



UNIVERSITI PUTRA MALAYSIA

***ASSOCIATION BETWEEN OCCUPATIONAL HEAT EXPOSURE WITH
PHYSIOLOGICAL CHANGES AMONG PALM OIL MILL WORKERS***

**BY
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ABSTRAK

TEGASAN HABA DAN HUBUNGANNYA DENGAN PERUBAHAN FISIOLOGI DI KALANGAN PEKERJA KILANG KELAPA SAWIT

NUR IZZATE SAID

Objektif: Satu kajian keratan rentas telah dijalankan untuk melihat kesan pendedahan haba ke atas perubahan fisiologi di kalangan pekerja kilang kelapa sawit di Kota Tinggi, Johor. **Kaedah kajian :** Seramai 74 orang yang bekerja di bahagian operasi telah dipilih sebagai responden kajian. Pemboleh ubah yang dikaji adalah WBGT Dalam, kadar haba metabolik, suhu teras badan, tekanan darah dan denyutan nadi. *Questemp⁰³⁴ Thermal Environmental Monitor* telah digunakan untuk mengukur suhu persekitaran. Manakala *OMRON T3 Automatic Blood Pressure Monitor* telah digunakan untuk mengukur tekanan darah dan *OMRON MC-510 Gentle Temperature Ear Thermometer* digunakan untuk mengukur suhu badan. **Hasil kajian :** Hasil kajian mendapati nilai min WBGT Dalam dibahagian operasi kilang kelapa sawit 1 ialah 30.60 °C manakala kilang kelapa sawit 2 ialah 30.78 °C. Pekerja bahagian operasi terdedah kepada haba semasa berada di proses *continuous sterilizer*, *press*, *kernel*, *bilik minyak*, *boiler*, dan *bilik engine*. Purata masa pengukuran yang paling singkat adalah selama 2 jam dan 8 jam untuk keseluruhan tempoh pendedahan. Terdapat perbezaan yang signifikan di antara suhu teras badan sebelum syif, selepas 2 jam dan selepas 8 jam bekerja ($p < 0.001$). Kadar denyutan nadi responden adalah berada di antara julat 83 – 90 denyutan perminit, menunjukkan tidak terdapat tuntutan kerja yang berlebihan ke atas fisiologi. Min suhu teras badan (36.03 ± 0.25 °C) dan kadar denyutan nadi (87.39 ± 1.69 bpm) selepas tamat syif 8 jam, menunjukkan pekerja mempunyai bacaan tubuh badan yang baik terhadap pendedahan haba. Lima daripada enam seksyen kerja yang dikaji mempunyai bacaan WBGT Dalam melebihi 28 °C (ACGIH TLV). **Kesimpulan :** Pekerja terdedah kepada tegasan haba yang sederhana sepanjang kajian ini berlangsung, walaubagaimanapun, suhu teras badan, tekanan darah dan denyutan nadi masih tidak mencapai tahap tegangan kepada fisiologi.

Kata kunci: Tegasan haba, pengukuran denyutan nadi, tekanan darah, industry kilang kelapa sawit, dan tegangan fisiologi.

ABSTRACT

ASSOCIATION BETWEEN OCCUPATIONAL HEAT EXPOSURES WITH PHYSIOLOGICAL CHANGES AMONG PALM OIL MILL WORKERS

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Objective: A cross sectional study was conducted to determine the heat exposure and its effect to physiological changes among palm oil mill workers in Johor. **Methodology:** Seventy four workers from the crude oil production were selected as respondents. Workers who met inclusive criteria were selected by simple random sampling. Variables measured were the environmental temperature (WBGT_{in}), relative humidity, metabolic workload, body core temperature, blood pressure and heart rate. Questemp⁰³⁴ Thermal Environmental Monitor was used to measure the environmental temperature in °C (WBGT_{in}). OMRON Blood Pressure Monitor Model T3 was used to measure blood pressure and heart rate while body core temperature was measured by OMRON MC-510 Gentle Temperature Ear Thermometer. Interviews using questionnaires were used to determine respondents' background, history of risk factor in heat exposure and other information related to heat stress. **Result:** Result showed that the mean environmental (WBGT_{in}) in palm oil mill 1 is 30.60 °C while in palm oil mill 2 was 30.78 °C. These production workers were exposed to heat during their working hour in different sections such as sterilizer, press, kernel, oil room, boiler and engine room. The average time of monitoring was 2 hours for intermittent exposure and 8 hours duration for overall exposure. There was significant difference between heat exposure and physiological changes before shift and after 2 hours ($p < 0.001$) and after working for 8 hours respectively. The average heart rate was in range 83 – 90 bpm indicating that there is no excessive physiological demand. The mean of body core temperature (36.03 ± 0.25 °C) and heart rate (87.39 ± 1.69 bpm) after 8 hours indicated a good body control of exposure. Five out six work sections monitored had temperatures greater than 28 °C (ACGIH TLV). **Conclusion:** The workers were exposed to moderate heat stress during the study period. However, body core temperature, blood pressure and heart rate did not reach unacceptable level of physiological reactions.

Keywords : Heat stress, heart rate measurements, blood pressure, palm oil mill industry, physiological changes

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LIST OF ACRONYMS AND ABBREVIATIONS

<	Less than
>	More than
≤	Less than or equal to
≥	More than or equal to
=	The same or equal to
%	Percent
N	Number of sample (population)
n	Number of sample (sample)
p	Significance level
cm	Centimeter
Kg	Kilogram
°C	Celsius
kcal/hour	Kilocalorie per hour
ACGIH	American Conference of Governmental Industrial Hygienists
NIOSH	National Institute for Occupational Safety and Health
TLV	Threshold Limit Value
WBGT	Wet Bulb Globe Temperature

CHAPTER 1

INTRODUCTION

1.1 Background

Over the past few decades, the palm oil industry in Malaysia has grown significantly. In to 2010, Malaysia has 4.85 million hectares of oil palm (MPOB, 2010) and this industry contributes about RM 60 billion in term of export revenues in 2010 for the country. Malaysia produced about 40 000 to 50 000 of crude palm oil (CPO) per day and production is expected to enjoy steady growth in the coming years.

Based on Economic Transformation Program (2009), the increasing of palm oil production may increase growing number of attractive job opportunities in mill. Processing of FFBS (fresh fruit bunches) in mills and palm kernel crushing to produce crude oil need workers and machine to handle it. Thus, with an increasing

demand of crude production this may create occupational hazards among the palm oil millers.

1.1.1 Heat stress as physical hazards

Workplace health is becoming a major public health issue for employers and all levels of governments (Gerard et al., 2010). Heat is one of the physical hazards that should give attention in environment of the workplace (Cullen et al., and Nadel et al., 1994). Extreme hot environments can overwhelm the body's coping mechanisms leading to a variety of serious and possibly fatal conditions (Azlis et al., 2007). Heat stress can be defined as the aggregate of environmental and physical factors that constitute total heat load imposed on the body (Alpaugh et al., and Hogan et al., 1992).

The temperature of workplace may significantly affect performance and the wellbeing of workers. Additional heat and humidity beyond the heat generated by the body during physical work may lead to notable performance decrement and may place the health of workers at risk (Pulat, 1992). Pulat also stated that high temperature of a workplace can also cause physiological changes such as increase body core temperature, blood pressure, heart rate and increased sweat rate that contribute to heat loss from body.

Workers are potentially exposed to heat will facing heat stress symptoms if they are not protected. Whenever, there is heat stress imposed on the human body will be resulting heat strain and may cause physiological reactions such as increased sweat production, higher body core temperature and increased heart rate (Rodahl, 2003). Under extreme conditions, the heat strain may cause health impairment such as heat cramps, heat exhaustion, heat syncope, heat rashes and heat stroke.

1.2 Problem statement

Palm oil processing is carried out in palm oil mills where oil is extracted from a palm oil fruit bunch. A typical mill has many operation comprises of sterilization, threshing and stripping, oil extraction, clarification, purification and storage. Almost of these processes involving higher temperature in production of oil such as in sterilization and digestion they used steam to cooked the FFB. Then the oil mixture is heated to 85 – 90°C in clarification tank. Besides that, palm oil mill are normally generate their own electricity by burning waste products of fruits, fibre and shell in a boiler. The boiler generates steam which produces very high temperature over 100°C.

This condition has invited uncomfortable atmosphere at working area. Approximately over 50% of workers at the production sections were exposed in higher temperature along their working hours (Jeanne et al., 1998).

The high temperature can influence the productivity of the industry. Joseph (2000) stated when one's ability to respond to heat stress is exceeded it can lead to reduced ability to perform good quality work, increased accidents on the job or health related illness.

In Malaysia, research about exposure to extreme temperature is still at early stage. Based on previous study done by Azwan (2000), Siti Fawziah (2002) and Nurul Ainun (2003) stated that ultimate temperature can reduce the quality of work, mental and physical ability besides increasing the risk of extreme temperature.

Why should this study be carried out? This study is to see the changes occur in physiological (body core temperature, blood pressure and heart rate) by temporal measuring (hourly) on the extreme temperature.

1.3 Study justification

In Malaysia, the study on exposure to high temperature and its effect on physiological changes among workers at palm oil mill industry have not been widely regarded as an important when discussing the problem and hazard faced by workers.

The purpose of this study is to expose all workers with the current work condition and body function specifically to effects of extreme temperature. The data obtained from this study can be applied by certain parties such as department of Occupational Safety and Health (DOSH) in effort to draw and implement guideline and exposure level that is safe and suitable in environment workplace. Furthermore, the enactment of law can be done to overcome the risk of working in high temperature comparable with different risk such as dust, noise and lead as written in Factory and Machinery Act (Act 139).

This study is also to expose the community and the workers specifically to the effects of the ultimate temperature to the heart rate and body core temperature and encourage the individual to be aware of their physiological changes, which they experience while working, regardless if those changes are negative or positive. Equipped of this knowledge and sense of awareness, employees can then identify hazards and risks they face during working.

This study can serve as a guideline for the administration of the factory in terms to provide solution and efficient control measure. This effort is important to ensure the concept of 'Making Safe Work Culture A Reality' that promoted by Department of Occupational Safety and Health will properly implemented by all sectors that involved in this problem to reduce accidents and any injury in the workplace. Hopefully, this study will increase awareness of safety and health among palm oil mill workers especially to the respondents.



1.4 Conceptual framework

The conceptual as figure 1.1 shows the variables involved in this study either the variables are studied or not. Work environment in palm oil processing from hot machinery exposure and type of clothing, are potential factors leading to heat stress.

Variables that will determine in this study are WBGT index and physiological changes on core body temperature and heart rate. The work environments of the occupational consist of environment temperature, air velocity, relative humidity and radiant heat. While physiological changes will observe are body core temperature, blood pressure and heart rate.

Occupational environment which are expose to high temperature can cause physiological changes in which will increase in body core temperature, blood pressure and heart rate. High temperature can affect the normal function of the body and show symptoms of the exposure.

Individuals working in hot environments are at an increases risk for development of heat-related illness such as heat rash, heat cramps, heat syncope, heat exhaustion and heat stroke. There are several factors can affect the potential for workers to developed heat induced conditions. They include acclimatization, physical fitness, age, alcohol and drug usage, atmospheric conditions and workload.

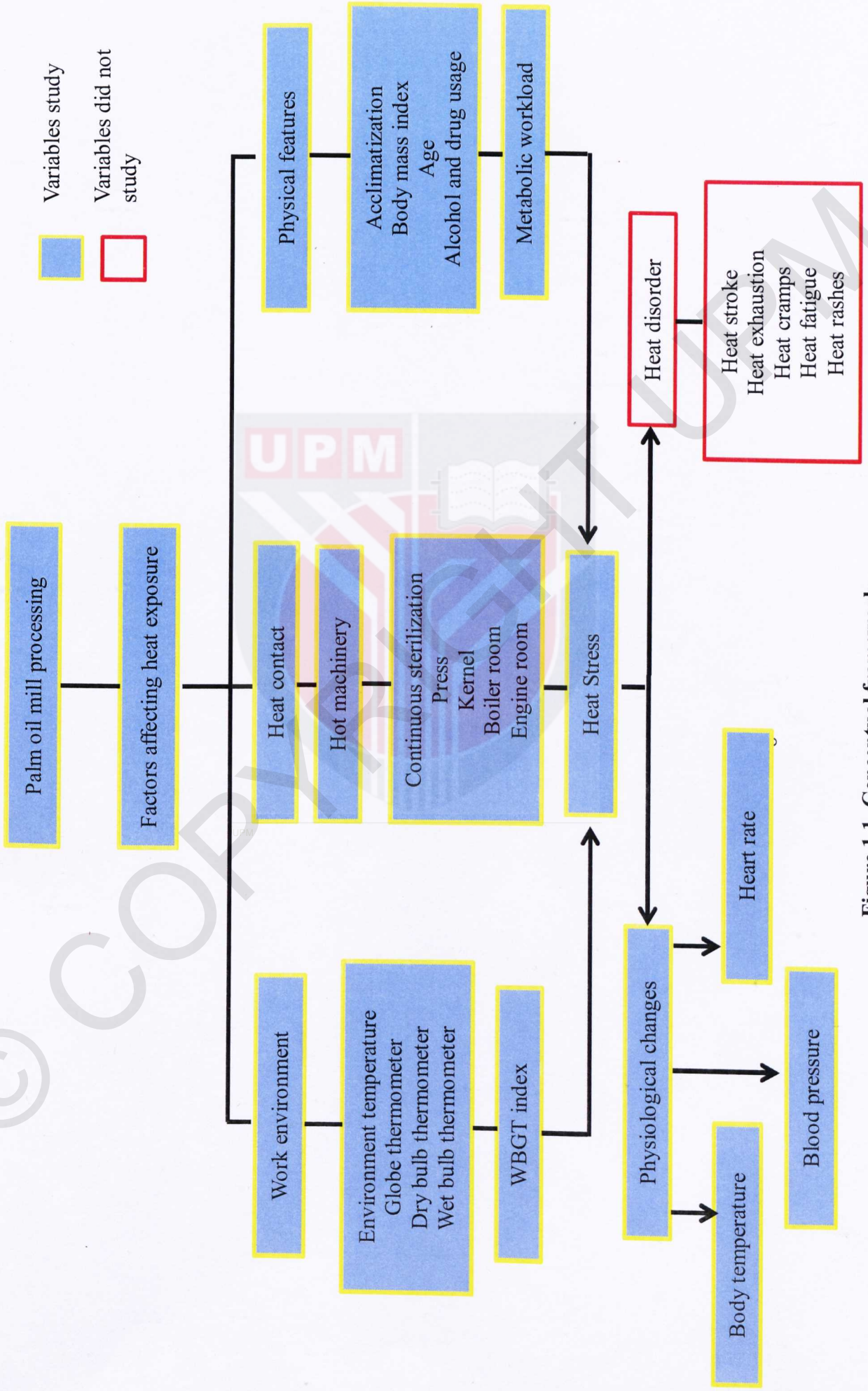


Figure 1.1 Conceptual framework

1.5 Study objectives

General : To determine the heat exposure and the association with physiological changes among palm oil mill workers.

Specific :

1. To measure heat stress index (dry bulb temperature, wet bulb temperature, globe temperature and WBGTin) and classification of heat stress.
2. To measure and compare the physiological parameters (body core temperature, blood pressure and heart rate) before work, after 2 hours and after 8 hours work.
3. To determine the prevalence of heat stress exposure among workers in palm oil processing unit.
4. To determine the correlation between body core temperature and physiological parameters of workers.
5. To determine the relationship between body temperature and contributing factors (age, BMI, systolic BP, diastolic BP and length of employment) among workers

1.6 Research hypothesis

1. There is significant difference between physiological parameters (body core temperature, blood pressure and heart rate) before work, after 2 hours and after 8 hours work.
2. There is significant correlation between WBGT_{in} and physiological parameters.
3. There is significant relationship between body temperature and contributing factors (age, BMI, systolic blood pressure, diastolic blood pressure and length of employment) among workers.

1.7 Definition

1.7.1 Conceptual definition

a) Heat stress

An aggregate of all the heat loss generated by exogenous and endogenous sources that work on the body (Khogali,1992).

b) WBGT (Wet Bulb Globe Temperature)/ Environment Temperature

WBGTin are measured in degree Celsius ($^{\circ}\text{C}$) or degree Fahrenheit ($^{\circ}\text{F}$). It is measured using four parameters : ambient or dry bulb temperature, natural wet bulb bulb temperature, globe temperature and relative humidity (Quest Technologies, 2003).

c) Relative Humidity

Relative humidity is measured using a natural wet bulb thermometer, which measres the amount of evaporative cooling taking place in an environment (Quest Technologies, 2003).

d) Globe Temperature (G)/ Radiant heat

Exposure to radiant heat is measured by the globe thermometer, which measures the heat form the environment, which will contribute to environment (Quest Technologies, 2003).

e) Dry bulb thermometer (DB)/ ambient air temperature

Dry bulb thermometer is temperature measured by a dry bulb thermometer. It is the temperature of workplace when a high solar heat load is present (Quest Technologies, 2003).

f) Air velocity

Wind, whether generated by body movement or air movement (V_a), is the rate in meters per second (m/sec) at which the air moves and is important in heat exchange between the human body and the environment, because of its role and in convective and evaporative heat transfer (ACGIH), 1986). Air velocity is measured base on direction of air. Situation for thermal comfort that recommended is not over 0.25 m/s (Jeanne, 1998).

g) Heart rate

Heart rate can be defined as rate of heartbeat. This rate has an effect on blood pressure. Each complete heart beat called a cardiac cycle. A cardiac cycle includes contraction (systole) and relaxation (diastole) of atria and ventricles (Thibodeau & Patton, 1997).

h) Body core temperature

The body core temperature is defined as the temperature of the tissues 2.5cm beneath the surface of the skin (Green et al.,1996).

i) Blood pressure

Blood pressure is the pressure or push of blood. It exist in all blood vessels, but it is highest in the arteries and lowest in veins. Blood pressure is influenced by four factors which are blood volume, strength of heart, heart rate and blood viscosity (Thibodeau & Patton, 1997).

1.7.2 Operational definition

a) Heat stress

Determined by measuring four parameters : WBGTin, Globe Temperature, Natural Wet Bulb Temperature, Relative Humidity and Dry Bulb Temperature as well as collecting other information such as workers' work load and exposure time (Angus, 1968).

b) WBGT (Wet Bulb Globe Temperature)/ Environment Temperature

Questemp^o34 Thermal Environment Monitor is placed at the workplace that expose to heat. The instrument records reading for eight hour per shift and calculates the WBGTin in index in degree Celcius (°C) automatically. The recorded data will be printed out the rate of 15 minutes per reading. (Quest Technologies, 2003).

c) Relative Humidity

The Natural Wet Bulb Thermometer gives an indication of the effects of humidity on an individual. Measurements are taken using a thermometer covered by a moistened cotton wick immersed into a reservoir containing distilled water. The information will be used in calculating the WBGT_{in} (Quest Technologies, 2003).

d) Globe Temperature (G)/ Radiant heat

The globe temperature gives an indication of the radiant heat exposure in an individual. A sensor is positioned inside a blackened copper sphere and the temperature rise in measurement. The information will be used in calculating the WBGT_{in} (Quest Technologies, 2003).

e) Dry bulb thermometer (DB)/ ambient air temperature

The dry bulb thermometer measures the ambient air temperature. This calculation is used in outdoor WBGT calculation when high solar radiant heat load may be present. The series of white plates surrounding the sensor shield it from radiant heat. The information will be used in calculating the WBGT_{in} (Quest Technologies, 2003).

f) Air velocity

Air velocity was measured by using Velocicheck Model TSI 8850. Measurement was done along eight hour of the work shift at the plant studied.

g) Heart rate

Heart rate unit is determined by the number of heartbeats per unit of time, typically expressed as beats per minute (bpm). The measurement of heart rate used OMRON T3 Automatic Blood Pressure which functions automatically. Reading is taken before work, after 2 hours and after work shift. Normal heart rate in adults is 60 – 90 bpm (Ramaekers, 1998)

h) Blood pressure

Blood pressure unit is in mmHg and heart rate recovery in beats per unit is measure using Omron T3, which functions automatically. Reading is taken before work, hourly during shift and after finish the work shift. A normal range arterial blood pressure value ≥ 10 (Thibodeau & Patton, 1997)

i) Body core temperature

Body core temperature was measured in degree Celcius ($^{\circ}\text{C}$) by using OMRON MC510 Gentle Temperature Ear Thermometer. This instrument measures the temperature through a thermo scan beam on the ear's tympanic membrane by continuous measurement.

CHAPTER 2

LITERATURE REVIEW

2.1 Heat stress

Heat is a form of energy. It can be generated either endogenous or exogenous process (Simon, 1994). Heat stress is cumulative of environmental and physical works factors that constitute the total heat load imposed on the body. The environmental of heat stress include air temperature, relative humidity, air flow velocity, radiant heat exchange, air movement and water vapor pressure. While the physical work will contributes to the total heat stress of the job by producing metabolic heat in the body in proportion to the intensity of the work. Clothing requirements also will affect the heat stress (ACGIH, 2001).

Heat stress represents an imbalance between the heat produced by an individual and the heat loss allowed to the environment. The latter is more often controlled by the clothing worn than by any combination of environmental conditions, there is no

single temperature or combination of temperature and humidity at which heat stress can be said to begin (Goldman et al. 1999).

The American Conference of Governmental Industrial Hygienists (1992) stated that workers should not be permitted to work when their deep body temperature exceeds 38°C (100.4°F). There are three workplace factors that influence the level of heat stress experienced by an individual and they are environmental conditions, work demands and clothing (Barker et al., 1999). Four components come into play when discussing environmental condition: temperature, humidity, radiant heat and air velocity (US Department of Labor, 2002).

2.2 Heat exchange

Heat exchange also known as heat balance taken into account the five source of heat gains and heat losses to determine if a body is able to maintain thermal equilibrium or if a body is experiencing an increase in heat storage. The five sources are fit into an equation as follows;

$$H = M \pm R \pm C_v \pm C_d - E \quad \text{———— Formula 1}$$

Where:

- E = evaporative heat loss
- H = body heat storage load
- M = metabolic heat gain
- R = radial/infrared heat load
- C_v = convection heat load
- C_d = conductive heat

The heat balance equation incorporates the major modes of heat exchange or loss by the body. As long as heat gained from radiation, convection and metabolic process does not exceed that loss through evaporation (Goestch et al., 1999)

2.3 Mechanism of heat transfer

The major modes of heat exchange between man and the environment are convection, radiation and evaporation.

2.3.1 Conduction

Conduction is the transfer of heat between two bodies that are touching or from one location to another within a body (Goestch et al., 1999). According to (John et al., 2011) conduction is the flow of heat through solids and liquids by vibration and collision of molecules and free electrons. (Nahle, 2010) stated that the molecules in a segment of a system at high temperature vibrate faster than the molecules in other regions of the same or another's systems which are at lower temperatures. The molecules with higher motions strike the less energized molecules and transfer some of their energy to the molecules at the colder regions of the system. Figure 2.1 showed the conduction processed.

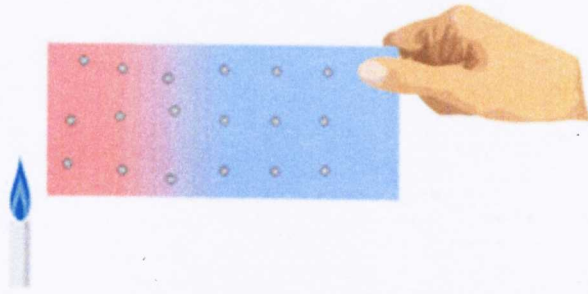


Figure 2.1 Conduction-as heated particles collide with their neighbours, energy is transferred from the hot side to cold side of the object by conduction (Source : <http://www.hk-phy.org/energy/domestic/heat>. Web. Retrieved on: March 18, 2012)

2.3.2 Convection

According to OSHA (2002), convection is transfer of heat in moving fluid. Air flowing past the body can cool the body if the temperature is low. On the other hand, air that exceeds 35°C can increase the heat load on the body. Convection is the transference of heat by air movement or body motion (<http://armymedical.tpub.com>) as showed in figured 2.2. Cool air making contact with the body is warmed and carried away by convection currents. More cool air moves over and around the body and is carried away by convection currents again. The faster the air moves, the faster the rate of convection. A person loses about 15 percent of body heat into the air by this method of heat transfer.

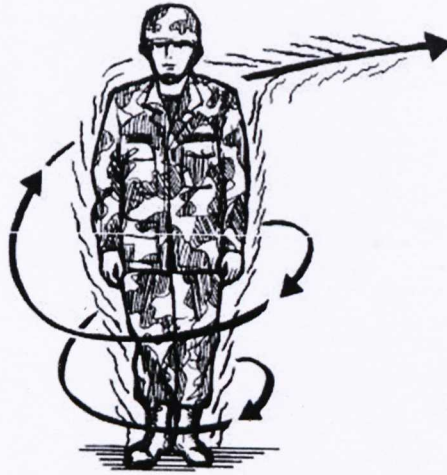


Figure 2.2 Convection – body heat to air (Source: <http://armymedical.tpub.com>.

Web. Retrieved on: March 23, 2012)

2.3.3 Evaporation

The evaporation of water (sweat) from the skin surface results in a heat loss from the body (NIOSH, 1986). At environmental temperatures above about 36°C, heat is lost exclusively by evaporation. At higher temperatures heat is taken up by the body from the environment by radiation, conduction and convection. Sweating then becomes profuse in order to maintain the balance between heat uptake and heat loss by evaporation. In order to be effective, sweat must be evaporated from the skin as showed in figure 2.3. If sweat merely drips from the surface of the skin or is wiped away, no heat will be lost (U.S Department Labor, 1999).

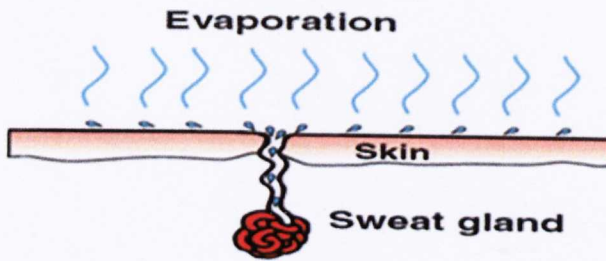


Figure 2.3 Sweat has to evaporate from skin to cool off body (Source : <http://www.fs.fed.us/t-d/pubs/htmlpubs>. Web. Retrieved on: March 23, 2012)

2.2.4 Radiation

Transfer of heat energy through space. A worker whose body temperature is greater than the temperature of the surrounding surfaces radiates heat to these surfaces. Hot surfaces and infrared light sources radiate heat that can increase the body's heat load (OSHA, 2005). Figure 2.4 showed the radiation processed.

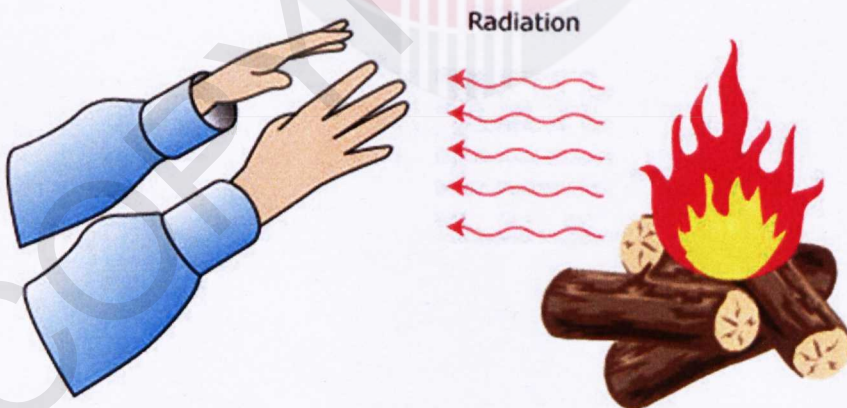


Figure 2.4 Radiation is the heat that feel coming from a fire. It warms the air using heat waves that radiate out from the fire in all directions until it is absorbed by objects (Source : <http://www.sciencelearn.org.nz>. Web. Retrieved on: March 18, 2012)

2.4 Physiological Response to Heat

2.4.1 Central Nervous System

The central nervous system is responsible for the integrated organization of thermoregulation. The hypothalamus of the brain is considered to be the central nervous system structure which acts as the primary seat of control (Guyton et al., 1996). Guyton also stated that, in general terms, the anterior hypothalamus operates as an integrator and 'thermostat' while the posterior hypothalamus provides a 'set point' of the core deep-body temperature and initiates the appropriate physiologic responses to keep the body temperature at the 'set point' if the core temperature changes.

According to Guyton et al., and Kapit et al., (1996) stated that, the body keeps its core temperature constant at about 37°C by physiological adjustments controlled by the hypothalamus (thermostat center) where there are neurons sensitive to changes in skin and blood temperatures. The temperature-regulating centers are found in the anterior portion of the hypothalamus. This area receives input from temperature receptors in the skin and mucous membranes (peripheral thermoreceptors) and from internal structures (central thermoreceptors), which include the hypothalamus itself. The temperature sensory signals from the preoptic area and those from the periphery are combined in the posterior hypothalamus to control the heat producing and conserving reactions of the body. The hypothalamic thermostat works in conjunction with other hypothalamic, autonomic and higher nervous

thermoregulatory centers to keep the core temperature constant. Some of these thermoregulatory responses are involuntary, mediated by the autonomic nervous system, some are neurohormonal and others are semi-voluntary or voluntary behavioral responses.

Based on NIOSH (1986), the anterior hypothalamus is the area which receives the information from the receptors sensitive to changes in temperature in the skin, muscle, stomach, other central nervous system tissues and elsewhere. In addition, the anterior hypothalamus itself contains neurons which are responsive to changes in temperature of the arterial blood serving the region. The neurons responsible for the transmission of the temperature information use monoamines among other neurotransmitter.

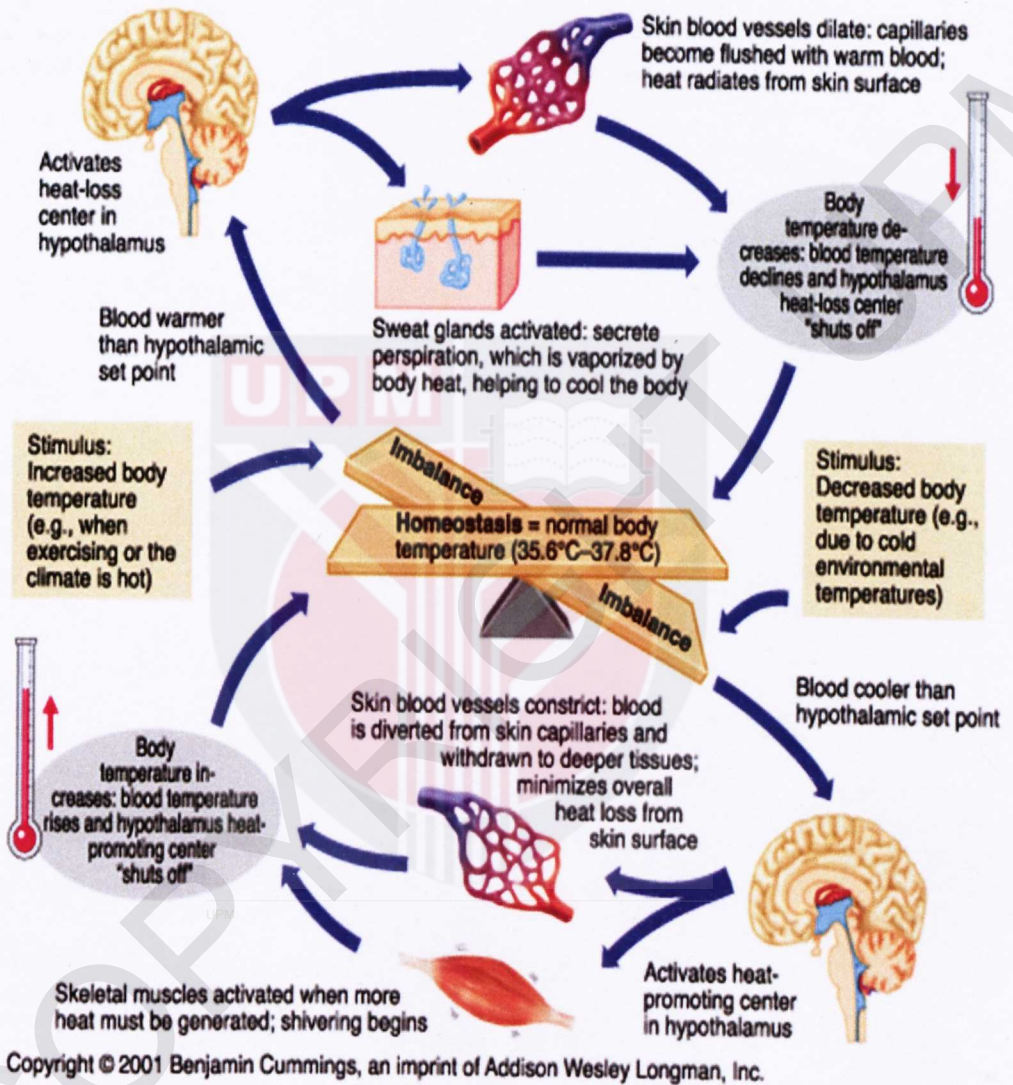


Figure 2.5 Thermoregulation.

(Source: <http://schoolworkhelper.net/2010/07/thermoregulation/>. Web. Retrieved on: 16th June 2012.)

2.4.2 Blood Pressure

Blood pressure is the pressure or push of blood (Thibodeau & Patton, 1997). It is the force caused by blood pushing up against the walls of the blood vessels (Green et al., 1996). It exists in all blood vessels, but it is highest in the arteries and lowest in the veins. Blood pressure is influenced by four factors, namely blood volume, strength of heart, heart rate and blood viscosity. A normal average arterial blood pressure is about 120mmHg systolic pressure and 80mmHg diastolic pressure. Systolic pressure is the maximum arterial pressure during each cardiac cycle while the diastolic pressure is the minimum arterial pressure during a cardiac cycle.

According to Kunst et al., (1993), exposure to higher or lower ambient temperature causes stress on the circulatory and other body systems. Exposure to higher temperatures causes an increase in blood viscosity and blood cholesterol levels and coupled with weak airflow and high relative humidity it reduces the evaporation of sweat and impairs body cooling (Zhou et al., 1999). If an individual's body cannot dispose of excess heat, it will store it (CDC, 2011)

In acute heat exposure, there is an increase in blood circulation at the skin and exercising muscles areas, and this met by a decrease of blood circulation at the renal, splanchnic in the mesoderm and non-exercising muscles (Nielson et al., 1993). When the body is overheated, blood flow to the skin increases to lose the excess heat and to maintain the stability of the internal movement. Warm blood from the body's core can then be cooled from the skin, which acts as a radiator. A continuous increase in

skin blood flow will lead to stress in the body's circulating systems (Thibodeau et al., & Patton et., 1997).

2.4.3 Heart rate

Heart rate is the rate of heart beat. This rate has an effect on blood pressure. Each complete heart beat is called a cardiac cycle includes contraction (systole) and relaxation (diastole) of atria and ventricles. Each cycle is completed in about 0.8 seconds (Thibodeau & Patton, 1997).

2.5 Factors affected by heat

2.5.1 Body morphology

Obesity is a liability when working in the heat because the specific heat of fat is much greater than that of muscle tissue, excess fat increases the insulator properties of the body surface and retards conduction of heat to the periphery (Carlisle, 2010). However, the extent that percentage body fat may impede thermal regulation is not fully known. In addition to possibly interfering with heat exchange, excess fat directly adds to the metabolic cost of activities in which the body weight must be moved, resulting in increased metabolic heat production (Kolka et al., 1993).

2.5.2 Gender

Sweat rate differences between males and females have been reported (Meyer et al., 1992; Kolka et al., 2001). Men repeatedly have been shown to have higher sweat rates than women in hot-dry and hot-wet climates, with their sweat rates often increasing more than those of women during heat acclimatisation. Women however, seem to be at least as efficient in temperature regulation as men because they maintain the same core body temperature (Armstrong & Maresh, 1991). Meyer et al. (1992) however, report that men and women have similar sweating rates when matched for VO₂ max (45 mL/kg min).

Meyer also stated that men having higher sweat sodium concentrations than women (60 mmol/L compared to 40 mmol/L) when exercising for 40 mins at 50% VO₂ max in 42°C and 18% RH. These losses were attained by the collection of sweat via a plastic bag attached to the lower back. The same author also reported that the concentration of sweat sodium in healthy subjects increases with age. The sweating response in this study was however pharmacologically rather than thermally induced. The method used to induce sweat may be important since the response by the sweat gland cannot be assumed to be the same for both modalities.

2.5.3 Age

The rate of sweating depends on many factors and is increased in proportion to the work rate and the environmental temperature and humidity (Maughan, 1991). Sweat rates are highly variable among individuals, and can often reach 2 L/hr for marathon runners exercising for prolonged periods. Middle aged men 45 years or older were shown to have higher heart rates, higher rectal temperatures and lower sweat rates than their younger counterparts during exercise in the heat, both pre- and post-acclimatization. Other reports of thermoregulatory decrements occurring with age have also been reported (Davies, 1979; Cena & Spotila, 1986).

2.5.4 Acclimatization

According to Angilletta, et al., (2009), acclimatization or acclimation is the process of an individual organism adjusting to a gradual change in its environment, (such as a change in temperature, humidity, photoperiod, or pH) allowing it to maintain performance across a range of environmental conditions.

Muza et al., (2004) stated that, continuous or repeated exposure to hot condition brings about a gradual adjustment of body functions resulting in a better tolerance of the climatic stress and improvement of physical work capabilities. Muza also stated overall acclimatization of heat is demonstrated by an increases sweat production, by lowered skin and core temperatures and by reduced heart rate, compared with the

reactions of the unacclimatized person at first exposure to hot climate. The process of acclimation is pronounced within about a week and full acclimatization is achieved within about 2 weeks.

2.6 Heat related illness

2.6.1 Heat cramps

Although the precise cause of heat cramps or involuntary muscle spasms has not been elucidated, much of the research concentrates on electrolyte imbalances in the exercising muscle and/or dehydration. Armstrong and Maresh (1991) reported heat cramps in the skeletal muscles of the legs, arms and abdomen of individuals who had lost a large volume of sweat and had drunk a large volume of unsalted fluid. It is assumed that adequate replenishment of both water and electrolytes can prevent heat cramps. These authors also concluded that heat cramps are less likely in acclimatized individuals. The main symptom of this condition is painful involuntary contraction of muscle.

2.6.2 Heat exhaustion

Heat exhaustion is believed to be caused by ineffective adjustments in the circulatory system, compounded by depletion of extracellular fluid (especially blood volume), owing to excessive sweating and inadequate fluid replacement. Blood

usually pools in the dilated peripheral vessels. This combination of factors drastically reduces the venous return necessary to maintain adequate cardiac output. Armstrong and Maresh (1991) stated that the incidence of heat exhaustion signs and symptoms is relatively high during the first eight days of heat acclimatization. This condition is characterized by weakness, vertigo, headache, nausea and peripheral vascular collapse.

2.6.3 Heat stroke

Heat stroke is essentially a failure of the heat regulating mechanisms as indicated by excessively high body temperatures. Although sweating usually ceases upon failure of thermoregulation, continued intense exercise may be accompanied by some sweating, but heat gain by the body greatly outstrips heat loss. If untreated, the disability progresses until death ensues due to circulatory failure and eventual damage to the central nervous system due to hypoxia and hyperthermia. Armstrong et al., and Maresh et al., (1991) report that there is no currently recognized relationship between heat acclimatization and the incidence of heat stroke which is characterized by hyperpyrexia, cessation of sweating.

According to Bouchama et al., (2002) stated that, the individual may become irrational or hallucinogenic. If untreated, the symptoms will cause collapse of the circulatory system, damage to the central nervous system, and death. Immediate first

aid is necessary for heat stroke. The person should be placed in a cool water bath or surrounded with ice packs.

2.6.4 Heat syncope

According to Armstrong et al., (2003), heat syncope another stage in the same process as heat stroke, occurs under similar conditions as heat stroke and is not distinguished from the latter by some authorities. Lawrence also stated that, the basic symptom of heat syncope is a body temperature above 40°C (104°F) with fainting, or weakness but without mental confusion, which does occur in heat stroke. Heat syncope is caused by mild overheating with inadequate water or salt. In young persons, it is far more common than true sunstroke.

Long hours of standing, postural changes or physical activity in hot weather can cause heat syncope. Weakness, light-headedness, restlessness, nausea, a sinking feeling, blurring of vision rapidly and markedly falling systolic blood pressure and weak pulse characteristic heat syncope. A victim's skin is also moist and cold to touch (Khogali, 1992).

2.6.5 Heat rash

Heat rash is also known as miliaria. These rashes occur in several forms. This heat related skin conditions do not have any long term implications (Bellin, 1999). They occur in hot and humid environment where sweat is not easily removed from the surface of the skin by evaporation and sweat gland become inflamed (CDC, 2011). These reduce the body's ability to tolerate heat and sweat adequately (Lugo-Amador et al., 2004).

Heat rash is the areas of the skin break out in small red, blister like, raised bumps caused by plugging of sweat gland ducts, retention of sweat and inflammation. This is also called 'prickly heat' because of the pricking sensation felt during heat exposure (James, 2006).

2.7 Previous study on effect of heat among industrial workers in Malaysia

Previous study showed that extreme temperature caused physiological changes in human body. As an example, a study that conducted by Goh (2001) in a plastic based factory showed Heat Stress Index (WBGT) is 28.75°C with their air velocity rate is 0.15 m/s and relative humidity rate is 55.10%. this show that Heat Stress Index (WBGT) is about the standard rate allowed by ACGIH, according Goestch (2000), another symptom that heat stress occurs among workers are increasing of heart rate 180 minus with age of the worker, increasing of body core temperature over than 38.5°C , fatigue, vomiting and headache. Table 2.1 showed the previous study conducted in Malaysia that the heat index mostly exceed the ACGIH standard rate except the study done by Nurul Ainun (2003)

Table 2.1 : Study prevalence on extreme temperature among industry workers in Malaysia (ACGIH TLV 25.9°C based on 75% working, 25% resting)

Researcher	Industry	Research sample	Result
1. Sharifudin (1997)	Iron and steel	N=306	High prevalence of acute and chronic symptoms Category : hot group
2. Azwan et. al (2000)	Automotive	N=112	WBGT TWA8 (31.8°C & 28.5 °C) Category : hot
3. Muhammadong (2000)	Iron	N=96	WBGT _{in} = 29.0 °C Category: hot and stress
4. Azwan et. al (2001)	Steel	N=164	WBGT _{in} > 28 °C Category: hot
5. Goh (2001)	Plastic	N=45	WBGT _{in} = 28.75 °C Category: hot
6. Siti Fawziah (2002)	Iron	N=34	WBGT _{in} = 30.25 °C Category: very hot and stress
7. Nurul Ainun (2003)	Automotive	N=42	WBGT _{in} = 27.28 °C Category: hot
8. Muznita (2003)	Automotive	N=42	WBGT _{in} = 29.81 °C ± 1.23 °C Category: very hot and stress
9. Victor Lazarus (2003)	Mill	N=42	WBGT _{in} > 28 °C Category: hot
10. Normalina (2004)	Petrochemical	N=60	WBGT _{in} 35.15 °C Category: very hot
11. Dubashini (2004)	Steel	N=60	Mean WBGT _{in} = 29.1 °C
12. Nur Hidayah (2005)	Rice Mill	N=42	WBGT _{in} = 30.1 °C Category: very hot
13. Norhadi Kasah (2005)	Canned Soup	N=26	WBGT _{in} = 31.6 °C Category: very hot
14. Nurul Izzah (2006)	Automotive	N=107	WBGT _{in} = 30.73 °C Category: very hot

CHAPTER 3

METHODOLOGY

3.1 Study Design

This is cross-sectional study design with the objective of determining heat exposure and the physiological parameters in terms of body core temperature, blood pressure and heart rate among workers in palm oil mill processing, Kota Tinggi, Johor.

3.2 Study Location

This study was conducted in 2 palm oil mills processing at Kota Tinggi, Johor. The palm oil mill processing was chosen because most of the production line workers are exposed to high temperature due to the heat emitted from the machinery.

3.2.1 Background Study Location

This study was conducted in Kota Tinggi Palm Oil Mill. This palm oil mill is under FelDa Palm Oil Industries. Its business activities focus on processing palm kernels produced by FELDA estates and selling kernel product, Crude Palm Kernel Oil (CPKO) and its by-product Palm Kernel Expeller (PKE).

There are consist approximately 80 workers in palm oil mill. In production line, there are several processes in each section that exposed workers to heat. Workers in production line have shift works which morning shift and night shift.

3.2.2 Work Process of Palm Oil Mill

There are several processes in a palm oil mill; the first process is a loading ramp. The loading ramp automates the discharging of FFB to the FFB conveyor. Automatic feeding system is to ensure no blockages occur at the discharge doors and also constant feeding to the FFB conveyor is also achieved.

Second process is, the FFB went to continuous sterilization where the FFB are cooked using steam at 40 psig. This continuous sterilization has horizontal cylindrical autoclaves that cooked for 60-90 minutes. The each cage of continuous sterilizer can hold 2.5 to 10 tons of FFB. Steam consumption varies from 140 kg/ton FFB for a single-peak cycle to 224 kg/ton FFB for a triple peak cycle.

Next, the FFB went to stripping or threshing process that involves separating the sterilized fruits from the bunch stalks. Sterilized FFBs are fed into a drum stripper and the drum is rotated, causing the fruits to be detached from the bunch.

After stripping, the fruits are moved into a digester where, the fruits are reheated to loosen the pericarp. The steam heated vessels have rotating shafts to which are attached stirring arms. The fruits are passed into a screw press, where the mixture of oil, water, press cake or fibre and nuts are discharged.

Then, a mixture of oil, water, solids from the bunch fibres is delivered from the press to a clarification tank. The mixture containing the crude oil is diluted with hot water to reduce its viscosity. A vibrating screen helps remove some of the solids. The oil mixture is heated to 85-90°C and allowed to separate in the clarification tank. A settling time for clarification is 1 to 3 hour. Oil from the top is skimmed off and purified in the centrifuge prior to drying in vacuum dryer. The final crude palm oil is then cooled and stored. The lower layer from the clarification tank is sent to the centrifugal separator where the remaining oil is recovered. The oil is dried in vacuum dryers, cooled and sent to storage tanks. The figure 3.1 showed the work process in the palm oil mill, Kota Tinggi.

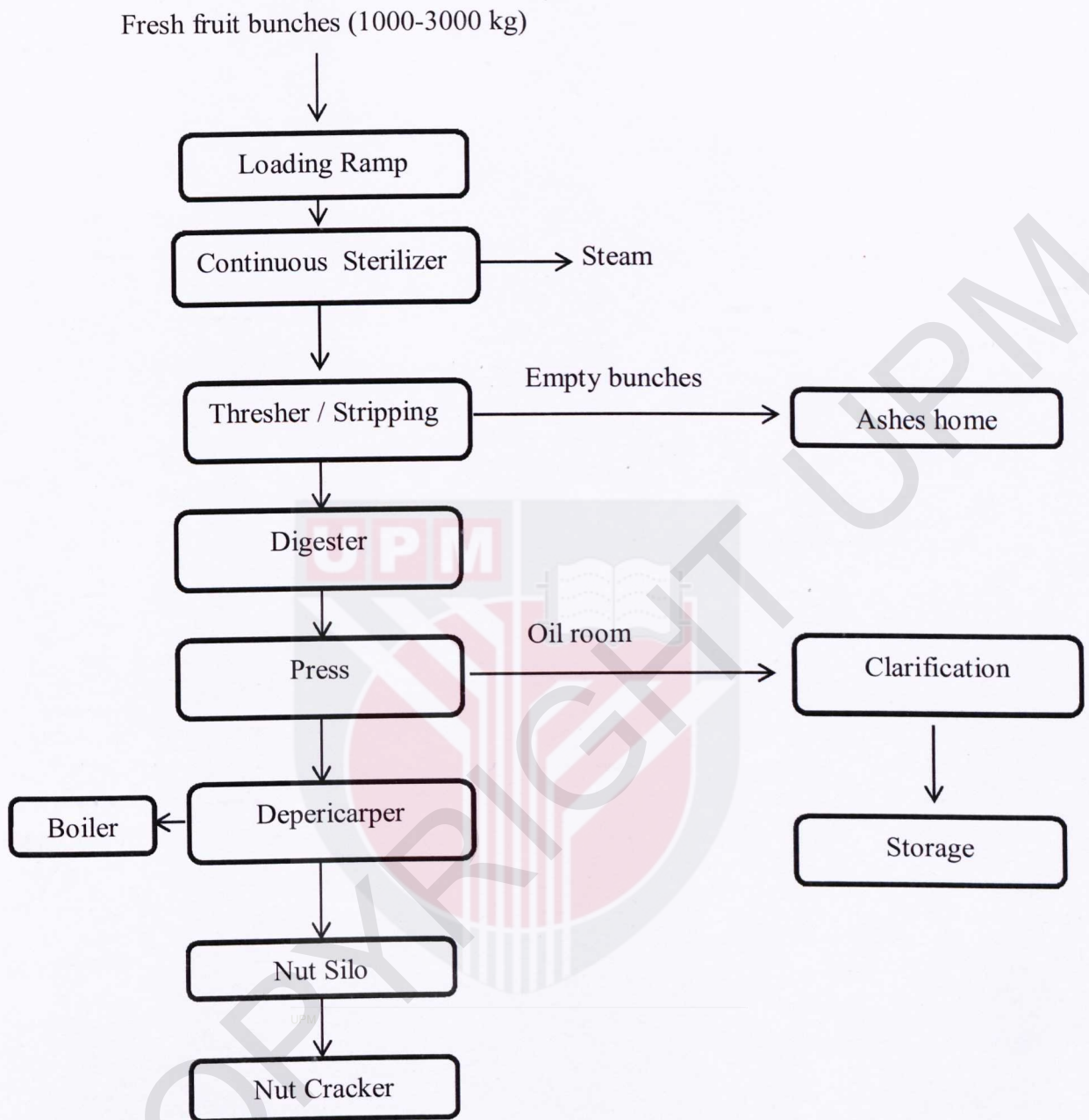


Figure 3.1 Work process in Felda Palm oil mill, Kota Tinggi

3.3 Study Population

The target population of this study is the workers in processing unit of palm oil mill in Felda Palm Oil, Kota Tinggi, Johor

3.4 Study Sample

3.4.1 Sampling frame

The sampling frame is a list of workers in processing unit at Felda Palm Oil Mill, Kota Tinggi, Johor obtained through human Resources Department. Workers who met the inclusive criteria were selected using simple random sampling.

3.4.2 Sampling Unit

The sampling unit is workers who are working in processing unit of palm oil that fulfills the inclusive criteria and exclusive criteria.

3.4.2.1 Inclusion criteria

- a) Male worker
- b) Production line workers and full time working in the factory
- c) Between 20-50 years of age (Debra,1999)

3.4.2.2 Exclusion criteria

- a) Has been diagnosed with :
- Diabetes, Hypertension, Asthma and Heart Disease
- b) BMI > 30kg/m²

3.4.3.3 Sampling size

Sampling Size Calculation

Sampling size is based on Snedcor and Cochran (1982) formulas as below :

$$\begin{aligned} N &= 4 \delta^2 / L^2 \\ &= 4.0 (17)^2 / (5)^2 \\ &= 47 \text{ respondents} \end{aligned}$$

Where

N = Sample size

δ = Standard deviation (SD) of previous study. The value of standard deviation is 17

L = Reliability of the research

Based on Vangelova (2006), the value of standard deviation for systolic blood pressure of heat exposed workers is 17. This standard deviation is chosen because gives the highest number of respondent compared to other variables. Calculation sample size is done by using 95% confidence interval (probability $\alpha \leq 0.05$). Even though only 47 samples are needed, 20% was added from the sample size to overcome the withdrawal of respondent and error during collecting data. Therefore 60 samples was collected in this study.

3.5 Method and Instrumentation

3.5.1 Questionnaire

A well-structured questionnaire in Bahasa Melayu was used to collect the information from respondents. The questionnaire used in this study divided in several parts; Part A is about the information regarding to individual background of the respondents, part B is working information, and lastly part C the question was asked about respondent's medical history, respondent's employment at the factory and health complaints when start working at this processing unit. Pre-test was conducted before the actual data are collecting. Respondent was interviewed in order to complete the questionnaire. Five to ten minutes were needed to finish a set of questionnaire.

3.5.2 Questemp⁰³⁴ Thermal Environmental Monitor

This instrument (Figure 3.2) was used to measure the WBGT_{in} or the environmental temperature for the work areas. It should be fixed on a tripod at 3.5 feet (1.1m) for standing individuals and 2 feet (0.6 m) for seated individuals. Its natural wet bulb thermometer cotton wick must be moistened and immersed in a reservoir containing distilled water. Ten minutes allowance was given to stabilize the readings and then the instrument was programmed to record and monitored the WBGT_{in} for hourly in the shift with a logging 15 minutes. This measurement was taken for 8 hours of working shift.

WBGT values are calculated by the following equations (NIOSH, 1986):

$$WBGT = 0.7WB + 0.3GT$$

Where: WBGT= Wet Bulb Globe Temperature index
 WB = Wet-Bulb Temperature
 GT = Globe Temperature

Eight hours exposure is a standard where calculation based time-weighted average WBGT (TWA-WBGTindoor) with the equation below (NIOSH, 1986):

$$\frac{WBGT_1 \times t_1 + WBGT_2 \times t_2 + \dots + WBGT_n \times t_n}{t_1 + t_2 + \dots + t_n} \quad (1)$$

Where:

$WBGT_1 \times t_1 + WBGT_2 \times t_2 + \dots + WBGT_n \times t_n =$ WBGT values per hour
 $t_1 + t_2 + \dots + t_n =$ duration of exposure per hour

Work load category is determined by averaging metabolic rates for the tasks and then ranking them either in light, moderate and heavy workload. The following equation showed calculation average metabolic rate (ACGIH, 2001):

$$\text{Average} = \frac{(M_1)(t_1) + (M_2)(t_2) + \dots + (M_n)(t_n)}{t_1 + t_2 + \dots + t_n} \quad (2)$$

Where: M = metabolic rate
 t = time in minutes



Figure 3.2 Questemp⁰34 Thermal Environmental Monitor

3.5.3 Seca Body Meter and Tanita Weighing Scale

The height and weight of the respondents were used to calculate their body mass index (BMI). Both measurements are taken before work. Seca Body Meter (Figure 3.3) was used to measure the height of workers. Tanita Weighing Scale (Figure 3.3) was used to scale the weight.



Figure 3.3 Seca Body Meter and Tanita Weighing Scale

3.5.4 Omron MC-510 Gentle Temperature Ear Thermometer

The ear thermometer (Figure 3.4) was used to measure the respondent's body core temperature. The sensor was inserted into the right ear and measurement will be taken. Respondents has been asked to calm and do not allow to talk while reading is taken. This measurement was taken before workers start their work, after 2 hours working and after 8 hours working.



Figure 3.4 Omron MC-510 Gentle Temperature Ear Thermometer

3.5.5 Omron T3 Automatic Blood Pressure Monitor

This instrument (Figure 3.5) was used to measure blood pressure and heart rate. It sense the systolic and diastolic the blood pressure value. This digital instrument function in automatically and the readings was take after it stop constantly for the systolic and diastolic blood pressure. The cuff was placed onto the left arm and was ensure that respondent remained in position while measurements are taken. The respondent are also to be told do not eat, drink or relieve at least 15 to 30 minutes before the measurement are taken.

Measurement was taken in a quiet and calm place because excessive noise can influence the rate and affect the reading. This measurement was taken 3 times which are before work, after 2 hours working and after 8 hours working.



Figure 3.5 Omron T3 Automatic Blood Pressure Monitor

3.5.6 Data collection workflow

Figure 3.6 showed the data collection workflow during the study conducted. The process was started at workplace environment where the measurement and subject are recruited. Next, the physiological monitoring which is body core temperature, blood pressure and heart were measured.

Data collection workflow

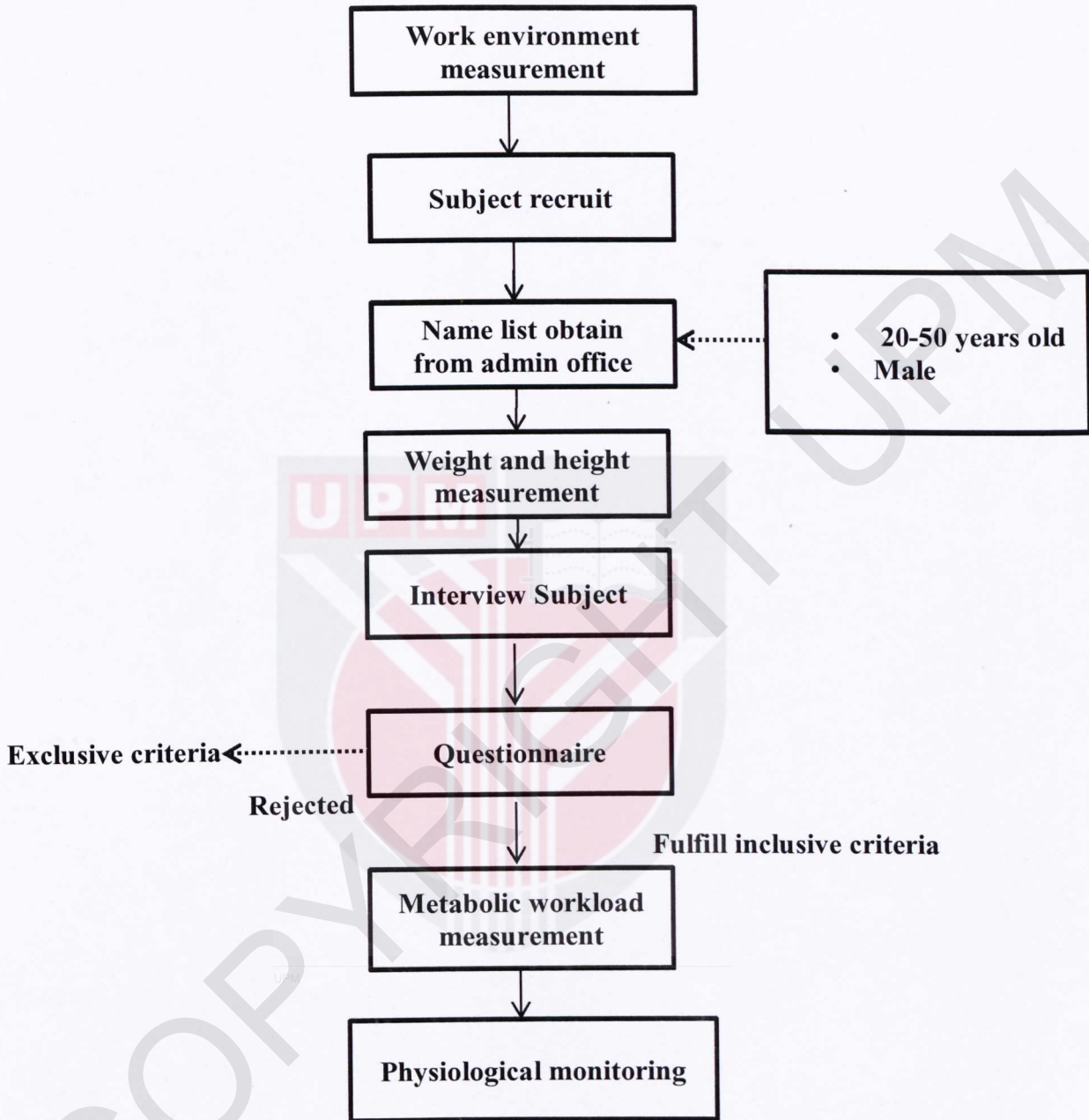


Figure 3.6 Data collection workflow

3.6 Data Quality Control

3.6.1 Pre-test of questionnaire

A pre-test was conducted to ensure the reliability and validity of the questionnaire used in this study. Ten percent (10%) of the sample size was used to test the questionnaire to ensure all the questions are relevant and easy to understand in the field of this study. The Cronbach's Alpha test was used to measure reliability of the questionnaire use in this study.

Reliability test was done using SPSS version 18.0 and the Alpha value for test done is 0.625. Hair et al. (1998) stated that reliability estimates between 0.60 and 0.70 represent the lower limit of acceptability in quantitative research studies. Thus alpha value greater than 0.60 for reliability estimates is considered adequate.

3.6.2 Standard Operating Procedure (SOP) for every instrument

An important aspect of a quality system is to work according to unambiguous Standard Operating Procedures (SOPs). A Standard Operating Procedure is a document which describes the regularly recurring operations relevant to the quality of the investigation. The purpose of a SOP is to carry out the operations correctly and always in the same manner. Every instruments used in this study was followed the SOPs providing by manufacturer.

3.6.3 Calibration of Questemp⁰³⁴ Thermal Environmental Monitor

The Questemp⁰³⁴ Thermal Environmental Monitor must be calibrated before use. It is to ensure the instrument is in good condition and to minimize error while taking the reading.

3.6.4 Adequate training before start using the instrument

Having a basis for most instrument used are needed in this study. The importance of adequate training for every instrument was done prior to minimize the error when process of collecting data. Missing and incomplete data was also can be eliminated when appropriate training was conducted before go for the field measurement.

3.7 Data analysis

All data gather for this study was analyzed using the latest statistical computer software, Statistical Package for Social Science (SPSS Windows) version 18.0.

Univariate analysis was used to produce the raw and basic statistical data of respondent background information (descriptive analysis), like age, education years

and race. The data will be presented in the form of mean, maximum and minimum value.

The specific objective was determined by analyzing the collected data using bivariate and multivariate analysis. Table 3.1 show the objectives and data analysis used in this study.

Table 3.1 : Objectives and statistical data analysis

Objectives	Data analysis	
	Parametric	Non-parametric
To measure heat stress index (dry bulb temperature, wet bulb temperature, globe temperature and WBGTin) and classification of heat stress.	Descriptive analysis	
To determine the prevalence of heat stress exposure among workers in processing unit.	Descriptive analysis	
To compare the physiological parameters (body core temperature, blood pressure and heart rate) before work, after 2 hours and after 8 hours work.	One-Way ANOVA	Friedman ANOVA test
To determine the correlation between WBGTin and physiological parameters of workers.	Pearson Correlation	Spearman-rho correlation
To determine the relationship between body temperature and contributing factors among workers.	Multiple linear regression	Multiple logistic regression

3.7.1 Determination of data distribution

Normality test (Kolmogorov-Smirnov One Sample Test) was used to determine the normality distributions of each variable studied before any statistical analysis were carried out on the variables. Table showed normal distribution of WBGTin for oil palm mill 1 and 2.

Table 3.3 showed that the variable studied of physiological parameters. The data have been compute to log because normality test showed not normally distributed ($p < 0.05$). Although normality showed not significant ($p < 0.05$), their respective skewness distribution is at ± 2 . In other words, they showed normal distribution skewness in their respective variables, but were either shift to the right of left side of the distribution curve. Thus, under this circumstance, the rest parameters do consider reach normality distribution and should analysis respective data with parametric test.

Table 3.2: Test of Normality

	Kolmogorov-Smirnov	Shapiro-Wilk
WBGTin Palm Oil Mill 1	0.060	0.050
WBGTin Palm Oil Mill 2	0.136	0.167

Significant difference at $p > 0.05$

Table 3.3: Determination of physiological parameters data distribution by Kolmogorov-Smirnov test

Physiological parameters (log)	Kolmogorov-Smirnov (sig)	Skewness	Kurtosis
Body Core temperature (before shift)	0.001	-0.435	-0.864
Body Core temperature (after 2 hours)	0.002	-0.364	-0.850
Body Core temperature (after 8 hours)	0.000	-1.214	2.192
Diastolic Blood Pressure (before shift)	0.000	-0.138	-1.326
Diastolic Blood Pressure (after 2 hours)	0.000	-0.203	-0.185
Diastolic Blood Pressure (after 8 hours)	0.000	-0.764	-0.764
Systolic Blood Pressure (before shift)	0.003	0.214	-0.174
Systolic Blood Pressure (after 2 hours)	0.000	0.802	1.126
Systolic Blood Pressure (after 8 hours)	0.000	-0.215	0.686
Heart rate (before shift)	0.000	-0.040	-0.776
Heart rate (after 2 hours)	0.000	-0.789	0.716
Heart rate (after 8 hours)	0.000	-1.012	0.165

3.8 Study Limitation

3.8.1 Information bias

There will be limitation in conducting this study. This situation will arise when the answer given by the respondent does not reflect the true situation they are currently facing. Other than that, the respondents tend to be forgetting certain information that might seem trivial but in fact, can affect the outcome of readings and others.

It is also might be observed when respondent may not be aware of certain factors, like being unaware of suffering from high blood pressure, thus they are not able to give answer that reflect their current physiological state. Questions that depend on their judgments and perception about their work and its environment can also produce answers that do not reflect the truth.

3.8.2 Environment factor

There will be excessive noise in this study limitation. In finding location in the factory to conduct the study, the researcher also need to consider the time it takes the respondent to walk to reach at measuring site. Its convenience and distance from the work area as these will affect the readings taken.

For choosing the measuring location nearest the worksite, the researcher needed to contend with the factory's noisy environment. It is because excessive noise will influence heart rate reading thus affecting the result.

3.9 Ethical consideration

This research been approved by Faculty of Medicine and Health Sciences Ethic Committees (Reference No: UPM/FPSK/PADS/T7-MJKEtikaPer/F01 (JKK (U) _Dis (11)18).

A written consent forms to participate in this study was given to the respondents for them to sign to be involved in this study. They are also was informed about the entire process measurement that will be carried out during this study. All information of the respondent will be kept confidentially.

CHAPTER 4

RESULTS

4.1 Distribution of socio-demographic data

This study was done among workers in two palm oil mills beginning from 6th January till 31th January 2012 at Kota Tinggi Johor. Seventy four (74) workers contribute in this study were selected based on simple random sampling criteria.

Data on age, race, BMI, education, years of employment and net income were determined for socio economic status. Table 4.1 show the background of respondents studied. The mean for age is 40.68 ± 7.56 . Majority of respondent has normal weight and the mean for BMI is 22.83 ± 3.13 . Almost of the respondent are working over 2 years and the mean for years of employment is 2.82 ± 0.51 .

Table 4.1 : Distribution socio-demographic data

Variables	Frequencies	Percent (%)
Race		
Malay	74	100
Chinese	0	0
Indian	0	0
Others	0	0
Age		
20 – 30	6	8.1
31 – 40	34	45.9
41 – 50	28	37.8
51 – 60	6	8.1
BMI		
<18.5 Underweight	3	4.0
18.5 – 23.0 Normal weight	49	66.3
23.1 – 27.4 Pre obesity	22	29.7
>27.4 Obesity	0	0
Education		
Primary	11	21.6
Secondary	63	78.4
Higher	0	0
Years of employment		
6 – 12 months	4	5.4
13 – 24 months	5	6.8
>24 months	65	87.8
Net Income		
RM 500 – RM 1000	27	36.5
RM 1000 – RM 2000	43	58.1
>RM 2000	4	5.1

4.1.2 Descriptive values for physiological parameters (body core temperature, diastolic BP, systolic BP and heart rate)

Table 4.2 shows the descriptive value for physiological parameters (body core temperature, diastolic BP, systolic BP and heart rate). From the results, mean values for body core temperature after 8 hours was higher compared to before shift and after 2 hours.

The mean values for systolic blood pressure was higher after 8 hours working compared to before shift and after 2 hours work. Whereas mean values for diastolic blood pressure was higher after 2 hours and after 8 hours of working.

The mean values for heart rate are much higher after 8 hours of working compared to heart rate before shift and after 2 hours working.

Table 4.2 : Descriptive values for physiological parameters (body core temperature, diastolic BP, systolic BP and heart rate

Variables	N=74	
	Mean ± SD	Range
Body core temperature (before shift)	35.04 ± 0.33 °C	34.3 – 35.60
Body core temperature (after 2 hours)	35.50 ± 0.35 °C	34.5 – 36.10
Body core temperature (after 8 hours)	36.03 ± 0.25 °C	35.00 – 36.4
Systolic BP (before shift)	121.42 ± 1.76 mm Hg	118 -127
Systolic BP (after 2hours)	124.57 ± 1.52 mm Hg	122 – 130
Systolic BP (after 8 hours)	129.27 ± 1.87 mm Hg	125 – 134
Diastolic BP (before shift)	81.01 ± 1.37 mm Hg	83 – 88
Diastolic BP (after 2hours)	83.46 ± 1.25 mm Hg	80 – 86
Diastolic BP (after 8 hours)	85.62 ± 1.64 mm Hg	78 – 84
Heart rate (before shift)	80.43 ± 2.36 bpm	76 – 86
Heart rate (after 2hours)	83.77 ± 1.74 bpm	79 – 87
Heart rate (after 8 hours)	87.39 ± 1.69 bpm	83 – 90

4.2 Heat stress index (WBGT_{in}), and metabolic workload in each section.

The first objective of this study was to measure the heat stress index which is WBGT_{in} and metabolic workload. These of two of indices are matched to see the threshold level according to ACGIH 1992. Table 4.3 and table 4.4 show the WBGT_{in} values in each section palm oil mill 1 and 2. The mean value of WBGT_{in} is slightly same, 30.68 °C and 30.78 °C respectively.

The independent t-test was done to compare the means between 2 palm oil mills. This study found that, there is no significant different between WBGT_{in} in palm oil mill 1 and palm oil mill 2 where $p > 0.05$. Table 4.5 showed the result for independent t-test.

Table 4.3 : WBGT_{in} for each section in palm oil mill 1

Section	WBGT _{in} (°C)	wetbulb	drybulb	Globe temperature	Relative Humidity	Classification of work
Sterilizer	28.32	27.60	33.00	30.0	72%	
Press	27.92	27.50	31.80	28.9	70%	
Kernel	28.48	28.90	30.30	27.5	68%	Medium
Oil room	31.59	31.7	32.2	31.8	73%	
Boiler	37.97	40.1	41.0	33.0	86%	
Engine room	29.29	27.7	31.2	33.0	75%	
Average WBGT_{in}	30.60					

Table 4.4 : WBGTin for each section in palm oil mill 2

Section	WBGTin (°C)	wetbulb	drybulb	Globe temperature	Relative humidity	Classification of work
Sterilizer	28.75	28.60	32.80	29.10	73%	Medium
Press	27.95	27.8	33.90	28.30	68%	
Kernel	29.99	31.40	32.00	31.60	78%	
Oil room	31.46	31.40	32.00	31.60	80%	
Boiler	37.47	39.30	37.20	33.20	84%	
Engine room	29.10	27.60	30.60	32.60	68%	
Average WBGTin	30.78					

Table 4.5 : Independent T-Test

	Mean ± SD	t	p
WBGTin Palm oil mill 1	30.60 ± 3.84	0.93	0.803
WBGTin Palm oil mill 2	30.78 ± 3.49		

p-value is not significant at $p > 0.05$

4.2.1 Metabolic workload

Table 4.6 and 4.7 showed the metabolic workload in each section of palm oil mills. Boiler was contributing the higher of metabolic workload compare the other section. In both palm oil mills, the classification of work all section is in medium category of workload.

Table 4.6 : Metabolic workload in each section of palm oil mill 1

Section	Metabolic workload (kcal/hour)	Classification of work
Sterilizer	200.23	Medium
Press	203.60	
Kernel	201.70	
Oil room	203.68	
Boiler	205.11	
Engine room	200.08	

Table 4.7 : Metabolic workload in each section of palm oil mill 2

Section	Metabolic workload (kcal/hour)	Classification of work
Sterilizer	202.17	Medium
Press	205.41	
Kernel	200.87	
Oil room	203.78	
Boiler	207.24	
Engine room	200.12	

4.3 Prevalence of heat stress

The second objective of this study was to determine the prevalence of heat stress among workers in palm oil mill. Table 4.8 shows acute symptoms that occur among the workers regarding heat stress symptoms.

Based on the table show the symptoms that occur when expose to extreme heat in the palm oil mill. As many as 74 respondents was reported fatigue, 59 respondents report having headache, and only 7 of respondents having problem in nausea.

Table 4.9 and 4.10 showed the prevalence of heat stress among 2 palm oil mill workers. This study found that, boiler section was give the higher prevalence compared the others section.

Table 4.8 Prevalence of heat stress health complaints among palm oil mill workers

Symptoms	Yes (%)	No (%)
Fatigue	74 (100)	0 (0)
Headache	59 (79.7)	15 (20.3)
Nausea	7 (9.5)	67 (90.5)
Uncoordinated muscle	16 (21.6)	58 (78.4)
Dizziness	13 (17.6)	61 (82.4)

N=74

Table 4.9 : Prevalence of heat stress among oil palm (OP) mill 1 and 2 workers

Section	WBGTin (°C)	Metabolic workload (kcal/hour)	Prevalence of Heat Stress (%)
Sterilizer OP 1	28.32	200.23	8.1
Sterilizer OP 2	28.75	202.17	8.1
Press OP 1	27.92	203.60	6.8
Press OP 2	27.95	205.41	6.8
Kernel OP 1	28.48	201.70	9.5
Kernel OP 2	29.99	200.87	9.5
Oil room OP 1	31.59	203.68	6.8
Oil room OP 2	31.46	203.78	6.8
Boiler OP 1	37.97	205.11	10.8
Boiler OP 2	37.47	207.24	10.8
Engine room OP 1	29.29	200.08	8.1
Engine room OP 2	29.10	200.12	8.1

N=74

4.4 Physiological changes before shift, after 2 hours and after 8 hours working

The third objective in this study was to measure and compare the physiological parameters (body core temperature, blood pressure and heart rate) before work, after 2 hours and after 8 hours work.

Table 4.11 showed the mean difference body core temperature before shift, after 2 hours and after 8 hours working. From the ANOVA test with a Greenhouse-Geisser correction, mean scores were statistically significant at $p < 0.001$. Greenhouse-Geisser is an adjustment made to the numbers of degrees of freedom (F value) when it is

known that observations do not obey the usual assumptions of being uncorrelated with constant variance (Hinton, 2004).

Result showed that the mean difference of systolic and diastolic blood pressure before shift, after 2 hours and after 8 hours working. From the ANOVA test with a Greenhouse-Geisser correction, mean scores were statistically significant at $p < 0.001$.

Result also showed that the mean difference of heart rate pressure before shift, after 2 hours and after 8 hours working. From the ANOVA test with a Greenhouse-Geisser correction, mean scores were statistically significant at $p < 0.001$.

Table 4.10 : Difference of body core temperature, blood pressure and heart rate before shift, after 2 hours and after 8 hours in both palm oil mills.

Variables	Mean ± SE (°C) (log)	p	F
Body core temperature			
Before shift – after 2 hours	1.54 ± 0.00		
Before shift – after 8 hours	1.55 ± 0.01	0.001*	288.869
After 2 hours – after 8 hours	1.56 ± 0.00		
Systolic Blood Pressure			
Before shift – after 2 hours	-0.011 ± 0.001		
Before shift – after 8 hours	-0.027 ± 0.001	0.001*	868.870
After 2 hours – after 8 hours	-0.016 ± 0.001		
Diastolic Blood Pressure			
Before shift – after 2 hours	-0.013 ± 0.001		
Before shift – after 8 hours	-0.024 ± 0.001	0.001*	456.436
After 2 hours – after 8 hours	-0.011 ± 0.001		
Heart rate			
Before shift – after 2 hours	-0.018 ± 0.001		
Before shift – after 8 hours	-0.036 ± 0.001	0.001*	486.381
After 2 hours – after 8 hours	-0.018 ± 0.001		

*p-value is significant at $p < 0.001$

Mauchy's $W = 0.806$, $df = 2$, $p < 0.001$ Greenhouse-Geisser : $df=1.670$, $F=288.869$,

Mauchy's $W = 0.870$, $df = 2$, $p < 0.001$ Greenhouse-Geisser : $df=1.770$, $F=868.870$,

Mauchy's $W = 0.766$, $df = 2$, $p < 0.001$ Greenhouse-Geisser : $df=1.621$, $F= 456.436$,

Mauchy's $W = 0.561$, $df = 2$, $p < 0.001$ Greenhouse-Geisser : $df=1.390$, $F=486.381$,

4.5 Correlation between body core temperature and physiological parameters (systolic blood pressure, diastolic blood pressure, and heart rate)

The fourth objective of this study was to compare between body core temperature (before shift, after 2 hours and after 8 hours) and physiological parameters. Table 4.11 showed the correlation between body core temperature and physiological parameters. The results showed that there were positive relationships and significance difference at $p < 0.05$ between body core temperature and systolic blood pressure after 2 hours. However result showed positive relationship and significance difference at $p < 0.05$ between body core temperature after 8 hours with systolic blood pressure and heart rate after 8 hours.

Table 4.11 : Correlation between body core temperature and physiological parameters (systolic blood pressure, diastolic blood pressure, and heart rate)

Variables	Pearson correlation		
		r	p
Body Core temperature (before shift)	Systolic Blood Pressure (before shift)	0.182	0.120
	Diastolic Blood Pressure (before shift)	0.046	0.695
	Heart rate (before shift)	0.101	0.392
Body Core temperature (after 2 hours)	Systolic Blood Pressure (after 2 hours)	0.296	0.011*
	Diastolic Blood Pressure (after 2 hours)	0.151	0.199
	Heart rate (after 2 hours)	0.157	0.181
Body Core temperature (after 8 hours)	Systolic Blood Pressure (after 8 hours)	0.247	0.034*
	Diastolic Blood Pressure (after 8 hours)	0.014	0.904
	Heart rate (after 8 hours)	0.325	0.005*

*p-value is significance at $p < 0.05$

4.6 Relationships between body temperature and contributing factors among workers.

The last objective in this study was to determine the relationship between body temperature and contributing factors among workers. Table 4.12 showed the coefficients of contributing factors influence body core temperature after 2 hours and after 8 hours. In this study the analysis on linear regression used to develop a significant prediction equation for the regression of body core temperature on age, BMI, length of employment, systolic blood pressure, diastolic blood pressure,

duration of exposure and WBGT_{in}. These equations form a mathematical model for prediction of body temperature after 2 hours and after 8 hours.

$$\text{Average Body temperature} = 26.18 - 0.033 (\text{Age}) - 0.045 (\text{BMI}) + 0.006 (\text{Length of employment}) + 0.100 (\text{Systolic Blood Pressure}) - 0.063 (\text{Diastolic Blood Pressure}) + 0.050 (\text{WBGT}_{in}) \quad (R=0.642)$$

The coefficients of multiple determinations (R) is 0.642; therefore about 64% of contributing factors of body temperature after 2 hours is explained by individual age, BMI length of employment, systolic blood pressure, diastolic blood pressure and WBGT_{in}.

From the equation, we noticed that age, BMI and diastolic blood pressure have negative relationship between the contributing factors and outcomes; whereas length of employment, average systolic blood pressure, duration of exposure and WBGT_{in} have positive relationship between outcomes and predictors. However, at the 5% significant level, it showed that all the contributing factors are considered to remove since test statistic conclude that p-value >0.05. Thus, there exist not enough evidence to conclude that contributing factors of age, BMI, length of employment, systolic blood pressure, diastolic blood pressure, duration of exposure and WBGT_{in} influence in body core temperature.

Table 4.12 : Relationship of contributing factors influence body core temperature after 2 hours

Risk factor	Average Body core temperature				
	β (unstandardized coefficients)	t-value	p-value	95%confident interval Lower boundary	Upper boundary
Age	-0.033	-0.971	0.386	-0.129	0.062
BMI	-0.045	-0.784	0.477	-0.204	0.114
Length of employment	0.006	0.292	0.785	-0.050	0.062
Systolic BP	0.100	1.069	0.345	-0.161	0.361
Diastolic BP	-0.063	-0.272	0.799	-0.705	0.579
Duration of exposure	0.493	0.482	0.655	-2.345	3.331
WBGTin	0.050	0.485	0.653	-0.236	0.336

p-value is not significance at $p > 0.05$

R-value = 0.642

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMENDATION

5.1 Socio-demographic background

This study was carried out involving 74 of respondent which they were worked in production line of up 6 months. Overall respondents in this study consisting of men aged between 25 – 50 years old. More than 60% of participants are within the normal Body Mass Index (BMI). The education level for respondents is 21.6% in primary while 78.4% at secondary level.

Respondents in palm oil mill are worked in two shifts which are morning and night shift. Normally respondents start their morning shift from 8 a.m. until 4 p.m. whereas for night shift they were starts working from 4 p.m. until 12 a.m. Almost total of respondent experience acute health problem such as fatigue and headache whereas only several respondents experience acute health problem such as nausea,

uncoordinated muscle and dizziness when they exposed at high temperature in workplaces.

5.2 Heat stress index (WBGTin) and metabolic workload

The first objective of this study was to measure the heat stress index (WBGTin) and metabolic workload. The WBGT measurement was measured to identify environmental conditions that can contribute significantly to heat stress. The results found that 5 from 6 sections in plant operation section have high WBGTin which are in very hot condition (range of temperature). Boiler section of OP 1 has the highest temperature which is 37.97°C. This due to section located in a closed area where heat not emancipates fully to environment. Whereas, press section of OP 2 give the lowest temperature which is 27.95 °C. Average of WBGTin of oil palm mill 1 and 2 is 30.60°C and 30.78°C where is above the recommended ACGIH TLV of 28.0°C. This study also found the independent t-test was showed there is no significant difference between palm oil mill 1 and palm oil mill 2.

This study also showed the metabolic workload of respondent are in medium work category. Besides that, this study also showed the metabolic workload of respondent are in medium work category (200-350 kcal/hour) by ACGIH, (1999). Overall of heat exposure level in all section of oil palm mill is unsuitable for 8 hours of working duration and not suitable with work they were carried out.

This study found that WBGTin value would be exceeded the limit by ACGIH for work that persists with medium category. Overall, every area in all section requires work 50% and rest 50% for every shift.

5.3 Changes in physiological parameters (body core temperature, systolic blood pressure, diastolic blood pressure and heart rate) in both palm oil mills

The second objective of this study was to measure and compare the physiological parameters of the respondents.

5.3.1 Body core temperature

The result indicate that there was significant difference ($p < 0.05$) of body core temperature after 2 hours and after 8 hours compare to before work. ANOVA test found is significance difference for body core temperature between 2 hours and 8 hours. Mean difference of body core temperature showed that increasing values for three difference time. Generally, the human body being warm blooded, maintains a fairly constant internal temperature, even though it is being exposed to varying environmental temperatures (Gupta et al., 2006).

The body keeps its core temperature constant at about 37°C by physiological adjustment controlled by the hypothalamus where there are neuron sensitive changes

in skin and blood temperatures (Dabrowski et al., 1997). When the body expose to heat, body temperature rises. Skin warmth receptors and blood convey these changes to the hypothalamic thermostat; the sweat glands are triggered to bring moisture to the skin's surface. Blood vessels will widen to bring more blood closer to the outer layer of skin (Dabrowski et al., 1997).

This study was supported by other studies done by Siti Fawziah (2002) and Goh (2001) that there was increasing in body core temperature reading after physical work due to the body generate excess heat. Work rate is the single most important factor that determines how much heat is generated in the core (Berry et al., 2010). It is obvious that the more vigorously we use our muscles, the more heat we generate. When we stop to rest, the rate of heat production can drop dramatically (Berry et al., 2010). Whereas research from Roffey et al., (2008) prove that when a person performs heavy physical labor, the metabolic rate increases as does the production of internal heat.

Herrmann (2003) in stated that humans are maintaining an average core temperature of 37 ± 0.5 degrees Celsius. Body core temperature varies slightly due to environmental and metabolic factors. Exercise or physical activity may raise core temperature by up to three degrees.

This study can conclude that the measurement of body core temperature was a good sign to show the effect of thermoregulation in the body.

5.3.2 Changes in systolic blood pressure and diastolic blood pressure

Sub of second objective in this study was to measure and compare the systolic and diastolic blood pressure among respondents. This study shows there are significant difference for means value for the three reading (before shift, after 2 hours and after 8 hours). ANOVA test was found that there is significant difference ($p < 0.001$) between 2 hours and 8 hours when compare with before shift.

Blood pressure is a helpful indicator of the body's internal conditions (Gardner et al., 2007). It is the measure of force against the arteries as blood pumped throughout the body (Voorhees, 2006). In order for the blood to move to the skin surface the heart must pump faster and the blood pressure will become greater (Gardner et al., 2007).

This study was supported studied by Siti Fawziah (2002) state that measurement of blood pressure is a method to see changes of body physiology which can describe existence of effect on physiological changes when exposed to heat. From the result, systolic blood pressure was significantly increased. The increment is about 3 mm Hg. Kunst et al., (1993) state that this increment was due to exposure to high temperature that leads to increase blood viscosity and consequently result in increment of exposure in blood flow.

Astrand et al., (2008) stated that in acute heat exposure, the skin blood flow increases at the expense of the blood flow through other tissues. Measurements of total blood

volume during acclimatization to heat have produced conflicting results, but most studies seem to indicate an increase in blood volume and will lead to increase in systolic and diastolic blood pressure (Harrison et al., 1983).

Jose et al., (2008) stated that there is a competition for blood flow between the skin and the muscles. The muscles need increased blood flow to meet the demands of metabolic activity and the skin needs increased blood flow to dissipate heat from the core of the body. Jose also stated that the combined needs of the skin and muscle for blood flow may exceed the cardiac output. However, cardiac output in a hot environment is achieved by a higher heart rate and a lower stroke volume. The reduction in stroke volume during hot conditions occurs because of vasodilation in the cutaneous vessels.

5.3.3 Changes in heart rate

Sub of second objective of this study is to measure and compare the heart rate before shift, after 2 hours and after 8 hours among respondents. This showed that, there is significant difference in mean values for the three reading. ANOVA test was found that there is significant difference ($p < 0.001$) of heart rate between 2 hours and 8 hours when compare with before shift.

Heart rate can be used as a gauge to determine exposure to heat and also metabolic workload. US Department of Health Service Centre, (2010) state that heart rate are also play an important guideline in evaluating dangerous occurrence of employee related to heat stress. This study was found that range of heart rate is 76 – 90 per minute. Croswell, (2011) from his article state that when performing of physical activity, heart rate increases in order to deliver oxygen quickly and directly where it is needed. The volume of blood to be moved to extremities during physical activities increases, requiring heart to pump harder and faster to accommodate the need.

Zenz et al.,(1994) state that average of heart rate for workers who work in 8 hour per day must not more than 100 beat per minute for moderate workload. However this situation still can cause significant increasing against heart rate if the work continuously performed.

Wilmore et al., and Costill et al., (2005) state that although heart rate increases rapidly with the onset of activity, providing physical activities intensity remains constant, heart rate will level off. This is known as steady-state heart rate where the demands of the active tissues can be adequately met by the cardiovascular system. However, there is an exception to this. During prolonged steady-state physical activities particularly in a hot environment, a steady-state heart rate will gradually increase. This phenomenon is known as cardiac drift and is thought to occur due to increasing body temperature.

Majority of the workers in the oil palm mill had worked for more than 6 months and thus had acclimatized themselves well with the environment. When exposure to heat takes place over an extended period in workplace, a process of physiological adaptation called acclimatization occurs (Shido et al., 1999). It is manifested as a reduction in the heart rate and internal body temperature at the expense of increased sweating.



Table 5.1 : Comparison with the earlier study related increase in body core temperature among employee exposed in high temperature.

Researcher	Industry	Reading of Body core temperature (°C)	Conclusion
Siti Fawziah (2002)	Steel	Before shift – 36.10	There is increasing in body core temperature before, after 2 hours and after 8 hours working
		After 2 hours – 36.30	
		After 8 hours – 36.20	
Goh (2001)	Plastic	Before shift – 36.30	There is increasing in body core temperature before, after 2 hours and after 8 hours working
		After 2 hours – 36.70	
		After 8 hours – 36.80	
Recently study (2012)	Palm oil mill	Before shift – 35.04	There is increasing in body core temperature before, after 2 hours and after 8 hours working
		After 2 hours – 35.50	
		After 8 hours – 36.03	

Table 5.2 : Comparison with the earlier study related in systolic and diastolic blood pressure among employee exposed in high temperature

Researcher	Blood Pressure	Reading of Blood pressure (mm Hg)	Conclusion
Siti Fawziah (2002)	Systolic	Before shift – 124.41	There is increasing in systolic and diastolic blood pressure before, after 2 hours and after 8 hours working
		After 2 hours – 122.53	
		After 8 hours – 122.59	
Steel industry	Diastolic	Before shift – 73.82	There is increasing in systolic and diastolic blood pressure before, after 2 hours and after 8 hours working
		After 2 hours – 78.00	
		After 8 hours – 76.32	
Recently study (2012)	Systolic	Before shift – 121.42	There is increasing in systolic and diastolic blood pressure before, after 2 hours and after 8 hours working
		After 2 hours – 124.57	
		After 8 hours – 129.27	
Palm oil mill industry	Diastolic	Before shift – 81.01	There is increasing in systolic and diastolic blood pressure before, after 2 hours and after 8 hours working
		After 2 hours – 83.46	
		After 8 hours – 85.62	

Table 5.3 : Comparison with the earlier study related in heart rate among employee exposed in high temperature

Researcher	Industry	Reading of heart rate (bpm)	Conclusion
Goh (2001)	Plastic	Before shift –71 After 2 hours – 76 After 8 hours –78	There is increasing in heart rate reading before
Recently study (2012)	Palm oil mill	Before shift – 80 After 2 hours – 83 After 8 hours – 87	shift, after 2 hours and after 8 hours of working

5.4 Prevalence of heat stress

The third objective of this study was to determine the prevalence of heat stress among respondents in palm oil mill. The results indicate that, the lower prevalence (6.8%) was in the press section. This was due to the location of the section are much bigger and has good ventilation system. The area also provided with a big fans for workers to work in more comfortable condition.

The higher prevalence of heat stress was in a boiler section (10.8%). This possibly due to the work process involved that generates a lot of heat to give main power to overall production process. Burner is a heart of the boiler which converts water to steam. This burner is heated by supplying fuels. Generally the steam needed to heat machine where heat is required created by the fuel for example coal and waste products. After the burners are heated up using the required fuels, then the gases or the fire from the burners are directly released on the boiler to heat up the water.

A boiler operator runs, maintains, and repairs boilers and other systems that are used to heat or cool large operation process. The workers are also responsible for ensuring that systems are kept in proper working order. This work activity may require them to work under very hot, noisy and dangerous condition. This is the reason to contribute higher prevalence of heat stress exposure among the respondents in the boiler section was detected.

5.5 Correlations between body core temperature and physiological changes

The fourth objective in this study was to determine the correlation between body core temperature and physiological changes among the respondents. From the result, this study found that there is a significant difference ($p < 0.05$) and low correlation (30%) between body core temperature and systolic blood pressure after 2 hours working ($r = 0.296$, $p = 0.011$). Thibodeau et al., and Patton et al., (1997) indicate that when the body core temperature increase, the blood flow also will increase and caused heat loss from the body to stabilize internal environment.

There was increasing of systolic blood pressure after 2 hours and 8 hours, however changes in body physiology doesn't confirm occurrence of heat stress incidence because it needs clinical examination from experts and doctor.

Parameters measurement unable to give more accurate values maybe due to automatic instrument usage which is OMRON T3. For the measurement of blood pressure, manual mercury manometer is more accurate to get the blood pressure reading compared to automatic device (Nelson, 2008). Manual operation requires more knowledge of the equipment and its use. Usually it requires manual operation of such as inflation of the arm cuff, use of stethoscope, determination of systolic/diastolic reading by sound, and visual recording of meter markings. The automatic OMRON T3 depends only to air cuff to get the reading of blood pressure. A single cuff is applied to the patients arm, and the machine inflates it to a level

assumed to be greater than systolic pressure. The cuff is deflated gradually. A sensor then measures the tiny oscillations in the pressure of the cuff caused by the pulse. Systolic is taken to be when the pulsations start, mean pressure is when they are maximal, and diastolic is when they disappear. According to Hambly, (2000) on his article stated that, such devices tend to over-read at low blood pressure, and under-read very high blood pressure. The result of blood pressure by automatic device gives big range after three times of measurement taken.

This study also found that there was low correlation (24%) between body core temperature and systolic blood pressure after 8 hours ($r=0.247$, $p=0.034$).

Generally, the measurement of blood pressure only showed the cardiac output of heart and does not show the specifically occurrence of heat stress. This was due of the several factors influence increasing and decreasing of blood pressure such as blood volume, the strong and efficiency of heart, heart rate and blood viscosity, Patton et al., and Thibodeau et al., (1997)

Study found that there was a significant difference and low correlation between body core temperature and heart rate after 8 hours working. There is increment of heart rate reading after 2 hours and after 8 hours working ($r=0.325$, $p=0.005$).

However, it was failed to prove statistically. These could be due the need of the production has to stop intermittently in order for the FFB to be loaded into the ramp

section. The whole process will take an average of an hour before FFB undergoes the next process. The workers have to stop from executing production works and perform other duties which are lighter than their normal work task. The light works usually involve less physical demands thus reducing the heart rate of the workers.

Thus from the result obtained, the hypothesis which states that there is a significant difference between body core temperature and physiological changes was rejected.

5.6 Relationship between body core temperature and contributing factor among respondents.

The last objective in this study was to determine the relationship between body core temperature and contributing factors among respondents. Based on multiple regression analysis, there is no significant difference between average body core temperature and individual factors. The result can be explained based on the study observation which clearly shows that respondents have a short break that enable them to drink. Maintaining the constant water intake can reduce body water loss and maintain the body in fluid balance (Workman et al., 2001). However, one of the important factors is the ability of the respondent to be acclimatized with the hot environment and work process. The entire respondent in this study was working in mill over 6 months where the duration period of exposure is adequate enough for the body to adapt to heat exposure. Armstrong et al., (1998) stated that during the acclimatization process body chemistry changes as it learns to conserve minerals

normally lost through sweat and urine. Sweating response becomes earlier and greater. Better cooling is achieved as blood flows closer to the skin.

From the study, only several of respondents have been really exposed to higher temperature during working hours. Respondents were worked in standing position and free to move at any area thus the body core temperature does not significant with duration of working.

From this study, only among respondent that have normal BMI and underweight was chosen to be involved. This is because BMI in obesity category will influence the reading of blood pressure. This showed that there is no significant difference between average body core temperature and BMI.

Therefore, the hypothesis of significant difference between average body core temperatures and contributing factors was rejected.

Conclusion

From this study, there are several finding that can conclude overall of the study. The findings are:

1. WBGT_{in} at 5 sections in concern of this study was above the standard temperature suggested by ACGIH, where is 28.5°C for medium work.
2. The study shows that there is increasing in physiological parameters before shift, after 2 hours and after 8 hours working.
3. There is significant difference between physiological changes (body core temperature, systolic and diastolic blood pressure and heart rate) before shift, after 2 hours and after 8 hours working.
4. This study found that the lower prevalence of heat stress exposure is in press section (6.8%) whereas the highest prevalence of heat stress is in the boiler section (10.8%).
5. There is a weak correlation between body core temperature and physiological changes after 2 hours and 8 hours working due to the of the production has to stop intermittently and workers was performed other duties which are lighter than their normal work task.
6. There is no significant relationship between average body core temperature and contributing factors.

Recommendations

The finding of this study show that the study group is susceptible induces of heat stress. In order to avoid and reduce the occurrence of this situation, there are several control measures should be taken. This is the alternative ways in minimizing the respondents from contact to heat.

a) Control heat at the workplace

- i. Plan for engineering control – this should be the first choice to reduce or eliminate the hazard. Installing the ventilation system and shielding can help to reduce the high temperature at work areas. Instead of reducing radiation from the source, shielding can be used to interrupt the path between source and receiver. Next, ensuring the air movement enter the work area also help to reduce the temperature. There are many methods for increasing air movement such as small personal fans can provide a refreshing movement of air on the face. This can be providing to workers that are highly exposed to high temperature such as in boiler section. Next, larger diameter fans suspended from the ceiling can provide a swirling air movement that is effective over a wide area. Exhaust fans, mounted in the roofs and walls, are useful for removing heated air. Although the initial cost of engineering control seems high, it has been found that the implementation cost is often offset by the resulting improvements to

production and decreased in downtime, with reduced absenteeism and improved motivation.

- ii. Administrative control – the employer should provide continuous training, heat control program to provide them a basic understanding of the effects of heat on the body and preventing heat-related illness from occurring. Other than that, administrative control includes planning and rescheduling work times may help the workers who expose to heat in considered time. Increasing the frequency and duration of breaks can be applied so that workers can get some rest and avoid worst effects of working in high temperatures. Train workers to recognize sign and symptoms of heat stress and start a ‘buddy system’ since people sometime not likely to notice their own symptoms.
- iii. Continuous monitoring of work section is important to ensure that the threshold limit value for not only high temperature but also other occupational hazards is not exceeded. As the boiler section is exceeding the TLV set by ACGIH it is advisable for employer to monitors those section so that it can ensure that the temperature are still in safe limit. Safe and health work practice should be applied to avoid hazards which can interrupt the health status of workers. The admin and workers should have good communication in order to

discuss problem regarding the work process and health status. Supervisor are also must take the responsibilities to ensure all the workers are not expose to prolong hour that may result in dehydration and high rate of sweating.

b) Improve physiological changes in the body

- i) Allow the workers to make behavioral adaptations before entering the full workload. This is to ensure the risk of workers experiencing heat disorder is lessened when they start work after period of acclimatization. Proper acclimatization also could help reduce the rate of high temperature and effectiveness of body's homeostatic control. Therefore it helps the body to become more adapt in handling heavy physical activities as well as environment temperature.
- ii) Dehydration has been shown to increase a worker's risk experiencing heat stress. It is advisable for employer to provide cool drinking water near workers and remind them to drink a cup every 20 minutes. Installing the water drinking station near workplace will minimize the time of workers to go to the canteen and ensure remain hydrated throughout the working hours. This is also en effort to hinder heat disorder such as heat cramps.

REFERENCES

- Abderrezak Bouchama, (2002). Heat stroke. *The New England Journal of Medicine*, pp 346.
- ACGIH- American Conference of Governmental Industrial Hygienists. (1999). Threshold Limit Values for Chemical Substances and Chemical Agents. *ACGIH:Cincinnati*.
- ACGIH- American Conference of Governmental Industrial Hygienists. (2001). Threshold Limit Values and Biological Exposure Indices for 2001. *ACGIH*.
- ACGIH. (2007). Threshold Limit Values for Chemical Substances and Chemical Agents. *ACGIH:Cincinnati*.
- Alpaugh, E and Hogan T. J. (1992). Temperature extremes in Barbara. *Fundamental of Industrial Hygiene 3rd edition USA: National Safety Council*, pp. 265-280.
- Amstrong, L. E. (2003). Heat syncope. In L. E. Amstrong, *Textbook of Exertional Heat Illness* (pp. 159-162). United States of America: Human Kinetics Publisher, Inc.
- Angilletta, M. (2009). *Thermal Adaptation : A Theoretical and Empirical Synthesis*. Oxford: Oxford University Press.
- Angilletta, M. (2009). Looking for answer to questions about heat stress: Researcher are getting warmer. *Functional Ecology*, 23:231-232.

Armstrong, L. E. (2003). Exertional Heat Illness during Training and Competition. *American College of Sports Medicine*, 557-572.

Astrand, Per-Olof. (2003). Acclimatization, Physiology of Temperature Regulation. In P.-O. Astrand, *Textbook of Work Physiology: Physiological Bases of Exercise* (pp. 406-410). United State of America : Library of Congress Cataloging-in-Publication Data.

Azlis Sani, Jalil. (2007). Heat stress investigation on laundry workers. *International Conference on Ergonomics 2007 (ICE07)* , (pp. 1-6). Kuala Lumpur.

Barker, D. K. (1999). Thermal characteristics of clothing ensembles for use in heat stress analysis. *American Industrial Hygiene Association Journal* , 60(1), 32-37.

Berry, C. (2010). A Guide to Preventing Heat Stress and Cold Stress. *N.C Department of Labor*, (pp. 1-28). United States.

Bonde, J. (1992). Semen quality in welders exposed to radiant heat. *Brit. J. Ind Med.*, 49:5-10.

Borghi, L. (1993). Hot Occupation and nephrotiasis. *The Journal of Urology*, 150(6): 1757-1760.

Brake, D. M. (1998). A new generation of health and safety protocols for working in heat. *Queensland Mining Industry Occupational Health and Safety Conference*. yeppon:Qld Mining Council, Brisbane.

- Barker, S. K. (1999). Thermal characteristics of clothing ensembles for use in heat stress analysis. *American Industrial Hygiene Association Journal*, 60(1), 32-37.
- CANADA Industrial Hygienist. (2009) .retrieved from Canada_Being Prepared for Summer: <http://www.ec.gc.ca/meteowweather/default>
- CDC-Centre for Disease Control and Prevention. (2011, July 14). *Humidex Rating and Work*. Retrieved from http://www.ccohs.ca/oshanswers/phys_agents/humidex.html
- Carlisle, D. (2010). Physiological Concerns of Heat. *Your body and Heat*, pp. 1-4.
- Cena, K. S. (1986). Thermal comfort of the elderly is affected by clothing, activity and psychological adjustments. *ASHRAE Transactions*, vol.92 329-342.
- Chen, M. L. (2003). Heat stress evaluation and worker fatigue in a steel plant. . *AIHA Journal*, 64, 352-359.
- Croswell, J. (2011, Feb 11). *Livestrong.com*. Retrieved April 18, 2012, from <http://www.livestrong.com/article/379581-exercises-to-increase-the-heart-rate/>
- Cullen, M. (1994). Thermal stressors in Cullen, M.R. In *Textbook of Clinical Occupational Environments Medicine* (pp. pp.658-666). Suanders Publisher.
- Dabrowski, D. (1997). Neurophysiology of thermoregulation. *The Physiology Coloring Book:Medical Books Center*.

Davies, C. T. (1979). Aerobic Performance of female marathon and male ultramarathon athletes. *Eur J Appl Physiol*, 41:233-245.

Gardner, S. (2007). Effects of temperature on blood pressure. *University of Colorado*, Retrieved from:
www.colorado.edu/eeb/courses/1230jbasey/abstracts_2007/17.htm

Gerard, I.J., Zwetsloot, A. R. (2010). "The organizational benefits of investing in workplace health". *International Journal of Workplace Health Management*, 143 - 159.

Goetich, D. L. (1999). *Occupational Safety and Health for Technologies, Engineers and Managers*. United States of America: Prentice Hall.

Goh, S. B. & Zailina, H. (2001). Heat Stress among Plastic Industry workers. *Malaysian Journal of Public Health*, (pp 59-66).

Goldman, R. F. (1999). Protecting Personnel at Hazardous Waste Sites. In M. G. William F. Martin, *Heat Stress in Industrial Protective Encapsulating Garments* (pp. 295-296). United States of America: Butterworth-Heinemann.

Gupta, A. K. (2006). Physiology of Heat Regulation : How the body regulates heat? In *Industrial Safety and Environment* (pp. 105-107). New Delhi, India: Laxmi Publications (P) LTD.

Guyton, A. (1996). Body Temperature, Temperature Regulation and Fever. In A. Guyton, *Textbook of Medical Physiology* (pp. 911-922). Philadelphia: W.B Saunders Company.

- Hair, J. F., Anderson, R.E., Tatham, R.L and Black, W.C (1998). *Multivariate Data Analysis*. Englewood cliffs, New Jersey: Prentice Hall.
- Hambly, P. (2000). *Nuffield Division of Anaesthetics : Measuring The Blood Pressure*. Retrieved from University of Oxford Web site:
http://www.nda.ox.ac.uk/wfsa/html/u11/u1106_01.htm
- Harrison, M. H. (1986). Effects on thermal stress and exercise on blood volume in humans. *Physiol Rev*, 65(1): 149-209.
- Herrmann. (2003). *Heat and Cold : How does Human Body Regulate Temperature*. Retrieved April 17, 2012, from
<http://www.iaaf.org/mm/Document/imported/42030.pdf>
- James, W. D., & Berger, T. G. (2006). *Andrews' Diseases of the Skin: clinical Dermatology* . Saunders Elsevier, ISBN 0-7216-2921-0.
- Jeanne, M. (1998). Encyclopedia of Occupational Health and Safety : Automobile and Transportation Equipment Industry Volume III. *Industries and Occupations ILO Geneva*, (pp. 91- 98).
- John D., Enderle, J. D. (2011). Biomedical Heat Transport : Thermal Conduction. In J. D. John D. Enderle, *Introducing to Biomedical Engineering* (pp. 975-976). United States of America: Academic Press.
- Jose Gonzalez-Alonso, C. G. (2008). The Cardiovascular Challenge of Exercising in the Heat. *Journal of Physiology*, 1-9.
- Joseph, A. (2000). Beware of Heat Stress. *Holmes Safety Association-Mine safety and Health Administration*, 1-28.

- Kapit, W.(1987). The Human Physiology . In W. e. Kapit, *The Physiology Coloring Book* (pp. 101, 134). Philadelphia: Harper Collins Publishing.
- Kenney, W. (2003). Invited Review: Aging and Human Temperature Regulation. *J. Appl Physiol*, 2598-2603.
- Kolka, K. K. (2001). Physiologic tolerance to uncompensable heat: intermittent exercise, field vs laboratory. *Med. Sci. Sports Exerc*, 33(3):422-430.
- Kolka, M. Q. (1993). Validation of a temperature telemetry system during moderate and strenuous exercise. *Journal of Thermal Biology*, 18:203-210.
- Lugo-Amador, N. M., Rothenhaus, T., Moyer, P. (2004). Heat-related illness. *Emergency Medicine Clinics North America*, 315-327.
- Kunst, A. E. (1993). Outdoor air temperature and mortality in the Netherlands : A time series analysis. *American Journal of Epidemiology*, 137(3):331-341.
- Maresh, C. M. (1991). The induction and decay of heat acclimatisation in trained athletes. *Sport Med*, 12(5):302-312.
- Maughan, R.J (1991). Fluid and electrolyte loss and replacement in exercise. *J. Sports Sci*, 117.
- Meyer, F. O.(1992). Sweat electrolyte loss during exercise in the heat : effects of gender maturation. *Medicine and Science in Sports and Exercise*, 24, 776-781.

Nag, A. K. (1999). Exposure limits of women in hot environment. *Ind. J. Med. Res.*, 138:110.

Nahle, N. S. (2010, July 29). Conduction is the Primary Mechanism of Heat Transfer at the Surface-Atmosphere Boundary Layer. *Academic Resources*. Monterrey, N.L, Mexico: Biology Cabinet Online.

Neilsen, (1994). Heat stress and acclimation. *Ergonomics*, 37 (1), 49-58.

Nelson, B., Kennedy, B., & Regnerus, C. (2008). Accuracy of automated blood pressure monitors. *PubMed*. US National Library of Medicine National Institutes of Health.

NIOSH, National Institute for Occupational Safety and Health. (revised 1986). Criteria for Recommended Standard Occupational Exposure To Hot Environments. *Department of Health and Human Services, Washington*, pp.1-107.

Nurul Ainun, H.(2003). *Ketegasan Haba dan Hubungannya dengan Perubahan Fisiologi di Kalangan Pekerja Lelaki Pembuatan Komponen Automatif (Laporan akhir Projek Ilmiah)*. Serdang, Selangor :Universiti Putra Malaysia

Pulat, B. (1982). *Fundamentals of Industrial Ergonomics* . United States of America: Prentice Hall.

Roffey, D. M. (2008). Exercise Intensity, Exercise Training and Energy Metabolism in Overweight and Obese Males. *PhD thesis Institute of Health and Biomedical Innovation*. Queensland University of Technology.

- Ramaekers, D., Ector, H. (1998). Heart rate variability and heart rate in healthy volunteers. *European Heart Journal.*, pp1334-1341.
- Safety, J. O. (2000, May 12). *Heat Related Injuries*. Retrieved from Health and safety department: <http://nwsu.edu/>
- Siti Fawziah, MN.(2002). *Tegasan Haba dan Perubahan Fisiologi Pekerja Kilang Besi (Laporan akhir Projek Ilmiah)*. Serdang, Selangor :Universiti Putra Malaysia
- Szakacs, J (2008). *Disorder of Thermoregulation*. Retrieved from www.szote.u-szeged.hu/patph/Thermoregulation.pdf.
- United State Health Service Centre Department. (2010). *Hot Environments- Health Effects*. Centre for Disease Control and Prevention . Retrieved April 20,2012 from http://www.ccohs.ca/oshanswers/phys_agents/heat_health.html
- Vangelova, Katia.(2006). Blood Pressure and Serum Lipids in Industrial Workers under Intense Noise and a Hot Environment. *De Gruyter Journal*, 303-312.
- Voorhees, V., Benjamin, W.(2006). "Blood Pressure". *Medline Plus*,U.S National Institute of Medicine and the National Institutes of Health. Retrieved from : www.nlm.nih.gov/medlineplus/ency/article/003398.htm
- Wilmore, J. H. (2005). *Physiology of Sport and Exercise : 3rd Edition*. Champaign, IL: Human Kinetics.
- Zenz. C., Dickerson, O. B. and Hovarth, E. (1994). *Occupational Medicine 3rd Edition*. Ohio, USA: Mosby Publication.
- Zhang, Z. (1995). Occupational Exposure to Extreme Temperature and Risk of Testicular Cancer. *Arch. Env. Health*, 50(1):13-17.
- Zhou, W.T., Fujita, M., Yamamoto, S. (1999). Thermoregulatory responses and blood viscosity in dehydrated heat exposed broilers. *Science Direct*.



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APPENDICES

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PENERANGAN KEPADA PESERTA

TAJUK KAJIAN: KETEGASAN HABA DAN HUBUNGANNYA DENGAN PERUBAHAN FISILOGI DI KALANGAN PEKERJA KILANG KELAPA SAWIT

PENYELIDIK : NUR IZZATE BT MOHD SAID

Apakah kajian ini?

Terdapat pelbagai potensi bahaya yang wujud di dalam sesebuah kilang. Potensi bahaya akan mengakibatkan kecederaan kepada pekerja. Haba merupakan salah satu daripada hazard fizikal yang harus diberi perhatian serius di persekitaran tempa kerja. Tegasan haba bermaksud jumlah fizikal kerja dan persekitaran yang menyumbang kepada keseluruhan bebanan haba kepada tubuh badan. Tindak balas haba dikenali sebagai tegangan haba. Pendedahan yang berterusan kepada haba yang tinggi boleh menyebabkan tindakbalas negatif kepada sistem tubuh badan seperti kekejangan serta pengaliran semula darah yang tidak cukup ke jantung dan organ-organ penting dalam badan, seterusnya menyumbang kepada berlakunya tegasan haba yang serius.

Apakah tujuan kajian ini?

Kajian ini adalah bertujuan untuk mengkaji pendedahan suhu tinggi dan hubungannya dengan perubahan fisiologi di kalangan pekerja kilang kelapa sawit.

Siapakah yang perlu terlibat dalam kajian ini?

Pekerja lelaki di bahagian operasi kilang kelapa sawit.

Apakah jenis ujian yang akan dijalankan?

Antara kaedah yang digunakan untuk mengenal pasti tegasan haba di alami pekerja adalah mengukur suhu parameter di tempat kerja, membuat anggaran metabolik kerja untuk setiap kerja dilakukan. Pengukuran Indeks Ketegasan Haba dilakukan menggunakan alat Suhu Global Basah Dalam (WBGT Dalam) dan Kadar Metabolik Habadiukur di semua seksyen operasi. Manakala pengukuran fisiologi pekerja pula diukur dengan mengambil suhu teras badan, mengukur tekanan darah dan kadar denyutan nadi.



Adakah bayaran dikenakan?

Pengkaji akan menanggung segala pembiayaan ujian yang akan dijalankan dan tiada sebarang bayaran dikenakan terhadap setiap responden.

Apakah faedah daripada kajian ini?

a) Kepada anda sebagai peserta

Kajian ini dapat mendedahkan responden dan komuniti pekerja kepada kesan-kesan daripada pendedahan suhu tinggi di tempat kerja dan menggalakan individu mengenal pasti akan perubahan simptom akut fisiologi tubuh semasa bekerja.

Seterusnya kajian ini dapat dijadikan langkah pencegahan bagi mereka yang terlibat dengan pendedahan suhu tinggi hasil daripada keputusan kajian untuk mengurangkan risiko pendedahan kepada pekerja. Harapan daripada kajian ini akan meningkatkan kesedaran keselamatan dan kesihatan antara pekerja kilang kelapa sawit terutama bagi responden-responden.

b) Kepada penyelidik

Memberikan pengetahuan baru mengenai hubungan antara pendedahan suhu tinggi dan hubungannya dengan perubahan fisiologi di kalangan pekerja kilang kelapa sawit.

Adakah maklumat dijamin sulit?

Semua maklumat yang diberikan oleh responden di dalam borang kaji selidik adalah dijamin sulit. Tiada huraian individu akan dibuat pada mana-mana bahagian di dalam kajian atau penerbitan.

Adakah hak anda?

Kajian ini melibatkan anda secara sukarela. Oleh itu, peserta mempunyai hak untuk menarik diri dari penyertaan dalam kajian ini pada bila-bila masa sekiranya peserta merasa tidak selesa untuk memberikan maklumat kepada pengkaji.



Apakah yang harus anda lakukan?

Anda dikehendaki menandatangani borang penyertaan responden yang menyatakan minat anda untuk menyertai kajian ini. Ianya boleh dilakukan setelah anda membaca dan

memahami isi kandungan penerangan ini. Borang penyertaan responden haruslah dikembalikan kepada penyelidik sebelum ujian dijalankan. Sekiranya anda mempunyai sebarang kemusykilan, penyelidik akan membantu untuk memberi maklumat yang selanjutnya.

Terima kasih atas kerjasama dan bantuan anda.

NUR IZZATE BT MOHD SAID

Penyelidik

B. Sc. Kesihatan Persekitaran dan Pekerjaan
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BORANG PERSETUJUAN RESPONDEN

TAJUK KAJIAN: KETEGASAN HABA DAN HUBUNGANNYA DENGAN PERUBAHAN FISIOLOGI DI KALANGAN PEKERJA KILANG KELAPA SAWIT

PENYELIDIK : NUR IZZATE BT MOHD SAID

Saya..... No.K/P:
alamat.....

.....dengan ini secara sukarela bersetuju untuk mengambil bahagian dalam penyelidikan yang dinyatakan di atas. Saya telah dimaklumkan mengenai latar belakang penyelidikan ini dari segi kaedah, kemungkinan kesan buruk dan komplikasi(rujuk kepada risalah maklumat). Saya faham bahawa saya mempunyai hak untuk menarik diri dari kajian ini pada bila-bila masa tanpa memberikan apa jua sebab. Saya juga faham bahawa kajian ini adalah sulit dan semua maklumat yang diberikan mengenai identiti saya adalah sulit dan persendirian.

Saya ingin *tahu/tidak ingin mengetahui keputusan ujian yang dijalankan ke atas sampel saya.

* potong mana yang tidak berkaitan

Tandatangan..... Tandatangan.....
(Responden) (Saksi)

Tarikh :..... Nama :.....

No.K/P :.....

Saya mengesahkan bahawa saya telah menjelaskan kepada responden latar belakang dan tujuan penyelidikan di atas.

Tarikh Tandatangan.....
(Penyelidik)



BORANG KAJI SELIDIK

KETEGASAN HABA DAN HUBUNGANNYA DENGAN PERUBAHAN FISIOLOGI DI KALANGAN PEKERJA KILANG KELAPA SAWIT

Dengan ini, sukacita dimaklumkan bahawa pihak tuan telah disenaraikan sebagai salah seorang responden dalam satu kajian penyelidikan yang mengkaji pendedahan suhu tinggi dan hubungannya dengan perubahan fisiologi di kalangan pekerja kilang kelapa sawit. Oleh yang demikian, saya memohon jasa baik pihak tuan untuk menjawab soalan-soalan yang terdapat dalam borang soal selidik ini secara tepat dan jujur. Segala maklumat kajian yang diterima akan dirahsiakan. Kerjasama dari pihak tuan amatlah dihargai.

No Responden:

--	--	--	--	--	--	--	--	--	--

Tarikh:

--	--	--	--	--	--	--	--	--	--

No Telefon:

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Tandatangan:

OCCUPATIONAL SAFETY AND HEALTH
IN AGRICULTURE:
PALM OIL INDUSTRY

KEGUNAAN
PENYELIDIK

BAHAGIAN B: MAKLUMAT PEKERJAAN

2.1 Maklumat pekerjaan terdahulu

2.1.1 Pernahkah anda bekerja di tempat lain sebelum ini?

1 Ya

0 Tidak

B1

2.1.2 Jika Ya, sila nyatakan jenis pekerjaan dan tempoh :

Jenis pekerjaan	Tempoh bekerja (jam)	Tahun bekerja
Total		

B1a
B1b

2.1.3 Pernahkah anda mengalami kemalangan atau kecederaan di tempat kerja sebelum ini ?

1 Ya

0 Tidak

B2

Jika Ya, sila nyatakan bahagian badan yang terlibat :

	Ya	Tidak	
2.1.3.1 Kepala	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B3 <input type="checkbox"/>
2.1.3.2 Tengku/leher	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B4 <input type="checkbox"/>
2.1.3.3 Bahu	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B5 <input type="checkbox"/>
2.1.3.4 Tangan/lengan	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B6 <input type="checkbox"/>
2.1.3.5 Jari	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B7 <input type="checkbox"/>
2.1.3.6 Siku	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B8 <input type="checkbox"/>
2.1.3.7 Belakang atas	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B9 <input type="checkbox"/>
2.1.3.8 Belakang bawah	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B10 <input type="checkbox"/>
2.1.3.9 Paha	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B11 <input type="checkbox"/>
2.1.3.10 Lutut	1 <input type="checkbox"/>	0 <input type="checkbox"/>	B12 <input type="checkbox"/>

OCCUPATIONAL SAFETY AND HEALTH
IN AGRICULTURE:
PALM OIL INDUSTRY

KEGUNAAN
PENYELIDIK

2.1.4 Pernahkah anda menerima rawatan untuk kemalangan atau kecederaan tersebut?

1 Ya

0 Tidak

B13

2.2 Maklumat pekerjaan sekarang

2.2.1 Apakah pekerjaan anda sekarang?

1 Kilang

B14

i) Continuous sterilizer

ii) Thresher

iii) Digester

iv) Press

v) Depericarper

vi) Nut silo

vii) Nut cracker

viii) Kernel silo

ix) Oil room

x) Boiler and engine room

xi) Workshop

xii) Effluent

xiii) Rumah abu

xiv) Store

2.2.2 Berapa lamakah anda telah bekerja sebagai (pekerjaan seperti di atas)?

_____ tahun

B15

OCCUPATIONAL SAFETY AND HEALTH
IN AGRICULTURE:
PALM OIL INDUSTRY

KEGUNAAN
PENYELIDIK

2.2.3 Adakah anda bekerja pada hari cuti?

1 Ya 0 Tidak

B16

Jika Ya, secara purata, berapa kerap anda bekerja lebih masa?

1 Sekali sebulan 2 Dua kali sebulan
3 Tiga kali sebulan 4 Empat kali sebulan

B17

2.2.4 Secara purata, berapa jam anda bekerja dalam sehari?

_____ jam

B18

2.2.5 Adakah kerja anda sekarang mengikut syif?

1 Ya 0 Tidak

B19

2.2.5 Berapa lamakah anda berehat dalam masa sehari anda bekerja?

_____ jam

B20

2.2.6 Adakah anda membuat kerja sambilan?

1 Ya 0 Tidak

B21

Jika ya, sila nyatakan maklumat yang berikut:

Jenis pekerjaan	Tempoh bekerja (jam)	Tahun bekerja
Total		

B21a

B21b

OCCUPATIONAL SAFETY AND HEALTH
IN AGRICULTURE:
PALM OIL INDUSTRY

KEGUNAAN
PENYELIDIK

BAHAGIAN C: MAKLUMAT SOSIAL/GAYA HIDUP

3.1 Sejarah pengambilan nikotin

3.1.1 Adakah anda pernah merokok?

1 Ya

0 Tidak

C1

3.1.2 Jika Ya, adakah anda masih merokok sekarang?

1 Ya

0 Tidak

C2

3.1.4 Jika Tidak, berapa lamakah anda telah berhenti merokok?

_____ tahun

C3

3.2 Sejarah pengambilan alkohol

3.2.1 Adakah anda pernah mengambil minuman beralkohol?

1 Ya

0 Tidak

C4

3.2.2 Adakah anda masih mengambil minuman beralkohol?

1 Ya

0 Tidak

C5

OCCUPATIONAL SAFETY AND HEALTH
IN AGRICULTURE:
PALM OIL INDUSTRY

KEGUNAAN
PENYELIDIK

3.3 Aktiviti Waktu Lapang

3.3.1 Pada masa lapang anda, adakah anda melakukan aktiviti-aktiviti yang berikut:

		<u>Ya</u>	<u>Tidak</u>	
3.3.1.1	Memburu	1 <input type="checkbox"/>	0 <input type="checkbox"/>	C6 <input type="checkbox"/>
3.3.1.2	Berkebun	1 <input type="checkbox"/>	0 <input type="checkbox"/>	C7 <input type="checkbox"/>
3.3.1.3	Memasak	1 <input type="checkbox"/>	0 <input type="checkbox"/>	C8 <input type="checkbox"/>
3.3.1.4	Kerja-kerja rumah	1 <input type="checkbox"/>	0 <input type="checkbox"/>	C9 <input type="checkbox"/>
3.3.1.5	Memancing	1 <input type="checkbox"/>	0 <input type="checkbox"/>	C10 <input type="checkbox"/>
3.3.1.6	Berkaraoke	1 <input type="checkbox"/>	0 <input type="checkbox"/>	C11 <input type="checkbox"/>
3.3.1.7	Bersukan	1 <input type="checkbox"/>	0 <input type="checkbox"/>	C12 <input type="checkbox"/>

3.3.2 Adakah anda pernah mengalami kecederaan berikut semasa melakukan mana-mana aktiviti-aktiviti (3.3.1.1 – 3.3.1.7) di atas yang membataskan pekerjaan anda?

1 Ya

0 Tidak

C13

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BAHAGIAN D: MAKLUMAT PERUBATAN

4.1 Adakah anda menghidap apa-apa penyakit yang berikut?

		<u>Ya</u>	<u>Tidak</u>	
1	Sakit jantung	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D1 <input type="checkbox"/>
2	Darah Tinggi (Hypertension)	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D2 <input type="checkbox"/>
3	Kencing Manis (Diabetes)	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D3 <input type="checkbox"/>
4	Skizofrenia	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D4 <input type="checkbox"/>
5	Insomnia	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D5 <input type="checkbox"/>
6	Asma	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D6 <input type="checkbox"/>

4.2 Adakah anda pernah mengambil sebarang ubat-ubatan untuk penyakit berikut:

		<u>Ya</u>	<u>Tidak</u>	
1	Sakit jantung	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D8 <input type="checkbox"/>
2	Darah Tinggi (Hypertension)	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D9 <input type="checkbox"/>
3	Kencing Manis (Diabetes)	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D10 <input type="checkbox"/>
4	Skizofrenia	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D11 <input type="checkbox"/>
5	Insomnia	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D12 <input type="checkbox"/>
6	Asma	1 <input type="checkbox"/>	0 <input type="checkbox"/>	D13 <input type="checkbox"/>

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BAHAGIAN E: TEGASAN HABA DAN PERUBAHAN FISIOLOGI

10.1 Pada pendapat anda, adakah persekitaran tempat kerja anda terdedah kepada haba?

1 Ya

2 Tidak

E1

10.2 Jika Ya, secara purata, berapa jam anda bekerja di dalam persekitaran yang panas tersebut?

_____ jam

E2

10.3 Berapa lamakah anda berehat dalam masa sehari anda bekerja?

10.4.1 Rehat: 30 minit pagi, 1 jam tengah hari, 30 minit petang

E3

10.4.2 Rehat: 2 jam tengah hari sahaja

E4

10.4.3 Rehat: 1 jam pagi, 1 jam tengah hari, 30 minit petang

E5

10.4 Simptom akut masalah kesihatan: adakah anda pernah mengalami gejala - gejala berikut semasa bekerja di stesen anda?

6.4.1 Keletihan

Ya	Tidak
<input type="checkbox"/>	<input type="checkbox"/>

E6

6.4.2 Pening

<input type="checkbox"/>	<input type="checkbox"/>
--------------------------	--------------------------

E7

6.4.3 Loya

<input type="checkbox"/>	<input type="checkbox"/>
--------------------------	--------------------------

E8

6.4.4 Kekejangan otot

<input type="checkbox"/>	<input type="checkbox"/>
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E9

6.4.5 Pitam

<input type="checkbox"/>	<input type="checkbox"/>
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E10

10.5 Adakah anda telah merasa biasa dengan keadaan panas di tempat kerja?

1 Ya

2 Tidak

E11

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10.6 Secara puratanya berapa lamakah anda berdiri, duduk, berjalan, menggunakan kedua-dua belah tangan semasa bekerja?

Sila isikan ruangan "**Masa**" pada jadual di bawah

	Kedudukan dan pergerakan badan	Kadar metabolisme (kcal/min)	Masa		Beban kerja (kcal) (diisi oleh penyelidik)
10.6.1	Berdiri	0.6	jam	min	
10.6.2	Duduk	0.3	jam	min	
10.6.3	Berjalan	2.0	jam	min	
10.6.4	Kerja menggunakan kedua belah tangan	1.5	jam	min	
10.6.5	Jumlah jam bekerja	1.0	jam	min	
Jumlah Beban Kerja Sehari					

10.7 Kategori Beban Kerja

Metabolic Rate	Category	Final
Up to 200 kcal/hour	Ringan	
200 – 350 kcal/hour	Sederhana	
350 – 500 kcal/hour	Berat	

10.8 Kategori waktu bekerja (Kitar kerja-rehat)

- 1 Bekerja secara berterusan bagi 8 jam
- 2 6 jam bekerja, 2 jam berehat bagi setiap jam
- 3 4 jam bekerja, 4 jam berehat bagi setiap jam
- 4 2 jam bekerja, 6 jam berehat

E12

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10.9 Workplace heat measurement (Diisi oleh penyelidik)

Temperature (°C)	Relative Humidity (%)	Air velocity (m/s)
WB =		
GT =		
DB =		

10.10 Kriteria Saringan bagi Pendedahan Ketegasan Haba Menurut ACGIH

Allocation of work in a work/rest cycle	Acclimatized				Action limit (Unacclimatized)			
	Light	Moderate	Heavy	Very heavy	Light	Moderate	Heavy	Very heavy
100% work	29.5	27.5	26.0	-	27.5	25.0	22.5	-
75% work; 25% rest	30.5	28.5	27.5	-	29.0	26.5	24.5	-
50% work; 50% rest	31.5	29.5	28.5	27.5	30.0	28.0	26.5	25
25% work; 75% rest	32.5	31.0	30.0	29.5	31.0	29.0	28.0	26.5

Notes:

Assumes 8-hour workdays in a 5-day workweek with conventional breaks.

TLVs assume that workers exposed to these conditions are adequately hydrated, are not taking medication, are wearing lightweight clothing, and are in generally good health.

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Bahagian ini diisi oleh penyelidik

10.11 Nilai deskriptif bagi parameter fisiologi responden bagi ketiga-tiga tempoh (sebelum syif bermula, 2 jam selepas syif bermula dan selepas tamat syif)

Suhu teras badan (sebelum syif bermula)	°C	E13
Suhu teras badan (selepas 2 jam)	°C	E14
Suhu teras badan (selepas 8 jam)	°C	E15

Tekanan darah distolik (sebelum syif bermula)	mm Hg	E16
Tekanan darah distolik (selepas 2 jam)	mm Hg	E17
Tekanan darah distolik (selepas 8 jam)	mm Hg	E18
Tekanan darah sistolik (sebelum syif bermula)	mm Hg	E19
Tekanan darah sistolik (selepas 2 jam)	mm Hg	E20
Tekanan darah sistolik (selepas 8 jam)	mm Hg	E21

Kadar denyutan nadi (sebelum syif bermula)	per minut	E22
Kadar denyutan nadi (2jam)	per minut	E23
Kadar denyutan nadi (selepas 8 jam)	per minut	E24