¹	<25	7.5×10 ¹
	TC ²	>1600	1600	350	23	<1.8	<1.8
4	APC ¹	2.4×10 ⁴	2.4×10 ³	5.6×10 ³	3.2×10 ²	<25	<25
	TC ²	>1600	920	540	23	<1.8	<1.8

¹ Aerobic plate count reported as cfu/ml

² Total coliforms reported as MPN/100ml

b.2 Appropriate soaking period

Table 15 shows the effect of soaking period on microbial quality of sacks. Sack samples collected after being soaked for 5 min or longer in 10 ppm chlorinated water found no aerobic and coliform bacteria.

b.3 Estimation of number of time that chlorinated water could be used for disinfecting sack

The experiment began with approx. 100 ppm Cl., which was the Cl concentration normally used for cleaning and disinfecting raw materials in food industry. It was found that each soaking batch reduced approx. 10 ppm residual Cl. To be able to maintain minimum effective Cl concentration of 9-10 ppm, 9 soaking batches could be used (Table16).

Table 15 Microbial qualities of sacks soaked in 10 ppm of chlorinated water at different soaking periods

Test	Parameters	Soaking time (min)			
		0	5	10	15
1.	APC ¹	2.6×10^3	<25	<25	<25
	TC ²	>1600	<1.8	<1.8	<1.8
2.	APC ¹	3.6×10^3	<25	<25	<25
	TC ²	1600	2	<1.8	<1.8
3.	APC ¹	5.4×10^3	<25	<25	<25
	TC ²	>1600	<1.8	<1.8	1.8
4.	APC ¹	1.2×10^4	<25	<25	<25
	TC ²	>1600	<1.8	<1.8	<1.8

¹ Aerobic plate count reported as cfu/ml² Total coliforms reported as MPN/100ml**Table 16** Residual chlorine concentration of chlorinated water after each use for sack soaking

Number of time	Chlorine concentration (ppm)		
	Test 1	Test 2	Test 3
0	104.5	100.5	110.0
1	86.5	86.5	94.5
2	78.0	82.5	85.0
3	63.0	69.0	72.5
4	61.0	57.5	64.8
5	59.2	42.5	50.2
6	32.0	31.6	35.1
7	22.3	25.8	27.5
8	14.0	16.1	18.0
9	10.3	9.2	10.4
10	4.2	4.9	4.5

c. Appropriate drying and storage condition of washed sacks

Methods for drying and storage of the washed sacks were performed differently even in the same factory. Table 17 indicates the difference in microbial qualities of the washed sacks that had been dried and stored under different conditions. Without or complete drying resulted in the sacks of better microbial quality than the ones that were partially dried especially as the washed sacks were stored for 24 h..

5.6 Test for the practicality of the developed measures

5.6.1 Sack cleaning

The developed measure for sack cleaning was tested for its practicality at a factory. Two hundred liters of 100 ppm chlorinated water was prepared each day for disinfecting sacks based on the normal incoming used sacks from the customers. However, each soaking batch of 5 min consisted of approx. 200 sacks. At the last soaking batch, final concentrations of residual chlorine were 61.0 and 16.7 ppm which were still higher than the minimum effective concentration of residual chlorine at 10 ppm as presented in Table 18.

Table 18 Residual chlorine concentration in chlorinated water before and after soaking last batch of dirty sack at the study site

Pail no.	Free chlorine concentration (ppm)	
	Before soaking	After soaking
1	68.4	61.0
2	21.0	16.7

During the test for practicality, it was found that not all sacks were totally soaked into the chlorinated water. As the sacks were completely submerged in the chlorinated water, coliforms bacteria decreased largely (Pail 2), but decreased slightly for the sacks that were not completely submerged (Pail 1). Table 19 indicates that the sacks on the top position were not efficiently disinfected which were different from the ones in the bottom position.

Table 17 Microbial quality of sacks after being dried and stored at different periods

Test	Dirty sack	Dry 0 h (no dry)			Dry 1 h (Partially dried)			Dry 4 h (complete dried)		
		Store 0 h	Store 12 h	Store 24 h	Store 0 h	Store 12 h	Store 24 h	Store 0 h	Store 12 h	Store 24 h
1.	APC ¹	4.6x10 ¹	1.5x10 ²	4.5x10 ²	<25	5.1x10 ²	1.3x10 ⁴	4.6x10 ¹	9.8x10 ¹	<25
	TC ²	<1.8	<1.8	<1.8	<1.8	<1.8	13	<1.8	<1.8	<1.8
2.	APC ¹	<25	7.5x10 ¹	1.6x10 ²	<25	3.8x10 ²	2.6x10 ⁴	<25	3.2x10 ¹	5.2x10 ¹
	TC ²	<1.8	<1.8	<1.8	<1.8	2	43	<1.8	<1.8	<1.8
3.	APC ¹	<25	2.8x10 ²	4.9x10 ³	2.7x10 ¹	4.3x10 ³	1.4x10 ⁴	3.9x10 ¹	6.4x10 ¹	<25
	TC ²	<1.8	1.8	<1.8	1.8	2	7.8	<1.8	<1.8	<1.8
4.	APC ¹	<25	3.1x10 ¹	2.3x10 ²	9.6x10 ¹	5.7x10 ¹	2.5x10 ³	3.3x10 ¹	8.5x10 ¹	<25
	TC ²	<1.8	<1.8	<1.8	1.8	<1.8	23	<1.8	2	<1.8

¹ Aerobic plate count reported as cfu/ml

² Total coliforms reported as MPN/100ml

Table 19 Microbial quality of sacks at different soaking positions after having been soaked in chlorinated water at the study site

Sample	Aerobic Plate Count (cfu/ml)		Total Coliforms (MPN/100ml)	
	Pail 1	Pail 2	Pail 1	Pail 2
Dirty sack	1.4×10^4	3.4×10^3	>1600	1600
Washed sack	8.7×10^3	1.6×10^3	1600	920
Cl-cleaned sack (Top)	7.2×10^3	2.5×10^3	240	170
Cl-cleaned sack (Bottom)	<25	<25	<1.8	<1.8

5.6.2 Verification of developed measures

After the developed technology had been transferred and applied in the processing, the changes of microbial quality as APC and total coliforms of samples collected were presented in Table 20 and 21, respectively. APC of all samples decreased at the % reduction ranged from 83.3 to 99.8%. While, total coliforms also decreased at % reductions ranged from 89.6 to 99.8%.

Table 20 Aerobic plate counts in water, ice, and sack samples collected at the study site before and after implementation of the developed measures

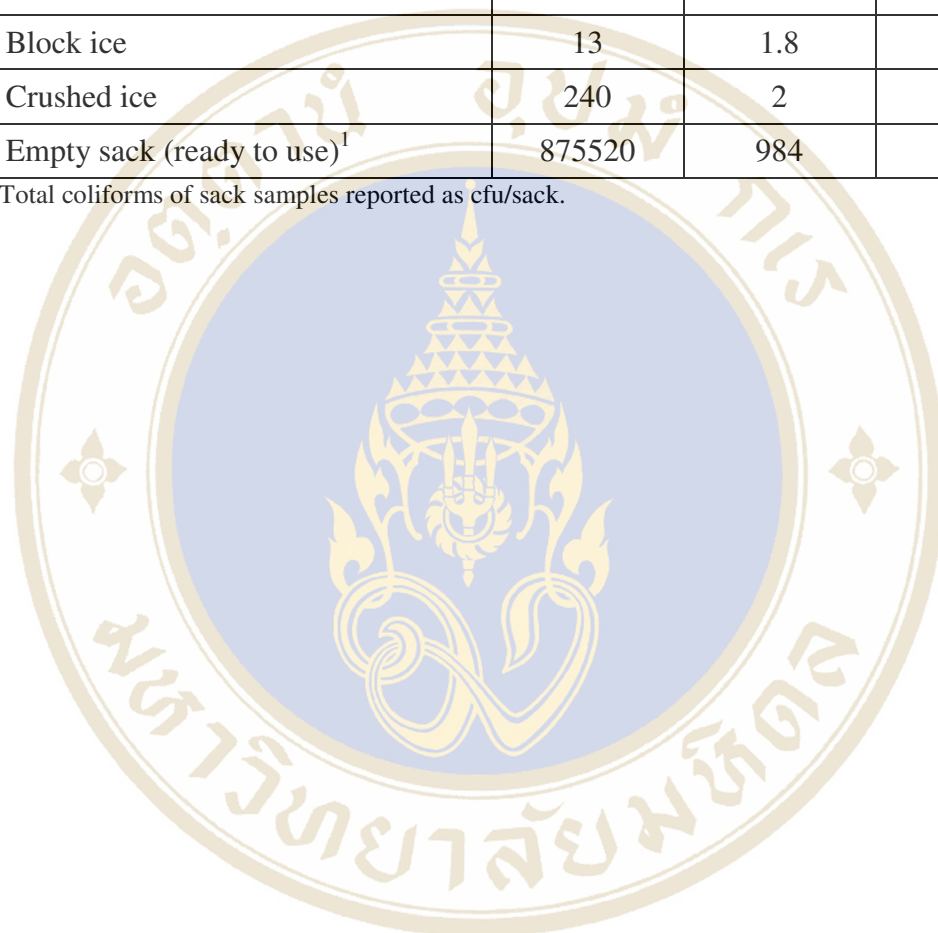
Sample	APC (cfu/ml)		
	Before	After	% Reduction
Treated water	1.2×10^3	<25	>97.9
Block ice	1.5×10^2	<25	83.3
Crushed ice	7.1×10^3	5.0×10^2	92.5
Empty sack (ready to use) ¹	8.8×10^8	1.6×10^5	99.8

¹ APC of sack samples reported as cfu/sack.

Table 21 Total coliforms in water, ice, and sack samples collected at the study site before and after implementation of the developed measures

Sample	Total Coliforms (MPN/100ml)		
	Before	After	% Reduction
Treated water	130	<1.8	>98.6
Block ice	13	1.8	86.1
Crushed ice	240	2	99.2
Empty sack (ready to use) ¹	875520	984	>99.9

¹Total coliforms of sack samples reported as cfu/sack.



CHAPTER VI

DISCUSSION

6.1 Water treatment process

According to the survey, most of the block ice producers had problems with their water treatment processes. This problem in fact could directly affect qualities of the ice even microbial quality which was found that freezing could not reduce number of microorganisms down to meet the Thai FDA standard (APPENDIX A). Due to lacking of knowledge on water treatment, producers did not pay enough attention on certain critical points i.e. quality of raw water, disinfection, appropriate treatment system, and water storage. Based on the Thai FDA guideline for bottled water production, source and quality of raw water were the primary important factors since they could affect costs of water treatment and storage. Use of chlorine for disinfection was the most economical, however most producers did not know the minimum effective dose of residual chlorine (0.2-0.5 ppm). In many factories, there were no controls on the use and storage of chlorine at the study sites; even it is only one step in the whole process that could adjust microbial quality to meet the standard for potable water (49). In addition, storage tank especially for the treated water must be well-protected and cleaned regularly. Similar to bottled water producer, block ice producer should be trained on specific GMP for bottled water production, as well.

6.2 Block ice making

Production process of block ice was involved mainly on specificity of structure of the premise and equipments which in fact were not so modern. Therefore, efficient maintenance program was required. Lubricants used in ice/water contacting equipments should be food-grade. Certain high risk areas which directly contacted to ice should be modified based on GMP requirement and classified as restricted areas. Highly used areas were found to be higher contaminated since the areas were more

frequently used by workers; however, the areas were not treated as restricted area. They were, therefore, contaminated from dirty boots of workers, abundant water from melted ice, accumulated dirt from wooden floor and so on. In addition, physical hazards such as pieces of wood, stone could be contaminated on the block ice. The area should be classified as restricted area where the floor surface should be made of a durable, cleanable and disinfect-able material such as stainless steel. The area should be limited to only authorized personnel, who had knowledge on basic GMP especially personal hygiene. Before entering the area, one should wear provided clean shoes and shoe floors must be cleaned and disinfected in chlorinated water. To avoid accumulated water and dirt, floor should be built with appropriate slope and drainage. Wearing cleaned gloves was the best practice for workers who needed to contact with ice.

Special maintenance should be on ice can, which if leakage could cause chemical hazard from chromium in anti-rusting agent. Table 10 indicates that the ice that contaminated with anti-rusting agent could provide chromium up to 4 times (0.24 mg/l vs. 0.05 mg/l) higher than the maximum allowance in the Thai FDA standard (APPENDIX A).

Water quality must be the concern during block ice production, as well. Certain amounts of water that were re-used for thawing and removing block ice should be treated as cooling water in canning line which must be changed regularly and maintained level of residual chlorine at 2.0 ppm (50).

6.3 Ice crushing and distribution

From this study, ice crushing machine might not be the main cause for biological hazard as long as no water accumulated in the machine too long. Residual ice in the machine melted and drained out without accumulation. Such finding agreed with the Thai FDA reports in 2007 (51). To avoid other hazards, the ice crushing machine, however, still needed an effective and appropriate cleaning and maintenance programs. In the distribution process, crushed ice was normally removed from the machine by hand. From our study, some coliforms were found on gloved hands of workers; however the number was still much lower than the standard of Department

of Medical Science. By wearing gloves that were regularly cleaned during crushed ice distribution, biological hazard could be minimized.

6.4 Sack cleanliness

Crushed ice was normally transferred into sack before distributing to various groups of customers for various uses at different locations, which could affect in contamination with different kinds of hazard. Ideally, these re-used sacks should be treated the same way as re-used plastic water pail. The developed cleaning method was proven to be practical for the factory. Additional facility that required was only 200-liter pail with 100 ppm chlorinated water. However, the efficiency of this cleaning method was based on the worker's behavior, which supposed to completely submerge the sacks and allow soaking period for at least 5 min. After cleaning, sack should be used at once or dried properly. Partially dried sack (1 h) that stored for 24 h was not recommended since loss of Cl and residual water allowed more growth of microorganism.

6.5 Additional requirement

Overall, qualities of blocked and crushed ice could not be improved if employer was not interested in or employees did not understand the principles of Good Manufacturing Practices. Training programs should be provided to every new worker and regularly to both full-time and part-time workers. Specific control points that had been emphasized in this study must be informed to the responsible workers and strictly controlled.

CHAPTER VII

CONCLUSION

Potential hazards being found in the production and distribution processes of block and crushed ice manufacturing were mostly preventable by good manufacturing practices (GMP). However, preventive measures of certain steps must be emphasized including raw water treatment and disinfection, prevention of chemical hazard during block ice making, microbial quality of water in thawing tank, cleanliness of ice-contacting areas, sack cleanliness and personal hygiene of workers.

7.1 Raw water treatment and disinfection processes

Since freezing and storage of block and crushed ice conditions could not reduce microbial risk, raw water must be properly treated and disinfected before being used for block ice production. Quality of water used for block ice production should at least pass standard for potable water. In addition, the treated water should be properly stored to prevent recontamination.

7.2 Chemical contamination during block ice making

Contamination of anti-rusting agent into block ice caused chemical hazard due to chromium contamination. To prevent such hazard, leaked ice can should be eliminated from the production line and proper handling during dropping can into brine tank should be emphasized. Maintenance of ice can need to be performed on regular basis.

7.3 Microbial quality of water used for ice-thawing

Water used for removing block ice from can is classified as water contacting to food, which must be potable water based on GMP. New potable water should be used. Otherwise, reused thawing water should be treated the same as cooling water for canning line by maintaining residual chlorine of higher than 2 ppm.

7.4 Contamination during block ice transportation

Due to its weight and slippery characteristic, it is unavoidable to transport block ice on a floor. Ice-contacting floors should be treated as restricted areas, where unauthorized personnel were not allowed. Authorized personnel must be strictly controlled for their personal hygiene.

7.5 Cleanliness of re-used sacks for packing

Re-used sacks for packing of tube ice could be cause of tube ice recontamination therefore they needed to be cleaned and sanitized properly. Method used for sack cleaning included washing with water and disinfecting in ≥ 7 ppm Cl for ≥ 5 min. The cleaned sacks could be stored for 24 h either dried or without drying. It was not recommended to store partially dried sacks due to increase microbial growth. In practice, initial chlorine concentration could begin at 100 ppm of 350 l chlorinated water, which could be efficiently used for disinfection of at least 2000 sacks.

7.6 Good Manufacturing Practices

GMP principles must be strictly followed especially on personal hygiene and machine maintenance program.

REFERENCES

1. อรุณ บำงตระกูลนนท์, อังคารศิริ ดีอ่วม, รัตนา คำแก้ว. ผลการศึกษาคุณภาพทางจุลชีววิทยาของน้ำแข็งสำหรับแช่อาหารในเขตคูสิตและพระนคร[online]. สารสังเขปจาก http://webdb.dmhc.moph.go.th/ifc_nih/a_nihR_search.asp?info_id=358 [เข้าถึงเมื่อ 10 กุมภาพันธ์ 2551]
2. กองควบคุมอาหาร สำนักงานคณะกรรมการอาหารและยา กระทรวงสาธารณสุข. เกณฑ์การขึ้นทะเบียนตำรับอาหารและการอนุญาตใช้ฉลากอาหาร น้ำแข็ง. นนทบุรี: ชุมนุมสหกรณ์การเกษตรแห่งประเทศไทย; 2545.
3. Codex Alimentarius Commission. Draft international code of hygienic practice for bottled (packaged) drinking waters (other than natural mineral water). N.p., Jul 1998.
4. Cheremisinof PN. Water management and supply. New Jersey: PTR Prentice-Hall, 1993.
5. Reid GW. Appropriate methods of treating water and wastewater in developing countries. Michigan: Ann Arbor Science, 1982.
6. World Health Organization. Guidelines for drinking-water quality volume 2: Health criteria and other supporting information. 2nd ed. Geneva: WHO, 1996.
7. Gupta AD. Study on ground water quality and monitoring in Asia and the Pacific: results of the regional survey. In: Economic and Social Commission for Asia and the Pacific. Water resources series no. 70. Bangkok (Thailand): United Nations, 1991: p.13-99

8. Attawit Wipatanawin. Study on post-treatment microbial contamination and bottled drinking water produced at pilot plant. [M.S. Thesis in Food and Nutrition]. Bangkok: Faculty of Graduate Studies, Mahidol University; 2003.
9. Gray NF. Water technology: an introduction for environmental scientist and engineers. London: Arnold; 1999.
10. Gray NF. Drinking water quality Problems and solutions. Chichester (England): John Wiley & Sons, 1996.
11. World Health Organization. Guidelines for drinking-water quality volume 3: Surveillance and control of community supplies. 2nd ed. Malta: WHO, 1997.
12. American Water Works Association. Water quality and treatment. A handbook of public water supplies. 3rd ed. New York: McGraw-Hill, 1971.
13. Cox CR. Operation and control of water treatment processes. Geneva: World Health Organization, 1969.
14. World Health Organization. Guidelines for drinking-water quality volume 1: Recommendations. 2nd ed. France: WHO, 1993.
15. American Water Works Association. Water quality and treatment. A handbook of community water supplies. 4th ed. New York: McGraw-Hill, 1990.
16. Anynomous. Inspector's technical guide: Reverse osmosis. [Online] Available from http://www.fda.gov/ora/inspect_ref/itg/itg36.html [Accessed date: 11 February 2008]
17. Environmental Protection Agency. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. 1999. [Online] Available from <http://www.epa.gov/owm/mtb/uv.pdf> [Accessed date: 11 February 2008]
18. White GC. Handbook of chlorination and alternative disinfectants. 3rd ed. New York: Van Nostrand Reinhold, 1992.
19. Faust SD, Aly OM. Chemistry of water treatment. Massachusetts: Butterwork, 1983.
20. Gupta AD. Study on ground water quality and monitoring in Asia and the Pacific: results of the regional survey. In: Economic and Social Commission for Asia and the Pacific. Water resources series no. 70. Bangkok (Thailand): United Nations, 1991: p.13-99

21. กองควบคุมอาหาร สำนักงานคณะกรรมการอาหารและยา กระทรวงสาธารณสุข. สื่อการเรียนรู้สำหรับการผลิตน้ำแข็งของประมงตาม หลักเกณฑ์ GMP สุขลักษณะทั่วไป. 2550.
22. Hayes PR. Food microbiology and hygiene. 2 nd ed. Essex (England): Elsevier Science, 1992.
23. Institute of Food Science and Technology (UK). Food and drink-good manufacturing practice: A guide to its responsible management. 3 rd ed. London: Institute of Food Science and Technology, 1991.
24. HACCP in the retail food industry, diary, food and environmental sanitation, 1998; 11:73-81.
25. กองควบคุมอาหาร สำนักงานคณะกรรมการอาหารและยา กระทรวงสาธารณสุข. คู่มือการประเมินสถานที่ผลิตน้ำแข็งด้วยตนเองตามหลักเกณฑ์ GMP สุขลักษณะทั่วไป. 2547.
26. Sara Mortimore and Carol Wallace. Food industry briefing series: HACCP. India: Blackwell publishing, 2001.
27. Inteaz Alli. Food quality and assurance: Principles and Practices. Florida: CRC Press LLC, 2004.
28. สุรัชช ศิลาวรรณ และคณะ. การปนเปื้อนเชื้อ Coliform bacteria ในแต่ละขั้นตอนการผลิตของโรงงานผลิตน้ำดื่มและน้ำแข็งใน เขตตรวจราชการที่ 13 ปี 2549. [online]. สาระสังเขปจาก <http://www.dpck5.com/SRRTcenter/coliform.pdf> [เข้าถึงเมื่อ 10 กุมภาพันธ์ 2551]
29. World Health Organization. Guidelines for drinking-water quality vol 2: Health criteria and other supporting information. Belgium: WHO, 1984.
30. Standard Methods for the examination of water and wastewater. 19th ed. Washington: American Public Health Association, 1995.
31. Zuane JD. Drinking water quality: Standards and control. New York: Van Nostrand Reinhold, 1990.
32. Mallinckrodt Baker Inc.'s Material Safety Data Sheet: Sodium Dichromate. [Online] Available from <http://www.jtbaker.com/msds/englishhtml/s3506.htm> [Accessed date: 11 February 2008]
33. Conor Reilly. Metal contamination of food: its significance for food quality and human health. 3rd ed. Cornwall: Blackwell Publishing, 2002.

34. Wanpimol, A. Microbiological quality of ice at factory, distributing agent and retail shop. [M.S. Thesis in Nutrition]. Bangkok: Faculty of Graduate Studies, Mahidol University; 1996.
35. Malasao, S. Microbiological quality of bottled water and ice. [B.Sc. in Medical Technology] Bangkok: Faculty of Medical Technology, Mahidol University; 1995.
36. Nongharnpitak, P. The quality of cube ice in plastic buggage at Khon Kaen municipality. [B.Sc. in Environmental Science]. Khon Kaen: Faculty of Science, Khonkaen University; 2000.
37. หนังสือพิมพ์คมชัดลึก. ฉบับวันที่ 11 มีนาคม 2547. สธ.หนักใจรถเร่ขายอาหารเชื้อแบคทีเรียปนเปื้อนสูง [online]. สาระสังเขปจาก <http://www.sasook.com/modules.php?name=News&file=article&sid=17> [เข้าถึงเมื่อ 10 กุมภาพันธ์ 2551]
36. หนังสือพิมพ์ไทยรัฐ. ฉบับวันที่ 25 สิงหาคม 2549. มันมากับอาหาร: จุลินทรีย์! ใน...น้ำแข็งบด [online]. สาระสังเขปจาก <http://www.thairath.co.th/news.php?section=agriculture06&content=17283> [เข้าถึงเมื่อวันที่ 11 กุมภาพันธ์ 2551]
37. Wilson, I.G., Hogg, G.M. and Barr, J.G. Microbiological Quality of Ice in Hospital and Community. *J. Hospital Infect.* 1997; 36:171-180.
38. Anonymous. 2002. Microbiological Quality of Ice for Cooling Drinks. Food Safety Authority of Ireland. [Online] Available from: http://www.fsai.ie/surveillance/food/ice_cooling_drinks.pdf [Accessed date: 11 February 2008]
39. Nichols, G., Gillespie, I, de Louvois, J. The Microbiological Quality of Ice Used to Cool Drinks and Ready-to-Eat from Retail and Catering Premises in the United Kingdom. *J Food Prot.* 2000; 63: 78-82.
40. Pawsey, R.K., and P. Howard. 2001. Drinking ice as a vector for gastrointestinal disease. *Brit Food J* 103:253-263.

41. Falcão, J.P., Dias, A.M.G., Correa, E.F. and Falcão, D.P. 2002. Microbiological quality of ice used to refrigerate foods. *Food Microbiol* 19:269-276
42. Environmental Health Services Brisbane Northside Public Health Unit. 2002. ANZ Food Surveillance Newsletter: Survey on the Microbiological Quality of Unpackaged Ice. [Online] Available from <http://www.foodstandards.gov.au/newsroom/foodsurveillancenewsletter/summeredition2002.cfm> [Accessed date: 11 February 2008]
43. Anonymous. 2005. The Microbiological quality of edible ice from ice manufacturing plants and retail businesses in Hong Kong. Risk Assessment Section. Food and Environmental Hygiene Department. [Online] Available from www.fedh.gov.hk/safefood/report/edible_ice/edible_ice_ra.html [Accessed date: 11 February 2008]
44. Lateef, A., Oloke, J.K., Gueguim Kana, E.B., and Pacheco, A.E. (2006). The microbiological quality of ice used to cool drinks and foods in Ogbomoso metropolis, Southwest, Nigeria. *Int J Food safety* 8: 39-43
45. Standard Methods for the examination of water and wastewater. 21th ed. Washington: American Public Health Association, 2005.
46. Maturin, L. and Peeler, J. T. Bacteriological Analytical Manual Online: Aerobic Plate Count. 2001. [Online] Available from <http://www.cfsan.fda.gov/~ebam/bam-3.html> [Accessed date: 14 May 2008]
47. Feng, P., Weagant, S. D., Grant, M. A. Bacteriological Analytical Manual Online: Enumeration of *Escherichia coli* and the Coliform Bacteria. 2002. [Online] Available from <http://www.cfsan.fda.gov/~ebam/bam-4.html> [Accessed date: 14 May 2008]
48. กลุ่มควบคุม สนับสนุน และพัฒนาสถานที่ผลิตอาหาร กองควบคุมอาหาร สำนักงานคณะกรรมการอาหารและยา. สรุปผลการดำเนินงาน โครงการสำรวจสถานการณืมาตรฐานการผลิตและคุณภาพความปลอดภัยของผลิตภัณฑ์น้ำแข็ง. 2549.

49. กองควบคุมอาหาร สำนักงานคณะกรรมการอาหารและยา. ปัญหาและแนวทางแก้ไขในการผลิตน้ำแข็ง.

2545.

50. คารณี หมู่จรพันธุ์. กองควบคุมอาหาร สำนักงานคณะกรรมการอาหารและยา. คู่มือการปฏิบัติตามหลัก

เกณฑ์และวิธีการที่ดีในการผลิตอาหารกระป๋อง. 2540.

51. อารยะ โรจนวณิชชากร, ฉัฐวดี ศรีทองเต็ม, พงษ์พันธ์ ชัญญเจริญ, วิรัตน์ดา ดวงใจ. สรุปผลการดำเนินงาน

โครงการพัฒนาความปลอดภัยเพื่อแก้ไขปัญหาการปนเปื้อนในโรงงานน้ำแข็งบริโศก กรณีศึกษา:

จังหวัดขอนแก่น 2550.





APPENDIX A
RELATED LAWS INVOLVED ICE

Notification of the Ministry of Public Health

No. 78 [B.E. 2527(1984)]

RE: Ice

By virtue of the provision of Section 5 and 6 (1), (2), (6), (7) and (10) of the Food Act 1979, the Minister of Public Health hereby issues a notification as follows:

Clause 1 The Notification of the Ministry of public health No. 19 (1979), Re: Prescribing Ice as Specially Controlled Food and Prescribing Quality or Standard, Principals, Conditions and Manufacturing Processes of Ice for Sales or Sold. Prescribing Quality or Standard of Containers, the Use of Containers, Storage and Label, dated 13th September, 1979 shall be revoked.

Clause 2 Ice shall be specially controlled food.

Clause 3 Ice manufactured for sales for consumption shall use clean water conforming to the following standards:

- (1) Physical properties.
 - (a) Colour, not exceeding to 20 Hazen Units.
 - (b) Odour, odourless except chlorine odour.
 - (c) Turbidity, not exceeding to 5.0 Silica Scale.
 - (d) pH value, ranged 6.5 – 8.5.
- (2) Chemical properties.
 - (a) Total solids, not exceeding to 500 mg. per 1 litre of clean water.

- (b) Total hardness, computed as Calcium Carbonate, not exceeding to 100.0 mg. per 1 litre of clean water.
 - (c) Arsenic, not exceeding to 0.05 p.p.m.
 - (d) Barium, not exceeding to 1.0 p.p.m.
 - (e) Cadmium, not exceeding to 0.01 p.p.m.
 - (f) Chloride, computed as Chlorine, not exceeding to 250.0 p.p.m.
 - (g) Chromium, not exceeding to 0.05 p.p.m.
 - (h) Copper, not exceeding to 1.0 p.p.m.
 - (i) Iron, not exceeding to 0.5 p.p.m.
 - (j) Lead, not exceeding to 0.1 p.p.m.
 - (k) Maganese, not exceeding to 0.05 p.p.m.
 - (l) Mercury, not exceeding to 0.002 p.p.m.
 - (m) Nitrate, computed as Nitrogen, not exceeding to 4.0 p.p.m.
 - (n) Phenol, not exceeding to 0.001 p.p.m.
 - (o) Silinium, not exceeding to 0.01 p.p.m.
 - (p) Silver, not exceeding to 0.05 p.p.m.
 - (q) Sulphate, not exceeding to 250.0 p.p.m.
 - (r) Zinc, not exceeding to 5.0 p.p.m.
 - (s) Fluoride, computed as Fluorine, not exceeding to 1.5 p.p.m.
 - (t) Chlorine residue, not exceeding to 0.5 p.p.m.
- (3) Microbiological properties.
- (a) Coliform bacterial count, (using the Most Probable Number Method) less than 2.2 per 100 ml. of clean water.
 - (b) *E. coli* bacteria shall not be found.
 - (c) Free of pathogenic microorganism.

Clause 4 Ice as stipulated in Clause 3 shall be of the quality or standard of clean water and shall contain no contaminant in that ice.

Clause 5 Manufacturing process of ice stipulated in Clause 3 shall protect any external contaminants during the manufacturing process.

Clause 6 Pipes, ice molds and utensils for manufacturing which contact the clean water or ice shall be made of non toxic material, durable and easy clean.

Clause 7 The surface of pipes, ice molds, and utensils for manufacturing which contact the clean water or ice shall be clean and not contaminated during the manufacturing process.

Clause 8 Manufacturing of ice for other purposes and not for consumption shall use clean water as stipulated in Clause 3 and may add other substances subject to the approval of the Office of Food and Drug Administration. Manufacturing of ice as stipulated in para 1 may follow the prescribed manufacturing process as Clause 5 or other processes can be used but pipes, ice molds and utensils which contact the clean water or ice shall follow the Clause 6 and 7.

Clause 9 Water which is used for cleaning pipes, ice molds, utensils which contact the clean water or ice and containers shall be the water of the same standard of water for manufacturing ice.

Clause 10 Storage of ice, grain hull, saw dust, sacks, coconut peels, mats or other similar material shall not be used for covering or wrapping ice.

Clause 11 Storage place for ice as stipulated in Clause 3 for sales or sold shall be:

- (1) Clean and the level higher than walking path in the place.
- (2) Made of non toxic material and smooth surface which is easy for cleaning.
- (3) Of the characteristic which is easy for cleaning and can protect from external contamination.

Clause 12 Containers for ice as stipulated in Clause 3 for sales or sold shall be:

- (1) Clean and releasing no substance to contaminate the ice in quantity that may be hazardous to health.
- (2) Made of non toxic substance and smooth surface, easy for cleaning.
- (3) Of the characteristic which is easy for cleaning and can protect from external contamination.
- (4) Never used as container for other substances than ice and containing no illustrations, devices or other statements that it has been used for packing other substances.

Vehicle which is used as container shall be the container as (1), (2) and (3).

Clause 13 Ice as stipulated in Clause 3 and 8 manufactured for sales or sold shall have label in Thai language, lettering shall be clearly legible and the size not smaller than 5 mm. on the container. The minimum contents of the text shall be as follows:

- (1) Name and address of the ice factory.
- (2) “Consumable Ice” in blue or “Non consumable Ice” in red either the case may be. The statement in para 1 shall not be enforced with the containers directly sold consumers.

This notification shall not affect the food licenses issued under the Notification of the Ministry of Public Health No. 19 (1979), Re: Prescribing Ice as Specially Controlled Food and Prescribing Quality or Standard, Principals, Conditions and Manufacturing Processes of Ice for Sales or Sold. Prescribing Quality or Standard of Containers, the Use of Containers, Storage and Label, dated 13th September, 1979. The license holder issued under the above mentioned Notification shall correct details of food as stipulated in this Notification within 90 days as of the effective date of this Notification.

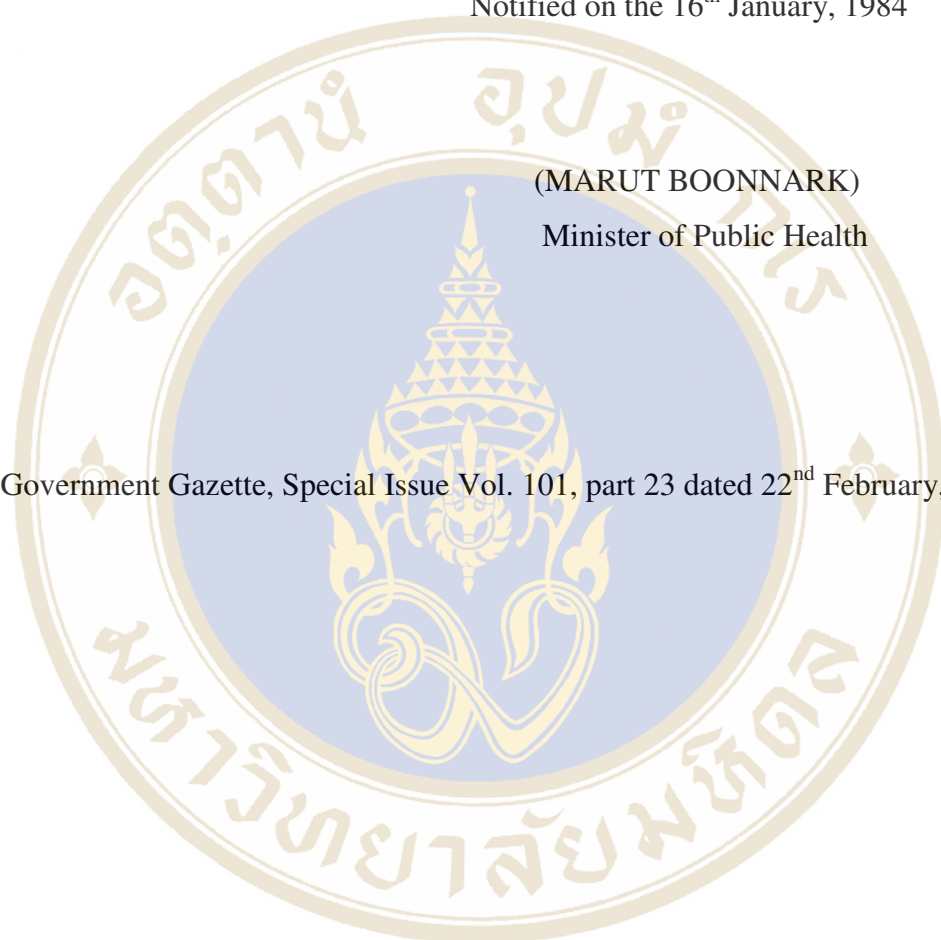
This Notification shall be enforced one hundred and eighty days as from the date of its publication in the Government Gazette henceforth.

Notified on the 16th January, 1984

(MARUT BOONNARK)

Minister of Public Health

(Government Gazette, Special Issue Vol. 101, part 23 dated 22nd February, 1984.)



Notification of the Ministry of Public Health**No. 137 [B.E. 2534(1991)]****RE: Ice (No. 2)**

Whereas it is deemed appropriate to amend the Notification of the Ministry of Public Health Re: Ice,

By virtue of Section 5 and Section 6 (1), (2), (6), (7) and (10) of the Food Act B.E. 2522(179), the Minister of Public Health hereby notifies that:

No. 1 The provisions of (e) of (2) of No. 3 of the Notification of the Ministry of Public Health No. 78 [B.E.2527(1984)] Re: Ice dated 16th January, 1984 shall be repealed and replaced by the following:

“(e) Cadmium not more than 0.005 mg. per 1 litre of clean water.”

No. 2 The provisions (i) and (j) of (2) of No. 3 of the Notification of the Ministry of Public Health No. 78 [B.E.2527(1984)] Re: Ice dated 16th January, 1984 shall be repealed and replaced by the following:

“(i) Iron not more than 0.3 mg. per 1 litre of clean water.”

“(j) Lead not more than 0.05 mg. per 1 litre of clean water.”

No. 3 The following shall be incorporated as (t), (u), (v) of (2) of No. 3 of the Notification of the Ministry of Public Health No. 78 [B.E.2527(1984)] Re: Ice dated 16th January, 1984:

“(t) Aluminium not more than 0.2 mg. per 1 litre of clean water.

(u) Alkylbenzene sulfonate not more than 0.2 mg. per 1 litre of clean water.

(v) Cyanide not more than 0.1 mg. per 1 litre of clean water.”

No. 4 The person granted certificate of food recipe registration or the person permitted to use label of food under the Notification of the Ministry of Public Health No. 78 [B.E.2527(1984)] Re: Ice dated 16th January, 1984 prior to the enforcement date of this Notification shall submit application for the amendment of the particulars therein so that they be in accordance with this Notification within one hundred and eighty days from the date of enforcement of the Notification, and upon having

submitted the application, the old certificated of food recipe registration or the old label may still be used until the permission is granted or until the person granting the permission informs the applicant of the disapproval thereof.

This Notification shall become effective on and from the day following the date of its publication in the Government Gazette.

Notified this 23rd day of April 1991

(PAIROJ NINGSANOND)

Minister of Public Health

(Ref.: Government Gazette, Volume 108, Part 94, of 28th May 1991)

Notification of the Ministry of Public Health

No. 254 [B.E. 2545(2002)]

RE: Ice (No. 3)

Whereas it is deemed appropriate to amend the Notification of the Ministry of Public Health Re: Ice,

By virtue of Section 5 and Section 6 (10) of the Food Act B.E. 2522(179), the Minister of Public Health hereby notifies that:

No. 1 The provisions of No. 13 of the Notification of the Ministry of Public Health No. 78 [B.E.2527(1984)] Re: Ice dated 16th January, 1984 shall be repealed and replaced by the following:

“Clause 13”

No. 2 The licence holder

No. 3 This Notification shall become effective on and from the day following the date of its publication in the Government Gazette.

Notified this 30th day of May 2002

(SUDARAT KAYURAPHAN)

Minister of Public Health

(Ref.: Government Gazette, Volume 119, Part 54, of 18th June 2002)

ประกาศกระทรวงสาธารณสุข
(ฉบับที่ 193) พ.ศ. 2543
เรื่อง วิธีการผลิต เครื่องมือเครื่องใช้ในการผลิต และการเก็บรักษาอาหาร

โดยที่เป็นการสมควรให้มีมาตรการการประกันคุณภาพของอาหารเพื่อให้อาหารมีคุณภาพมาตรฐาน และเพื่อคุ้มครองผู้บริโภคให้ได้รับอาหารที่ปลอดภัย

อาศัยอำนาจตามความในมาตรา 5 และมาตรา 6(7) แห่งพระราชบัญญัติอาหาร พ.ศ.2522 อันเป็นพระราชบัญญัติที่มีบทบัญญัติบางประการเกี่ยวกับการจำกัดสิทธิและเสรีภาพของบุคคล ซึ่งมาตรา 29 ประกอบกับมาตรา 35 มาตรา 48 และมาตรา 50 ของรัฐธรรมนูญแห่งราชอาณาจักรไทยบัญญัติให้กระทำได้โดยอาศัยอำนาจตามบทบัญญัติแห่งกฎหมาย รัฐมนตรีว่าการกระทรวงสาธารณสุขออกประกาศไว้ ดังต่อไปนี้

ข้อ 1 ให้อาหารดังต่อไปนี้ เป็นอาหารที่กำหนดวิธีการผลิต เครื่องมือเครื่องใช้ในการผลิต และการเก็บรักษาอาหาร

- (1) อาหารทารกและอาหารสูตรต่อเนื่องสำหรับทารกและเด็ก
- (2) อาหารเสริมสำหรับทารกและเด็กเล็ก
- (3) นมดัดแปลงสำหรับทารกและนมดัดแปลงสูตรต่อเนื่องสำหรับทารกและเด็กเล็ก
- (4) น้ำแข็ง
- (5) น้ำบริโภคในภาชนะบรรจุที่ปิดสนิท
- (6) เครื่องดื่มในภาชนะบรรจุที่ปิดสนิท
- (7) อาหารในภาชนะบรรจุที่ปิดสนิท
- (8) นมโค
- (9) นมเปรี้ยว
- (10) ไอศกรีม
- (11) นมปรุงแต่ง
- (12) ผลิตภัณฑ์ของนม
- (13) วัตถุเจือปนอาหาร
- (14) สีผสมอาหาร
- (15) วัตถุที่ใช้ปรุงแต่งรสอาหาร
- (16) โซเดียมซัลเฟตและอาหารที่มีโซเดียมซัลเฟต
- (17) อาหารสำหรับผู้ที่ต้องการควบคุมน้ำหนัก
- (18) ซา

- (19) กาแฟ
- (20) น้ำปลา
- (21) น้ำที่เหลือจากการผลิตโมโนโซเดียมกลูตาเมต
- (22) น้ำแร่ธรรมชาติ
- (23) น้ำส้มสายชู
- (24) น้ำมันและไขมัน
- (25) น้ำมันถั่วลิสง
- (26) ครีม
- (27) น้ำมันเนย
- (28) เนย
- (29) เนยแข็ง
- (30) กี่
- (31) เนยเทียม
- (32) อาหารกึ่งสำเร็จรูป
- (33) ซอสบางชนิด
- (34) น้ำมันปาล์ม
- (35) น้ำมันมะพร้าว
- (36) เครื่องดื่มเกลือแร่
- (37) น้ำมันถั่วเหลืองในภาชนะบรรจุที่ปิดสนิท (ยกเว้นที่มีสถานที่ผลิตที่ไม่เข้าลักษณะเป็นโรงงานตามกฎหมายว่าด้วยโรงงาน)
- (38) ซีอิ๊วโกแลต
- (39) แยม เยลลี่ มาร์มาเลด ในภาชนะบรรจุที่ปิดสนิท
- (40) อาหารที่มีวัตถุประสงค์พิเศษ
- (41) ไข่เยี่ยวม้า
- (42) รอยัลเยลลี่และผลิตภัณฑ์รอยัลเยลลี่
- (43) ผลิตภัณฑ์ปรุงรสที่ได้จากการย่อยโปรตีนของถั่วเหลือง
- (44) น้ำผึ้ง (ยกเว้นที่มีสถานที่ผลิตที่ไม่เข้าลักษณะเป็นโรงงานตามกฎหมายว่าด้วยโรงงาน)
- (45) ข้าวเติมวิตามิน
- (46) แป้งข้าวกล้อง
- (47) น้ำเกลือปรุงอาหาร
- (48) ซอสในภาชนะบรรจุที่ปิดสนิท

- (49) ขนมปัง
- (50) หมากฝรั่งและลูกอม
- (51) รุ้นสำเร็จรูปและขนมเยลลี่
- (52) อาหารที่มีวัตถุที่ใช้เพื่อรักษาคุณภาพหรือมาตรฐานของอาหารรวมอยู่ในภาชนะบรรจุ
- (53) ผลิตภัณฑ์กระเทียม
- (54) ผลิตภัณฑ์จากเนื้อสัตว์
- (55) วัตถุแต่งกลิ่นรส
- (56) อาหารที่มีส่วนผสมของว่านหางจระเข้
- (57) อาหารแช่เยือกแข็ง

ข้อ 2 ผู้ผลิตอาหารตามข้อ 1 เพื่อจำหน่ายต้องปฏิบัติตามวิธีการผลิต เครื่องมือเครื่องใช้ในการผลิต และการเก็บรักษาอาหาร ที่กำหนดไว้ในบัญชีแนบท้ายประกาศนี้

ข้อ 3 ผู้นำเข้าอาหารตามข้อ 1 เพื่อจำหน่าย ต้องจัดให้มีใบรับรองวิธีการผลิต เครื่องมือ เครื่องใช้ในการผลิต และการเก็บรักษาอาหาร ไม่ต่ำกว่าเกณฑ์ที่กำหนดไว้ในบัญชีแนบท้ายประกาศนี้

ข้อ 4 ให้ผู้ที่ได้รับใบอนุญาตผลิตอาหาร หรือใบสำคัญการขึ้นทะเบียนตำรับอาหาร หรือใบสำคัญ การใช้ฉลากอาหาร ตามข้อ 1 ก่อนวันที่ประกาศนี้ใช้บังคับที่ปฏิบัติไม่เป็นไปตามข้อ 2 หรือข้อ 3 ทำการปรับปรุงแก้ไขหรือจัดให้มีใบรับรองแล้วแต่กรณี ให้ถูกต้องตามประกาศนี้ภายในสองปี นับแต่วันที่ประกาศนี้ใช้บังคับ

ข้อ 5 ประกาศนี้ ให้ใช้บังคับเมื่อพ้นกำหนดหนึ่งร้อยแปดสิบวัน นับแต่วันถัดจากวันประกาศในราชกิจจานุเบกษาเป็นต้นไป

ประกาศ ณ วันที่ 19 กันยายน พ.ศ.2543

(ลงชื่อ) กร ทัพพะรังสี

(นายกร ทัพพะรังสี)

รัฐมนตรีว่าการกระทรวงสาธารณสุข

(คัดจากราชกิจจานุเบกษาฉบับประกาศทั่วไป เล่ม 118 ตอนพิเศษ 6 ง. ลงวันที่ 24 มกราคม 2544)

บัญชีแนบท้ายประกาศกระทรวงสาธารณสุข (ฉบับที่ 193) พ.ศ.2543
เรื่อง วิธีการผลิต เครื่องมือเครื่องใช้ในการผลิต และการเก็บรักษาอาหาร ตามหลักเกณฑ์วิธีการที่ดีใน
การผลิตอาหารว่าด้วยสุขลักษณะทั่วไป

การผลิตอาหารจะต้องมีการกำหนดวิธีการผลิต เครื่องมือ เครื่องใช้ในการผลิต และการเก็บรักษาอาหาร ซึ่งการ
 ดำเนินการดังกล่าวนั้นจะต้องคำนึงถึงสิ่งต่าง ๆ ดังต่อไปนี้

ลำดับ ที่	หัวข้อ	เนื้อหา
1.	สถานที่ตั้งและ อาคารผลิต	<p>1.1 สถานที่ตั้งตัวอาคารและที่ใกล้เคียง ต้องอยู่ในที่ที่จะไม่ทำให้อาหารที่ผลิตเกิดการปนเปื้อนได้ง่าย โดย</p> <p>1.1.1 สถานที่ตั้งตัวอาคารและบริเวณโดยรอบสะอาด ไม่ปล่อยให้มีกลิ่นเหม็น สิ่งที่ไม่ใช้แล้ว หรือสิ่งปฏิภูลอันอาจเป็นแหล่งเพาะพันธุ์สัตว์และแมลง รวมทั้งเชื้อโรคต่าง ๆ ขึ้นได้</p> <p>1.1.2 อยู่ห่างจากบริเวณหรือสถานที่ที่มีฝุ่นมากผิดปกติ</p> <p>1.1.3 ไม่อยู่ใกล้เคียงกับสถานที่นํารังเกียจ</p> <p>1.1.4 บริเวณพื้นที่ตั้งตัวอาคารไม่มีน้ำขังและสกปรก และมีท่อระบายน้ำ เพื่อให้ไหลลงสู่ทางระบายน้ำสาธารณะ ในกรณีที่สถานที่ตั้งตัวอาคารซึ่งใช้ผลิตอาหารอยู่ติดกับบริเวณที่มีสภาพไม่เหมาะสม หรือไม่ปฏิบัติตามข้อ 1.1.1-1.1.4 ต้องมีกรรมวิธีที่มีประสิทธิภาพในการป้องกันและกำจัดแมลงและสัตว์นำโรค ตลอดจนฝุ่นผงและสาเหตุของการปนเปื้อนอื่น ๆ ด้วย</p>
		1.2 อาคารผลิตมีขนาดเหมาะสม มีการออกแบบและก่อสร้างในลักษณะที่ง่ายแก่การทะนุบำรุงสภาพ รักษาความสะอาด และสะดวกในการปฏิบัติงาน โดย
		1.2.1 พื้น ฝาผนัง และเพดานของอาคารสถานที่ผลิต ต้องก่อสร้างด้วยวัสดุที่คงทน เรียบ ทำความสะอาด และซ่อมแซมให้อยู่ในสภาพที่ดีตลอดเวลา
		1.2.2 ต้องแยกบริเวณผลิตอาหารออกเป็นสัดส่วน ไม่ปะปนกับที่อยู่อาศัย
		1.2.3 ต้องมีมาตรการป้องกันสัตว์และแมลงไม่ให้เข้าไปในบริเวณอาคารผลิต
		1.2.4 จัดให้มีพื้นที่เพียงพอที่จะติดตั้งเครื่องมือและอุปกรณ์ที่ใช้ในการผลิตให้เป็นไปตามสายงานการผลิตอาหารแต่ละประเภท และแบ่งแยกพื้นที่การผลิตเป็นสัดส่วนเพื่อป้องกันการปนเปื้อนอันอาจเกิดขึ้นกับอาหารที่ผลิตขึ้น
		1.2.5 ไม่มีสิ่งของที่ไม่ใช้แล้วหรือไม่เกี่ยวข้องกับการผลิตอยู่ในบริเวณผลิต
		1.2.6 จัดให้มีแสงสว่างและการระบายอากาศที่เหมาะสมเพียงพอสำหรับการปฏิบัติงานภายในอาคารผลิต

ลำดับ ที่	หัวข้อ	เนื้อหา
2.	เครื่องมือ เครื่องจักร และ อุปกรณ์ในการ ผลิต	<p>2.1 ภาชนะหรืออุปกรณ์ในการผลิตที่สัมผัสกับอาหาร ต้องทำจากวัสดุที่ไม่ทำปฏิกิริยากับอาหารอันอาจเป็นอันตรายต่อผู้บริโภค</p> <p>2.2 ใต้อ่างที่เกี่ยวข้องกับกระบวนการผลิตในส่วนที่สัมผัสกับอาหาร ต้องทำด้วยวัสดุที่ไม่เกิดสนิม ทำความสะอาดง่าย และไม่ทำให้เกิดปฏิกิริยาที่อาจเป็นอันตรายแก่สุขภาพของผู้บริโภค โดยมีความสูงเหมาะสมและมีเพียงพอในการปฏิบัติงาน</p> <p>2.3 การออกแบบติดตั้งเครื่องมือ เครื่องจักร และอุปกรณ์ที่ใช้เหมาะสมและคำนึงถึงการปนเปื้อนที่อาจเกิดขึ้น รวมทั้งสามารถทำความสะอาดตัวเครื่องมือ เครื่องจักร และบริเวณที่ตั้งได้ง่ายและทั่วถึง</p> <p>2.4 เครื่องมือ เครื่องจักร และอุปกรณ์ในการผลิต ต้องเพียงพอต่อการปฏิบัติงาน</p>
3.	การควบคุม กระบวนการ ผลิต	<p>3.1 การดำเนินการทุกขั้นตอนจะต้องมีการควบคุมตามหลักสุขาภิบาลที่ดี ตั้งแต่การตรวจรับวัตถุดิบและส่วนผสมในการผลิตอาหาร การขนย้าย การจัดเตรียม การผลิต การบรรจุ การเก็บรักษาอาหาร และการขนส่ง</p> <p>3.1.1 วัตถุดิบและส่วนผสมในการผลิตอาหาร ต้องมีการคัดเลือกให้อยู่ในสภาพที่สะอาด มีคุณภาพดี เหมาะสำหรับการใช้ในการผลิตอาหารสำหรับบริโภค ต้องล้างหรือทำความสะอาดตามความจำเป็นเพื่อขจัดสิ่งสกปรก หรือสิ่งปนเปื้อนที่อาจติดหรือปนมากับวัตถุนั้น ๆ และต้องเก็บรักษาวัตถุดิบภายใต้สภาวะที่ป้องกันการปนเปื้อนได้โดยมีการเสื่อมสลายน้อยที่สุด และมีการหมุนเวียน</p> <p>สต็อกของวัตถุดิบและส่วนผสมอาหารอย่างมีประสิทธิภาพ</p>
		<p>3.1.2 ภาชนะบรรจุอาหารและภาชนะที่ใช้ในการขนถ่ายวัตถุดิบและส่วนผสมในการผลิตอาหาร ตลอดจนเครื่องมือที่ใช้ในการนี้ ต้องอยู่ในสภาพที่เหมาะสมและไม่ทำให้เกิดการปนเปื้อนกับอาหารในระหว่างการผลิต</p> <p>3.1.3 น้ำแข็งและไอน้ำที่ใช้ในกระบวนการผลิตที่สัมผัสกับอาหาร ต้องมีคุณภาพมาตรฐานตามประกาศกระทรวงสาธารณสุข เรื่อง น้ำแข็งและน้ำบริโภค และการนำไปใช้ในสภาพที่ถูกต้องลักษณะ</p>
		<p>3.1.4 น้ำที่ใช้ในกระบวนการผลิตอาหาร ต้องเป็นน้ำสะอาดบริโภคได้ มีคุณภาพมาตรฐานตามประกาศกระทรวงสาธารณสุข เรื่อง น้ำบริโภค และการนำไปใช้ในสภาพที่ถูกต้องลักษณะ</p>

ลำดับ ที่	หัวข้อ	เนื้อหา
		<p>3.1.5 การผลิต การเก็บรักษา ขนย้าย และขนส่งผลิตภัณฑ์อาหาร ต้องป้องกันการปนเปื้อนและป้องกันการเสื่อมสลายของอาหารและภาชนะบรรจุด้วย</p> <p>3.1.6 การดำเนินการควบคุมกระบวนการผลิตทั้งหมด ให้อยู่ภายใต้สภาวะที่เหมาะสม</p>
		<p>3.2 จัดทำบันทึกและรายงานอย่างน้อยดังต่อไปนี้</p> <p>3.2.1 ผลการตรวจวิเคราะห์ผลิตภัณฑ์</p> <p>3.2.2 ชนิดและปริมาณการผลิตของผลิตภัณฑ์และวันเดือนปีที่ผลิต</p> <p>โดยให้เก็บบันทึกและรายงานไว้อย่างน้อย 2 ปี</p>
4.	การสุขาภิบาล	<p>4.1 น้ำที่ใช้ภายในโรงงาน ต้องเป็นน้ำสะอาดและจัดให้มีการปรับคุณภาพน้ำตามความจำเป็น</p> <p>4.2 จัดให้มีห้องส้วมและอ่างล้างมือหน้าห้องส้วมให้เพียงพอสำหรับผู้ปฏิบัติงาน และต้องถูกสุขลักษณะ มีอุปกรณ์ในการล้างมืออย่างครบถ้วน และต้องแยกต่างหากจากบริเวณผลิต หรือไม่เปิดสู่บริเวณผลิตโดยตรง</p> <p>4.3 จัดให้มีอ่างล้างมือในบริเวณผลิตให้เพียงพอและมีอุปกรณ์การล้างมืออย่างครบถ้วน</p>
		<p>4.4 จัดให้มีวิธีการป้องกันและกำจัดสัตว์และแมลงในสถานที่ผลิตตามความเหมาะสม</p> <p>4.5 จัดให้มีภาชนะรองรับขยะมูลฝอยที่มีฝาปิดในจำนวนที่เพียงพอ และมีระบบกำจัดขยะมูลฝอยที่เหมาะสม</p> <p>4.6 จัดให้มีทางระบายน้ำทิ้งและสิ่งโสโครกอย่างมีประสิทธิภาพ เหมาะสม และไม่ก่อให้เกิดการปนเปื้อนกลับเข้าสู่กระบวนการผลิตอาหาร</p>
5.	การบำรุงรักษาและการทำความสะอาด	<p>5.1 ตัวอาคารสถานที่ผลิตต้องทำความสะอาดและรักษาให้อยู่ในสภาพสะอาด ถูกสุขลักษณะโดยสม่ำเสมอ</p> <p>5.2 ต้องทำความสะอาด ดูแลและเก็บรักษาเครื่องมือ เครื่องจักร และอุปกรณ์ในการผลิตให้อยู่ในสภาพที่สะอาดทั้งก่อนและหลังการผลิต สำหรับชิ้นส่วนของเครื่องมือเครื่องจักรต่าง ๆ ที่อาจเป็นแหล่งสะสมจุลินทรีย์ หรือก่อให้เกิดการปนเปื้อนอาหาร สามารถทำความสะอาดด้วยวิธีที่เหมาะสมและเพียงพอ</p>
		<p>5.3 พื้นผิวของเครื่องมือและอุปกรณ์การผลิตที่สัมผัสกับอาหาร ต้องทำความสะอาดอย่างสม่ำเสมอ</p>

ลำดับ ที่	หัวข้อ	เนื้อหา
6.	บุคลากรและ สุขลักษณะ ผู้ปฏิบัติงาน	<p>6.1 ผู้ปฏิบัติงานในบริเวณผลิตต้องไม่เป็นโรคติดต่อหรือโรคนำรังเกียจตามที่กำหนดโดยกฎกระทรวง หรือมีบาดแผลอันอาจก่อให้เกิดการปนเปื้อนของผลิตภัณฑ์</p> <p>6.2 เจ้าหน้าที่ผู้ปฏิบัติงานทุกคนในขณะที่ดำเนินการผลิตและมีการสัมผัสโดยตรงกับอาหาร หรือส่วนผสมของอาหาร หรือส่วนใดส่วนหนึ่งของพื้นที่ผิวที่อาจมีการสัมผัสกับอาหาร ต้อง</p> <p>6.2.1 สวมเสื้อผ้าที่สะอาดและเหมาะสมต่อการปฏิบัติงาน กรณีที่ใช้เสื้อคลุมก็ต้องสะอาด</p> <p>6.2.2 ล้างมือให้สะอาดทุกครั้งก่อนเริ่มปฏิบัติงาน และหลังการปนเปื้อน</p> <p>6.2.3 ใช้ถุงมือที่อยู่ในสภาพสมบูรณ์และสะอาดถูกสุขลักษณะ ทำด้วยวัสดุที่ไม่มีสารละลายหลุดออกมาปนเปื้อนอาหารและของเหลวซึมผ่านไม่ได้ สำหรับจับต้องหรือสัมผัสกับอาหาร กรณีไม่สวมถุงมือต้องมีมาตรการให้คนงานล้างมือ เล็บ แขนให้สะอาด</p> <p>6.2.4 ไม่สวมใส่เครื่องประดับต่าง ๆ ขณะปฏิบัติงาน และดูแลสุขอนามัยของมือและเล็บให้สะอาดอยู่เสมอ</p> <p>6.2.5 สวมหมวก หรือผ้าคลุมผม หรือตาข่าย</p> <p>6.3 มีการฝึกอบรมเจ้าหน้าที่ผู้ปฏิบัติงานเกี่ยวกับสุขลักษณะทั่วไป และความรู้ทั่วไปในการผลิตอาหารตามความเหมาะสม</p> <p>6.4 ผู้ที่ไม่เกี่ยวข้องกับการผลิต ปฏิบัติตามข้อ 6.1-6.2 เมื่ออยู่ในบริเวณผลิต</p>

ประกาศกระทรวงสาธารณสุข

(ฉบับที่ 239) พ.ศ.2544

เรื่อง แก้ไขเพิ่มเติมประกาศกระทรวงสาธารณสุข (ฉบับที่ 193) พ.ศ.2543

โดยที่เป็นการสมควรแก้ไขเพิ่มเติมประกาศว่าด้วยเรื่อง วิธีการผลิต เครื่องมือเครื่องใช้ในการผลิต และการเก็บรักษาอาหาร

อาศัยอำนาจตามความในมาตรา 5 และมาตรา 6(7) แห่งพระราชบัญญัติอาหาร พ.ศ.2522 อันเป็นพระราชบัญญัติที่มีบทบัญญัติบางประการเกี่ยวกับการจำกัดสิทธิและเสรีภาพของบุคคล ซึ่งมาตรา 29 ประกอบกับมาตรา 35 มาตรา 48 และมาตรา 50 ของรัฐธรรมนูญแห่งราชอาณาจักรไทยบัญญัติให้กระทำได้โดยอาศัยอำนาจตามบทบัญญัติแห่งกฎหมาย รัฐมนตรีว่าการกระทรวงสาธารณสุขออกประกาศไว้ ดังต่อไปนี้

ข้อ 1 ให้ยกเลิกความในข้อ 1(21) (52) และ (56) ของประกาศกระทรวงสาธารณสุข (ฉบับที่ 193) พ.ศ.2543 เรื่อง วิธีการผลิต เครื่องมือเครื่องใช้ในการผลิต และการเก็บรักษาอาหาร ลงวันที่ 19 กันยายน พ.ศ.2543

ข้อ 2 ให้ยกเลิกความในข้อ 1(57) แห่งประกาศกระทรวงสาธารณสุข (ฉบับที่ 193) พ.ศ.2543 เรื่อง วิธีการผลิต เครื่องมือเครื่องใช้ในการผลิต และการเก็บรักษาอาหาร ลงวันที่ 19 กันยายน พ.ศ.2543 และให้ใช้ความต่อไปนี้แทน

“(57) อาหารแช่เยือกแข็งที่ได้ผ่านการเตรียม (prepared) และหรือการแปรรูป (processed)”

ข้อ 3 ประกาศนี้ให้ใช้บังคับตั้งแต่วันถัดจากวันประกาศในราชกิจจานุเบกษาเป็นต้นไป

ประกาศ ณ วันที่ 11 กันยายน พ.ศ.2544

ลงชื่อ สุदारัตน์ เกยุราพันธุ์

(นางสุदारัตน์ เกยุราพันธุ์)

รัฐมนตรีว่าการกระทรวงสาธารณสุข

(คัดจากราชกิจจานุเบกษาฉบับประกาศทั่วไป เล่ม 118 ตอนพิเศษ 90 ง. ลงวันที่ 14 กันยายน พ.ศ.2544)

APPENDIX B

MPN INDEX TABLE

Table B1 Most Probable Number (MPN) of Bacteria Per 100 ml of Test Material Using 3 Tubes With 10, 1 and 0.1 ml of Test Material and 95 percent confidence intervals

Pos. tubes ¹			MPN/ 100ml	Conf. lim. ²		Pos. tubes ¹			MPN/ 100ml	Conf. lim.	
10	1	0.1		Low	High	10	1	0.1		Low	High
0	0	0	<3.0	--	9.5	2	2	0	21	4.5	42
0	0	1	3.0	0.15	9.6	2	2	1	28	8.7	94
0	1	0	3.0	0.15	11	2	2	2	35	8.7	94
0	1	1	6.1	1.2	18	2	3	0	29	8.7	94
0	2	0	6.2	1.2	18	2	3	1	36	8.7	94
0	3	0	9.4	3.6	38	3	0	0	23	4.6	94
1	0	0	3.6	0.17	18	3	0	1	38	8.7	110
1	0	1	7.2	1.3	18	3	0	2	64	17	180
1	0	2	11	3.6	38	3	1	0	43	9	180
1	1	0	7.4	1.3	20	3	1	1	75	17	200
1	1	1	11	3.6	38	3	1	2	120	37	420
1	2	0	11	3.6	42	3	1	3	160	40	420
1	2	1	15	4.5	42	3	2	0	93	18	420
1	3	0	16	4.5	42	3	2	1	150	37	420
2	0	0	9.2	1.4	38	3	2	2	210	40	430
2	0	1	14	3.6	42	3	2	3	290	90	1,000
2	0	2	20	4.5	42	3	3	0	240	42	1,000
2	1	0	15	3.7	42	3	3	1	460	90	2,000
2	1	1	20	4.5	42	3	3	2	1100	180	4,100
2	1	2	27	8.7	94	3	3	3	>1100	420	--

Table B2 Most Probable Number (MPN) of Bacteria Per 100 ml of Test Material Using 5 Tubes With 10, 1 and 0.1 ml of Test Material and 95 percent confidence intervals

Pos. tubes¹	MPN/	Pos. tubes¹	MPN/	Pos. tubes¹	MPN/
10;1;0,1	100ml	10;1;0,1	100ml	10;1;0,1	100ml
000	<1.8	100	2	200	4.5
001	1.8	101	4	201	6.8
002	3.6	102	6	202	9.1
003	5.4	103	8	203	12
004	7.2	104	10	204	14
005	9	105	12	205	16
010	1.8	110	4	210	6.8
011	3.6	111	6.1	211	9.2
012	5.5	112	8.1	212	12
013	7.3	113	10	213	14
014	9.1	114	12	214	17
015	11	115	14	215	19
020	3.7	120	6.1	220	9.3
021	5.5	121	8.2	221	12
022	7.4	122	10	222	14
023	9.2	123	12	223	17
024	11	124	15	224	19
025	13	125	17	225	22
030	5.6	130	8.3	230	12
031	7.4	131	10	231	14
032	9.3	132	13	232	17
033	11	133	15	233	20
034	13	134	17	234	22
035	15	135	19	235	25
040	7.5	140	11	240	15
041	9.4	141	13	241	17
042	11	142	15	242	20
043	13	143	17	243	23
044	15	144	19	244	25
045	17	145	22	245	28
050	9.4	150	13	250	17
051	11	151	15	251	20
052	13	152	17	252	17
053	15	153	19	253	26
054	17	154	22	254	29
055	19	155	24	255	32

Table B2 Most Probable Number (MPN) of Bacteria Per 100 ml of Test Material Using 5 Tubes With 10, 1 and 0.1 ml of Test Material and 95 percent confidence intervals (continued)

Pos. tubes¹ 10;1;0,1	MPN/ 100ml	Pos. tubes¹ 10;1;0,1	MPN/ 100ml	Pos. tubes¹ 10;1;0,1	MPN/ 100ml
300	7.8	400	13	500	23
301	11	401	17	501	31
302	13	402	21	502	43
303	16	403	25	503	58
304	20	404	30	504	76
305	23	405	36	505	95
310	11	410	17	510	33
311	14	411	21	511	46
312	17	412	26	512	64
313	20	413	31	513	84
314	23	414	36	514	110
315	27	415	42	515	130
320	14	420	22	520	49
321	17	421	26	521	70
322	20	422	32	522	95
323	24	423	38	523	120
324	27	424	44	524	150
325	31	425	50	525	180
330	17	430	27	530	79
331	21	431	33	531	110
332	24	432	39	532	140
333	28	433	45	533	180
334	31	434	52	534	210
335	35	435	59	535	250
340	21	440	34	540	130
341	24	441	40	541	170
342	28	442	47	542	220
343	32	443	54	543	280
344	36	444	62	544	350
345	40	445	69	545	440
350	25	450	41	550	240
351	29	451	48	551	350
352	32	452	56	552	540
353	37	453	64	553	920
354	41	454	72	554	1600
355	45	455	81	555	>1600

APPENDIX C

CALCULATION

1. Risk of ice contamination from sack

- Calculation of microbial quality of whole sack

- Size of 1 sack = $19 \times 32 = 608 \text{ in}^2$ (2 sides = 1216 in^2)
- Size of sack used for analysis = $(1 \times 1 = 1 \text{ in}^2) \times 5$ pieces
= 5 in^2 in buffer solution 225 ml
- Sack: determined number of colonies = 1.6×10^4 cfu/ml
determined total coliforms = >1600 MPN/100 ml

In buffer 225 ml; number of colonies = $225 \times 1.6 \times 10^4$ cfu/ 225 ml

From sack 5 in^2 ; number of colonies = $225 \times 1.6 \times 10^4$ cfu/ 5 in^2

From sack 1216 in^2 ; number of colonies = $\frac{1216 \times 225 \times 1.6 \times 10^4}{5}$ cfu/1 sack
= 8.8×10^8 cfu/1 sack

In sample 100 ml; total coliforms = 1600 MPN/100 ml

In buffer 225 ml; total coliforms = $1600 \times 225 / 100$ MPN/225 ml

From sack 5 in^2 ; total coliforms = $1600 \times 225 / 100$ MPN/ 5 in^2

From sack 1216 in^2 ; total coliforms = $\frac{1216 \times 1600 \times 225}{5}$ MPN/1 sack
= 875520 MPN/1 sack

- Calculation of microbial quality of crushed ice contained in sack

- 1 sack contained 20 kg of crushed ice = 20000 ml of crushed ice
- Microbial qualities of sack: number of colonies = 8.8×10^8 cfu/1 sack

Total coliforms = >875520 MPN/1 sack

$$\begin{aligned}
 \text{Contamination of crushed ice from sack} &= 8.8 \times 10^8 \text{ cfu/1 sack} \\
 &= 8.8 \times 10^8 \text{ cfu/20000 ml of crushed ice} \\
 &= \frac{8.8 \times 10^8}{20000} \text{ cfu/ml of crushed ice} \\
 &= 4.4 \times 10^4 \text{ cfu/ml of crushed ice}
 \end{aligned}$$

$$\begin{aligned}
 \text{Contamination of crushed ice from sack} &= 875520 \text{ MPN/1 sack} \\
 &= 875520 \text{ MPN/20000 ml of crushed ice} \\
 &= \frac{875520 \times 100}{20000} \text{ MPN/100 ml of crushed ice} \\
 &= 4378 \text{ MPN/100ml of crushed ice}
 \end{aligned}$$

- Calculation of microbial quality of crushed ice-contacted sack

- 1 sack = 19 x 32 in² contacted crushed ices = 4426.2 g = 4426.2 ml
 - Microbial qualities of sack: number of colonies = 8.8×10^8 cfu/1 sack
- Total coliforms = > 875520 MPN/1 sack

$$\begin{aligned}
 \text{Contamination of tube ice from sack} &= 8.8 \times 10^8 \text{ cfu/1 sack} \\
 &= 8.8 \times 10^8 \text{ cfu/4426.2 ml of (contacted) crushed ice} \\
 &= \frac{8.8 \times 10^8}{4426.2} \text{ cfu/ml of (contacted) crushed ice} \\
 &= 1.9 \times 10^5 \text{ cfu/ml of (contacted) crushed ice}
 \end{aligned}$$

$$\begin{aligned}
 \text{Contamination of ice from sack} &= 875520 \text{ MPN/1 sack} \\
 &= 875520 \text{ MPN/13700 ml of (contacted) crushed ice} \\
 &= \frac{875520 \times 100}{4426.2} \text{ MPN/100 ml of (contacted) crushed ice} \\
 &= 19780.4 \text{ MPN/100 ml of (contacted) crushed ice}
 \end{aligned}$$

2. Preparation of chlorine solution

2.1 Preparation from 10% NaOCl solution

Molecular weight of NaOCl = 23 (Na) + 16 (O) + 35.5 (Cl) = 74.5

NaOCl 74.5 parts have Cl 35.5 parts

Consequently, NaOCl 10% have Cl = $35.5 \times 10\% / 74.5 = 4.8\%$

NaOCl 100 parts have Cl 4.8 parts

1,000,000 parts have Cl $4.8 \times 1,000,000 / 100$

= 48,000 parts (ppm)

Formula

Amount of 10% NaOCl used \times Concentration of Cl in NaOCl (48,000)
= Concentration of Cl needed \times Amount of water for disinfection

2.2 Preparation from 65% Ca(OCl)₂ powder

First of all 65% Ca(OCl)₂ powder should be dissolved to 10% Ca(OCl)₂ solution in the ratio of 10 g of Ca(OCl)₂ powder to 55 g of water. This solution was left overnight and used only clear solution.

Molecular weight of Ca(OCl)₂ = 40 (Ca) + 2 \times [16 (O) + 35.5 (Cl)] = 143

Ca(OCl)₂ 143 parts have Cl 71 parts

Consequently, Ca(OCl)₂ 10% have Cl = $71 \times 10\% / 143 = 5.0\%$

Ca(OCl)₂ 100 parts have Cl 5.0 parts

1,000,000 parts have Cl $5.0 \times 1,000,000 / 100$

= 50,000 parts (ppm)

Formula

Amount of 10% Ca(OCl)₂ used \times Concentration of Cl in Ca(OCl)₂ (50,000)
= Concentration of Cl needed \times Amount of water for disinfection

APPENDIX D

Hazard Analysis

Table C1 Hazard analysis in Block ice and crushed ice manufacturing

Raw material/ Process step	Type ¹	Hazard	Control Measure
MODULE 1: Water treatment			
1.1 Water source	B	Microbial existence: coliforms and <i>E. coli</i>	Effective water treatment at later step
1.2 Chlorine compounds	B	Microbial contamination (from air, soil)	Store at room temperature, clean, dry, and light protection
1.3 Store raw water	B	- Microbial growth	Effective water treatment at later step
		- Microbial contamination (from environment)	Effective handling of water tank
1.4 Chlorination	B	Microbial existence	Control of the amount of added chlorine
1.5 Treat water by water treatment facilities	B	Microbial contamination (from unclean facilities)	Effective maintenance
1.6 Store treated water	B	Microbial contamination (from water tank)	Effective cleaning program
MODULE 1: Block ice making			
2.1 Addition of water into the set of ice can	B	Microbiological exist	Water should be checked by using coliforms, chlorine, hardness, and pH test kits
	C	Chlorine residual	
2.2 Submerge the ice cans into the brine cooling pool	C	Anti-rusting agent contamination	Repair or discard the leaked ice can
	C	Lubricant contamination	The lubricant of the crane used must be food grade.
2.3 Aeration while freezing	B	Microbiological exist	The inlet air should be filtered before pumping into the ice-blocking unit.

¹ Type of hazards P = physical hazard, C = chemical hazard B = biological hazard

Table C1 Hazard analysis in Block ice and crushed ice manufacturing (continued)

Raw material/ Process step	Type ¹	Hazard	Control Measure
2.4 Suck out the impurities		No hazard identified	
2.5 Submerging the ice cans into the thawing tank	B	Microbial contamination	The water used in the tank must be clean or treated water and should be changed at certain of time. The cans must not be completely submerged in the water.
	C	Chlorine residual	Chlorine residual in water should be checked by using chlorine test kit.
2.6 Removing the block ice from the cans	B	Cross contamination	The platform of the removing area must be cleaned properly.
MODULE 3: Crushed ice and distribution			
3.1 Sack	B	Microbiological existence: coliforms, <i>E. coli</i> and vegetative pathogens	Effective cleaning at step 3.7
3.2 String		No hazard identified	
3.3 Storage of the block ice	B	Microbial contamination	Effective cleaning program for the store room and effective hand-washing and sanitation of workers
3.4 Sorting		No hazard identified	
3.5 Storage of string	B	Microbiological contamination (from air, soil)	Effective cleaning program
3.6 Cutting the block ice	B	Microbiological contamination (from machine)	Effective cleaning program for the machine and effective hand-washing and sanitation of workers

¹Type of hazards P = physical hazard, C = chemical hazard B = biological hazard

Table C1 Hazard analysis in Block ice and crushed ice manufacturing (continued)

Raw material/ Process step	Type¹	Hazard	Control Measure
3.7 Cleaning by water	B	Microbiological contamination (from water used)	Control of quality of water used
3.8 Discarding not-in-use sack	B	Microbiological contamination (from air, soil)	Effective hand-washing and sanitation of workers
3.9 Crushing the ice	B	Microbiological contamination (from machine)	Effective hand-washing and sanitation of workers
3.10 Ready-to-use sack	B	Microbiological contamination (from air, soil)	Effective cleaning program
3.11 Fill in sack and tie by string	B	Microbiological contamination (from workers' hands)	Effective hand-washing and sanitation of workers
3.12 Tying the sack up with string	B	Microbiological contamination (from ice container)	Effective hand-washing and sanitation of workers
3.13 Loading onto transport	B	Microbiological contamination (from workers' hands, truck)	Effective hand-washing and sanitation of workers and vehicle

¹ Type of hazards P = physical hazard, C = chemical hazard B = biological hazard

BIOGRAPHY



NAME Miss. Kukkanang Sirilaksanamanon

DATE OF BIRTH May 8, 1982

PLACE OF BIRTH Bangkok, Thailand

INSTITUTIONS ATTENDED Chulalongkorn University, 2000-2004:
Bachelor of Science
(Food Technology)

Mahidol University, 2005-2008:
Master of Science
(Food and nutrition for development)

HOME ADDRESS 35 Soi Pattanakarn 58, Suanluang, Bangkok
Tel. 081-556-6594

E-MAIL ADDRESS s.kukkanang@gmail.com