

PERFORMANCE EVALUATION OF SEMI-AUTOMATED
FILLING MACHINE FOR
“OTAK-OTAK” PRODUCTION

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Praise to Allah for giving me opportunities to complete my study in Master of
Mechanical Engineering

For my beloved Pa and Ma

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ABSTRACT

The food industry has been a part of the service sector in Malaysia. The “otak-otak” industry typically categorised as SMEs which having common limitations of extensively depended on human labour instead of advanced machinery. As the “otak-otak” industries are dealing with a less complicated process, the manual production method is typically selected. Though the production process is not complicated, human limitations might cause production performance and product quality degradation. However, the impact of semi-automation to the production of “otak-otak” remained unclear, thus require the investigation. Through the use of statistical process control, the performance of the manual and semi-automated production process was determined. The integration approached of using ARENA and experimental data was successfully simulates the real production situation. The impact of the implementation of the semi-automated production system was determined and found positively improved the total production performance. This new process has satisfied the minimum requirement of the recommended process capability ratio. Numbers of production issues associated with manual production were determined including the inconsistent utilisation of operator, long value-added time, long product waiting as well as the quality issue of weight inconsistency. The utilization of the operator increased between 10.60 percent to 23.65 percent with the use of a semi-automation system compared to manual operation. The value-added time of semi-automation operation is also shorter than the value-added time of manual operation with the smallest difference of 0.88 seconds and the biggest difference of 1.49 seconds besides, 37.25 percent to 75.80 percent improvement for waiting time. For the aspect of manufactured parts per 1 million, the semi-automated operation has greatly reduced the percentage of product failure in the production of more than 50%. The weight of the “otak-otak” also can be maintain within the range of company specification (25 ± 1 grams).

ABSTRAK

Industri makanan telah menjadi sebahagian daripada sektor perkhidmatan di Malaysia. Industri "otak-otak" dikategorikan sebagai PKS yang mempunyai kekurangan yang identikal berkaitan kebergantungan kepada buruh manusia berbanding mesin berteknologi tinggi. Sebagaimana industri "otak-otak" mempunyai proses yang tidak begitu rumit, kaedah pengeluaran secara manual biasanya menjadi pilihan. Walaupun tidak rumit, keterbatasan kemampuan manusia dijangka boleh menyebabkan pengurangan prestasi pengeluaran dan kemerosotan kualiti produk. Walau bagaimanapun, impak penggunaan teknologi separa-automasi dalam pengeluaran "otak-otak" masih tidak jelas, dan memerlukan kajian lanjut. Melalui penggunaan kaedah pengawalan proses secara statistik, perbandingan prestasi proses pengeluaran manual dan separa automasi telah dilakukan. Penggunaan perisian ARENA melalui integrasi bersama data daripada uji kaji berjaya menghasilkan simulasi keadaan pengeluaran sebenar. Kesan pelaksanaan sistem pengeluaran secara separa automasi telah dinilai dan didapati memberi kesan positif kepada peningkatan prestasi pengeluaran secara keseluruhan. Proses baru ini telah memenuhi keperluan minimum nisbah keupayaan proses yang disyorkan. Isu-isu pengeluaran yang berkaitan kaedah pengeluaran secara manual berjaya dikenalpasti antaranya penggunaan operator yang tidak konsisten, masa nilai tambah yang panjang, masa produk menunggu yang lama serta isu kualiti berkaitan ketidakseragaman berat produk. Penggunaan operator dilihat meningkat antara 10.60 peratus hingga 23.65 peratus dengan penggunaan sistem separa-automasi berbanding operasi manual. Masa tambah nilai bagi operasi separa-automasi juga lebih pendek berbanding masa nilai tambah bagi manual operasi dengan perbezaan terkecil adalah 0.88 saat dan perbezaan terbesar adalah 1.49 saat, selain 37.25 peratus hingga 75.80 peratus peningkatan untuk masa menunggu. Dalam aspek pembuatan bahagian setiap 1 juta, operasi separa-automasi telah banyak mengurangkan peratusan kegagalan produk dalam pengeluaran lebih daripada 50%. Berat otak-otak juga dapat dikawal dalam julat spesifikasi syarikat (25 ± 1 gram).

TABLE OF CONTENTS

TITLE	i
DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	v
TABLE OF CONTENTS	vi
LIST OF TABLES	xi
LIST OF FIGURES	xiv
LIST OF SYMBOLS AND ABBREVIATIONS	xvii
LIST OF APPENDICES	xx
CHAPTER 1 INTRODUCTION	1
1.1 Background of study	1
1.2 Problem statement	7
1.3 Objective	8
1.4 Significant of the study	8
1.5 Scope of study	9
1.6 Thesis Outline	9
CHAPTER 2 LITERATURE REVIEW	11
2.1 Small and Medium Enterprises (SMEs)	11

2.1.1	Small and Medium Enterprises (SMEs) in Malaysia	14
2.1.1.1	SMEs contributions to the Malaysian Economy	15
2.1.1.2	Weakness of SMEs	16
2.1.2	Vendor selection	18
2.2	Food safety	20
2.2.1	Physical contamination	21
2.2.2	Chemical contamination	22
2.2.3	Biological contamination	22
2.2.3.1	Cross-contamination	22
2.2.4	Bacterial food poisoning	23
2.2.4.1	Conditions for bacterial growth	23
2.2.4.2	Control of bacterial growth	23
2.2.5	Other food spoilage causes	24
2.3	Industrial engineering (IE)	24
2.3.1	Fundamentals of industrial engineering	25
2.3.1.1	Human factors	26
2.3.1.2	Process control for quality Improvement	26
2.3.1.3	Project scheduling	27
2.3.1.4	Cost concepts and estimation	27
2.3.1.5	Work sampling	28
2.3.2	Human factor	28
2.3.2.1	Compensation (incentive)	29
2.3.2.2	Motivation and manufacturing worker commitment	29



2.3.2.3	Impact of training on manufacturing worker performance	31
2.3.2.4	Technology	32
2.3.2.5	Manufacturing worker and safety regulation	32
2.3.2.6	Maintenance and repairs	33
2.4	Production systems	35
2.4.1	Facilities	36
2.4.2	Manufacturing support systems	39
2.4.3	Manual labour in production system	41
2.4.3.1	Manual labour in factory operations	42
2.4.3.2	Labour in manufacturing support Systems	45
2.4.4	Automation in production systems	47
2.4.4.1	Automated manufacturing systems	47
2.4.4.2	Computerized manufacturing support systems	50
2.4.4.3	Reasons for automating	50
2.4.5	Automation principles and strategies	51
2.4.5.1	The USA principle	52
2.4.5.2	Ten strategies for automation and Process improvement	53
2.4.6	Research gap	55
2.5	Quality programs for manufacturing	55
2.5.1	Quality in design and manufacturing	56
2.5.2	Traditional and modern quality control	57



2.5.2.1	Traditional quality control	57
2.5.2.2	The modern view of quality control	59
2.5.3	Process variability and process capability	61
2.5.3.1	Process variations	61
2.5.3.2	Process capability and tolerance	62
2.5.4	Statistical process control	64
2.5.4.1	Control charts	65
2.5.4.2	Other SPC tools	72
2.5.4.3	Implementing SPC	77
2.5.5	Research on statistical process control (SPC)	78
2.6	ARENA simulation software	83
2.6.1	Research on production simulation using ARENA	84
CHAPTER 3 METHODOLOGY		90
3.1	Flow chart	90
3.2	Case study company	93
3.3	Production assessment	94
3.4	Determination of the source of the quality issues	98
3.5	Implement the process improvement	101
3.5.1	Semi-automation	102
3.5.1.1	Conveyer	103
3.5.1.2	Filling machine and cutter	105
3.5.1.3	Machine control system	108
3.6	Comparative study	110
CHAPTER 4 RESULT AND DISCUSSION		117
4.1	Manual operation	117

4.1.1	Analysis of the production line	118
4.1.1.1	Weight of “otak-otak”	118
4.1.1.2	Times of operators	122
4.1.1.3	Cause and effect diagram	137
4.1.1.4	ARENA simulation software	142
4.2	Semi-automation operation	147
4.2.1	Weight of “otak-otak”	148
4.2.2	Times of operators	152
4.2.2.1	Operator 1	153
4.2.3	ARENA simulation software	154
4.3	Comparison between manual and semi-automation operation	159
CHAPTER 5 CONCLUSION		170
5.1	Conclusion	170
5.2	Recommendation	173
REFERENCE		174
APPENDIX		192



LIST OF TABLES

1.1	Import and export of processed food in Malaysia (\$US billion)	4
1.2	Types of “otak-otak” in Malaysia	5
1.3	Lists of “otak- otak” industries in Malaysia	5
2.1	Distribution of firms by number of employees in different countries	12
2.2	Qualitative indicators in discerning SMEs from large companies	13
2.3	Number of SMEs establishment by sectors	14
2.4	New standard definition of SMEs in Malaysia	15
2.5	The priority criteria in vendor selection	19
2.6	Relative strengths and attributes of humans and machines	38
2.7	Situation of manual labour preferred over automation	42
2.8	Reason for automation	51
2.9	Ten strategies and process improvement	53
2.10	Two aspects of quality	56
2.11	Factors in favour of wide and narrow tolerances	63
2.12	Defect rate as a function of process capability index for a process operating in statistical control	64
2.13	Constants for the \bar{x} and R charts	67
2.14	Past research on control chart in the process of production system	78
2.15	Methodology of control chart in manufacturing	80
2.16	Past research on ARENA simulation software of production system	84
2.17	Parameter of ARENA simulation software in production line	87
3.1	Constants for the \bar{x} and R charts	96
3.2	Recommended minimum values of the process capability ratio, C_{pk}	100
3.3	Specification of filling machine	103
3.4	Specification of motor	104

3.5	Specification of pneumatic machine	106
3.6	Component of machine system	109
4.1	Analysis from control charts of weight of “otak-otak” (manual Operation)	119
4.2	Process mean, capability process ratio and manufactured parts in 1 million of manual operation	121
4.3	Analysis from control chart of times of operator 1 of manual operation	125
4.4	Analysis from control chart of times of operator 2 of manual operation	126
4.5	Analysis from control chart of times of operator 3 of manual operation	127
4.6	Analysis from control chart of times of operator 4 of manual operation	128
4.7	Analysis from control chart of times of operator 5 of manual operation	130
4.8	Analysis from control chart of times of operator 6 of manual operation	131
4.9	Analysis from control chart of times of operator 7 of manual operation	132
4.10	Analysis from control chart of times of operator 8 of manual operation	133
4.11	Analysis from control chart of times of operator 9 of manual operation	134
4.12	Analysis from control chart of times of operator 10 of manual operation	135
4.13	Process out of statistical control	138
4.14	Why-why analysis on production line of manual operation	141
4.15	Mean and standard deviation by operator of manual operation	142
4.16	Estimation of maximum output of the “otak-otak” in a day for two weeks of manual operaton	144
4.17	Value added time for each product of manual operation	144
4.18	Waiting time in each process of manual operation	145
4.19	Number of products waiting of manual operation	145

4.20	Utilization of operator of manual operation	146
4.21	Product seized by operator of manual operation	146
4.22	Estimation of output of “otak-otak” in filling station of manual operation	147
4.23	Analysis from control charts of weight of “otak-otak” (semi-automation operation)	148
4.24	Process mean, capability process ratio and manufactured parts in 1 million of semi-automation operation	151
4.25	Analysis from control chart of times of operator 1 of semi-automation operation	153
4.26	Mean and standard deviation by operator of semi-automation operation	155
4.27	Estimation of maximum output of the “otak-otak” in a day for two weeks of semi-automation operation	156
4.28	Value added time for each product of semi-automation operation	157
4.29	Waiting time in each process of semi-automation operation	157
4.30	Number of products waiting of semi-automation operation	158
4.31	Utilization of operator of semi-automation operation	158
4.32	Product seized by operator of semi-automation operation	158
4.33	The difference of percentage of product failure (%) between two operation	160
4.34	Estimation of maximum output of production line	161
4.35	Estimation of maximum output of filling station	161
4.36	Average of five variables in the process of manual operation	162
4.37	Average of five variables in the process of semi-automation operation	163
4.38	Reduction of product waiting time by percentage in semi-automation operation	166

LIST OF FIGURES

1.1	Percentage number of establishments by sectors involve in economic census	3
1.2	Production process of “Otak-otak”	7
2.1	Level of implementation of extensive networking	13
2.2	Overview of SMEs by state	15
2.3	Vendor selection process criteria	18
2.4	Industrial engineering activities and techniques	25
2.5	Fundamental of industrial engineering	26
2.6	Categories or level of production system	35
2.7	Overview and relationship among six parts of production systems	36
2.8	Categories of manufacturing systems	37
2.9	Information processing cycle	39
2.10	Automation migration strategy for introducing new product	44
2.11	Structure of a material requirement planning (MRP) system	45
2.12	Opportunities for automation and computerization in a production systems	47
2.13	Three types of automation relative to production quantity and product variety	48
2.14	Control chart	65
2.15	Control charts used as the feedback loop in statistical process control	70
2.16	Cyclic pattern of control chart	70
2.17	Shift in process level of control chart	71
2.18	Trend pattern of control chart	71
2.19	Mixture pattern of control chart	72
2.20	Example of histogram	72

2.21	Example of pareto chart that uses of 80% total populations or samples	73
2.22	Example of check sheet	74
2.23	Example of defect concentration diagram	75
2.24	Example of flowchart	75
2.25	Example of scatter diagram	76
2.26	Example of the cause and effect diagram	77
3.1	Methodology	91
3.2	Workplace layout	93
3.3	Check sheet	95
3.4	Control chart	97
3.5	Process capability index	98
3.6	Control charts by zones	99
3.7	Good performance of process capability	100
3.8	Poor performance of process capability	100
3.9	“Otak-otak” filling machine	102
3.10	Illustration of conveyer of fish paste (Otak-otak)	104
3.11	Electric DC motor with gear	105
3.12	Pneumatic machine	105
3.13	Illustration of semi-solid extruder cutter	106
3.14	Illustration of semi-solid extruder cutter at different angle of view	107
3.15	Evolution of semi-solid extruder cutter	108
3.16	Wiring of the machine system	110
3.17	The assign place for each operator	111
3.18	ARENA model for filling station (manual operation)	112
3.19	ARENA model for filling station (automation operation)	112
3.20	ARENA model for wrapping station	113
3.21	ARENA model for whole production line (manual operation)	113
3.22	ARENA model for whole production line (automation operation)	115
3.23	ARENA model for whole production line (semi-automation operation)	116
4.1	Production line	118

4.2	Control chart of average weight of “otak-otak” (manual operation)	120
4.3	Process capability of average weight of “otak-otak” (manual operation)	122
4.4	Cyclic pattern control chart	124
4.5	Shift in process level pattern control chart	124
4.6	Trend pattern control chart	124
4.7	Control chart of average times of operator (filling station) for manual operation	136
4.8	Control chart of average times of operator (wrapping station) for manual operation	137
4.9	Cause and effect diagram of “otak-otak” production	139
4.10	Control chart of average weight of “otak-otak” (semi-automation operation)	149
4.11	Process capability of average weight of “otak-otak” (semi-automation)	152
4.12	Control chart of average times of operator (filling station) for semi-automated operation	154
4.13	Value added time for each product	163
4.14	Waiting time in each process	164
4.15	Number of products waiting	167
4.16	Utilization of operator	168
4.17	Product seized by operator	169



LIST OF SYMBOLS AND ABBREVIATIONS

A	-	Ampere
A_2	-	constant for \bar{x} chart
c	-	Number of Quality Defects
\bar{c}	-	Mean of c
C_p	-	Process Capability
C_{pk}	-	Process Capability Ratio
D_3	-	constant for R chart
d_i	-	Defective Items
m	-	Series of Samples
m^3/mm	-	Volume per millimeter
ml^3	-	Volume of liquid
n	-	Number of Measurements in The Sample, i
$N.m$	-	Torque
\bar{p}	-	Mean of Proportion
p_i	-	Proportion
Pa	-	Pascal
pH	-	Quantitative measure of the acidity or basicity of aqueous or other liquid solutions
R	-	Minimum of sample – Maximum of sample
\bar{R}	-	Mean of the R values for the m Samples
s	-	Sample Standard Deviation
V	-	Voltage
W	-	Watt
x	-	Sample
\bar{x}	-	Mean of x
$\bar{\bar{x}}$	-	Mean of the \bar{x} values for the m Samples

x_i	-	Measurement i of The Part Characteristic of Interest
σ	-	Standard Deviation
μ	-	Process Mean (Nominal Value of The Product Characteristic)
ARENA-		Discrete Event Simulation and Automation Software
ASTM -		American Society for Testing and Materials
BEP	-	Break Even Point
BMI	-	Business Monitor International
BOM	-	Bill of Material
CIM	-	Computer-Integrated Manufacturing
cm	-	Centimeter
DC	-	Direct Current
F&B	-	Food and Beverage
GDP	-	Gross Domestic Product
GOM	-	Government of Malaysia
HACCP-		Hazard Analysis and Critical Control Points
IE	-	Industrial Engineering
IMP	-	Industrial Malaysian Plan
g		gram
LCL	-	Lower Control Limit
LNTL	-	Lower Natural Tolerance Limits
LSL	-	Lower Specification Limit
LTL	-	Lower Tolerance Limit of The Tolerance Range
M&E	-	Machine and Equipment
MCDM-		Multiple Criteria Decision Making
MIDA	-	Malaysian Investment Development Authority
MITI	-	Ministry of International Trade and Industry
mm	-	millimeter
MRP	-	Material Requirement Planning
NSDC	-	National SME Development Council
OECD	-	Organisation for Economic Co-operation and Development
OHS	-	Occupational Health and Safety
PKS	-	Perusahaan Kecil dan Sederhana
PLC	-	Programable Logic Control
PVC	-	Polyvinyl Chloride

ppm	-	Parts per Million
QC	-	Quality Control
RPM	-	Revolutions per Minute
SCADA-		Supervisory Control and Data Acquisition
SMEs	-	Small and Medium Enterprises
SPC	-	Statistical Process Control
SQC	-	Statistical Quality Control
TQM	-	Total Quality Management
UK	-	United Kingdom
UTL	-	Upper Tolerance Limit of The Tolerance Range
UCL	-	Upper Control Limit
UNTL	-	Upper Natural Tolerance Limits
USL	-	Upper Specification Limit
VAC	-	Volts of Alternating Current
WIP	-	Work in Process



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PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Schematic Diagram	193
B	Weight of Otak-otak for Manual Operation	195
B1	Data Collection of Weight of Otak-otak for Manual Operation	196
B2	Control Charts of Weight of Otak-otak for Manual Operation	198
B3	Process Capability of Weight of Otak-otak for Manual Operation	206
C	Times of Operator 1 for Manual Operation	211
C1	Data Collection of Times of Operator 1 for Manual Operation	212
C2	Control Charts of Times of Operator 1 for Manual Operation	214
D	ARENA Simulation for Manual Operation	222
D1	Maximum Output in A Day of Otak-otak for Manual Operation	223
D2	Simulation of 12000 Pieces of Otak-otak for Manual Operation	225
D3	Filling Station Output of Otak-otak for Manual Operation	239
E	Weight of Otak-otak for Automation Operation	244
E1	Data Collection of Weight of Otak-otak for Automation Operation	245
E2	Control Charts of Weight of Otak-otak for Automation Operation	247

E3	Process Capability of Weight of Otak-otak for Automation Operation	255
F	Times of Operator 1 for Automation Operation	260
F1	Data Collection of Times of Operator 1 for Automation Operation	261
F2	Control Charts of Times of Operator 1 for Automation Operation	263
G	ARENA Simulation for Automation Operation	271
G1	Maximum Output in A Day of Otak-otak for Automation Operation	272
G2	Filling Station Output of Otak-otak for Manual Operation	274
G3	Simulation Of 12000 Pieces of Otak-otak for Atomation Operation	276



CHAPTER 1

INTRODUCTION

1.1 Background of study

Food industry is one of the major industries worldwide that involves food security in a country. A group of companies that provides the same goods and services is called an industry. It is important to analyse an industry to determine its competitiveness. This is to develop a strategy and determines an industry boundary and its business (Eskandari, Miri, Gholami, & Nia, 2015; Gould, 1997).

Food industry is a low margin industry but is necessary for the community. A series of industrial activities, such as processing, conversion, preparation, preservation, and packaging of food is called as food industries. These days, food industries cover a variety of businesses from small, traditional, family-run activities which consume a lot of labour to a large, capital-intensive, and highly mechanized industrial processes. Local agriculture and fishing are the main sources of food industries (Parmeggiani, 1972). In most countries, food and beverage manufacturing can be encouraged by the government actively playing its role in providing incentives to indirectly promote the industry. Overall competitiveness could be enhanced through technology and innovation as well as adding value to the employee.

The development of the food industry is essential due to the occurrence of food shortage and overpopulation. A new approach like new technology in this sector must be considered. With the help of new technology, sustainable and product development in this sector can be enhanced (Jahanshahi, & Jafari, 2009). The food industry has been paid special attention and priority by the government in developing countries caused by (Cheraghali, Reza, & Amirahmadi, 2005);

- i) The increase of employment openings in terms of participants that are directly and indirectly involved in food production of national income.
- ii) The product of higher added value has been more commercialized rather than raw material in world exports.
- iii) Limited resources have been a problem of developed countries and they need to plan to optimise the resource and lack of management skills in large scale investments. Uses of small quantities of this resources as in the food industry are encouraged, and this industrial activity has been expanded by the government.
- iv) Consumer behaviour changes caused by the awareness of lifestyle patterns towards higher and more nutritious quality product. This will raise the income level.

The food industry has been a part of the service sector in Malaysia. This sector is largely influential in the growth of the economy in Malaysia. From 2011 to 2012, the total food and beverage export remained stable at RM 15.5 billion (Abu, 2016). The food industry in Malaysia has been focusing on functional food, healthy food, convenience food, food ingredients and halal food. The food industry has become a key growth area in Malaysia (Ayupp & Tudin, 2013). Manufacturing development like employment generation, foreign exchange savings and value-added creation has been contributed by this industry (Ahmed, 2012).

The characteristic of food industry that is dynamic internally and externally makes its important in the Malaysian economy (Ayupp & Tudin, 2013). The economic census conducted by Dr. Hj. Abdul Rahman Hasan in 2011 found that the service sector accounted for the largest with 73.1% (689,717) from a total number of 943,526 establishments. This economic census was established to benchmark the economic statistics in this country. Gross Domestic Product (GDP), Indices and Input Output tables have been rebased according to this benchmark of economic census.

Comprehensive study or survey has been conducted from previous census which states more expansion of new industries in services sector. The incorporation of census on Small and Medium Enterprises (SMEs) is included in this study (Hasan, 2011). Figure 1.1 shows the percentage of establishments by sectors involved in the economic census. It is shown that the service sector is the major part of economy in Malaysia. The service sector is composed of establishment such as food and beverage,

transport, accommodation and real estate. The establishment of food and beverage represents the largest part of the service sector which is 30.6% (Hasan, 2011).

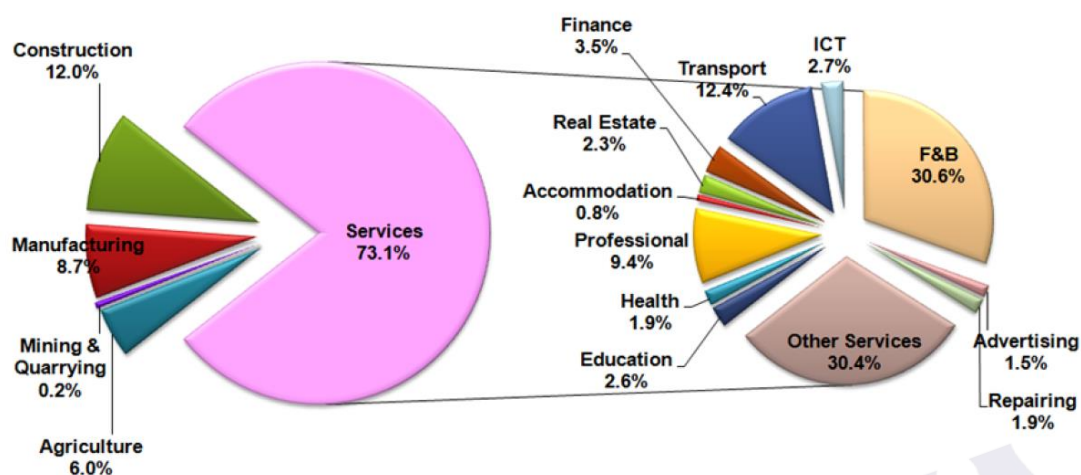


Figure 1.1: Percentage of Establishments by Sector Involved in Economic Census (Hasan, 2011).

In 2013, more than RM13 billions of annual export value produced by Malaysia was caused by processed foods exported to more than 200 countries (Malaysian Investment Development Authority, 2013). Investment of RM24.6 billion had been targeting on the food processing industry in the Industrial Malaysia Plan 2006-2020 (IMP3) period (Ministry of International Trade and Industry Malaysia, 2013). There are more than 9,000 firms in Malaysia that are classified in the food processing industry in which 95% consists of small-scale firms (Ghani, 1995).

The food processing industry better suits the flexible organizational structures which can change at various stages of production process that can fulfil consumers' demand (Bogue & Ryan, 2000). The availability of raw material and supplies can create a firm's competitive advantage, which can be characterised as a strong backbone for this industry (Jarrett, 1996; McMaster, 1992). This factor must be supported by the government that is vital to this industry for international expansion (Aaby & Slater, 1989). Depending on various factors, the success of food processing industry could be seen in both domestic and international markets (Ayupp & Ismail, 2011).

Foreign trade is open to Malaysia to become politically and economically stable. Food manufacturing in Malaysia is involved in 6500 small and medium-sized establishments, and nearly 10 percent of manufacturing output is for accounting. The food processing sector is one of the critical industries for the overall economy. This

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