HAZARD IDENTIFICATION, RISK ASSESSMENT AND RISK CONTROL (HIRARC) FOR THE USE OF CALCIUM CARBIDE (CAC2) AS RIPENING AGENT AMONG MANGO FARMERS IN NORTHERN REGION OF MALAYSIA

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ABSTRACT

The objective of this study is to identify hazard, risk and recommended control mechanism for CaC2 handling through HIRARC. The assessment was determined using DOSH risk matrix, DOSH risk ranking and hierarchy of control tools which incuded elimination, substitution, isolation, engineering controls, administrative controls and personal protective equipments (PPE). From this study, there were three activities determined in this study that have a capacity to instigate hazards to farmers which were carbide wrapping, ripening process and fruits checking after ripening process is over. There were for type of controls applied in this process and it's included engineering control, isolation, administrative and PPE. In conclusion, there is a need to conduct HIRARC because it is considered as preventive measures since control is applied when hazard has been identified and analyzed, and its associated risk are assessed.

Key words: Calcium carbide, HIRARC, Chemical fruits ripening

INTRODUCTION

Calcium carbide (CaC_2) is one of the chemical ripening agents that has been used for fruits and vegetables ripening (Goonatilake 2008) since ancient. This substance is venerated among farmers because ripening process can be accelerated within 24 hours and furthermore, the cost of using this chemical for ripening is low (Singal, Kumud and Thakral, 2010). In Malaysia, CaC_2 is widely used for fruits ripening specially mangoes (Siddiqui and Dhua, 2009). There are two types of carbide forms used for ripening which are in powder form and small block. Acetylene gas was released from the reaction between CaC_2 and water (Sy and Wainwright, 1990). It has a similar function as ethylene gas, a natural/biological ripening gas (Hossain, Akhtar and Anwar, 2015). However, the impurities (arsine and phosphine) that present in the acetylene gas made CaC_2 become hazardous to human health (Rahman et al., 2008). The concentration of phosphine released from the CaC_2 reaction was at 95 ppm (Bingham et al., 2001) and this value was exceeded the life and health value (IDLH) set by the United States NIOSH which is 50 ppm (NIOSH, 2003).

The use of high amount of CaC_2 on raw fruits contribute to the CaC_2 toxicity due to the existence of impurities (arsine and phosphine) (Public Health England, 2009). Shortness of breath, wheezing, cough, and sore throat are among the symptoms that may appear temporarily once exposed to CaC_2 (Siddiqui and Dhua, 2010) and if the exposure level is above the Protective Action Criteria (PAC) values which are PAC-1 = 30 mg/m^3; PAC-2 = 50mg/m^3; PAC-3 = 250mg/m^3, farmers may suffer pulmonary edema (New Jersey Department of Health and Senior Services, 2003). In Malaysia, there are no acts and regulations regarding the use of CaC_2 in post-harvest phase in agricultural sector either related to occupational safety or food safety. Besides, there are very few studies conducted regarding the effects of CaC_2 use as a fruit ripening agent on workers and also consumers. However in countries like Bangladesh, India and Nepal, there are several laws related to the use of CaC_2 such as in Bangladesh (Pesticide Law 2007, Pure food rules and Act 1967 and 2005, Quarantine rules 1968, Mobile Court Act 2009 and Penal Code 1869, in India (Food Safety and Standards Act 2006, Prevention of Food Adulteration Rules 1955 and Food Safety and Standards Regulations 2001 (Islam, Rahman, Mursalat, Rony and Khan, 2015) and for Nepal (Food Rules Act, 2007 (1970) (Islam, Rahman, Mursalat, Rony and Khan, 2015).

HIRARC is an approach of assessing hazards and their related risks that will divulge a system to confine the risks (DOSH Malaysia, 2008). The procedure in HIRARC includes work activities categorization, followed by identification of hazards, risk assessment, and last but not least is selecting a control (DOSH Malaysia, 2008). The risks instigating from the use of CaC_2 are managed through 'hierarchy of controls' (Basiran, Baharudin and Anwar, 2016). This process requires an evaluation of current control whether it is indispensable to make any changes to the present control system or to instigate a new control process. The hierarchy of controls comprises of elimination, substitution, isolation, engineering controls, administrative controls, and personal protective equipment (Basiran, Baharudin and Anwar, 2016).

METHODOLOGY

This study was conducted among farmers and fruit sellers who applied CaC_2 for fruits ripening in Perak, Perlis and Kedah. The northern part of Malaysia was chose for this study due to its huge mango production with total production (Metric Tons) in 2013 are 5821.9, 4684.6 and 4844.2 for Perak, Perlis and Kedah respectively (Jabatan Pertanian, 2013) There were three approaches were used in conducting HIRARC which included DOSH risk matrix, DOSH risk ranking and hierarchy of control tools (Basiran, Baharudin, & Anwar, 2016). HIRARC was conducted for ripening activities in the farms and at the fruit stalls. The work activities were determined and this encompassed the defined task, stages in process and the physical areas (DOSH Malaysia, 2008). For each work activities, hazards were identified and grouped into categories. Hazards were identified through the observation on workplace, potential accident factors and the employee and employer complaints.

The likelihood of an occurrence (Table 1) and the severity of hazards (Table 2) were used in the risk analysis and estimation where relative risk is equal to likelihood times severity (Relative risk = Likelihood x Severity)(DOSH Malaysia, 2008). The risk then was determined using risk matrix as in Table 3 (DOSH Malaysia, 2008). In order to control the workplace hazard efficiently, the relative risk value finalized from the risk matrix table were then applied to emphasize actions need to be taken as shown in Table 4 (DOSH Malaysia, 2008). The HIRARC for this study was completed in a form of table.

Table 1. Likelihood of an occurrence

Likelihood (L)	Example	Rating
Most likely	The most likely result of the hazard/event being realized	5
Possible	Has a good chance of occurring and is not unusual	4
Conceivable	Might be occur at some time in future	3
Remote	Has not been known to occur after many years	2
Inconceivable	Is practically impossible and has never occurred	1

Table 2. Severity of hazard

Severity(S)	Example	Rating
Catastrophic	Numerous fatalities, irrecoverable property damage and productivity	5
Fatal	Approximately one single fatality major property damage if hazard is realized	4
Serious	Non-fatal injury, permanent disability	3
Minor	Disabling but not permanent injury	2
Negligible	Minor abrasions, bruises, cuts, first aid type injury	1

Table 3. Risk matrix table

	Severity (S)				
Likelihood (L)	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Where,

Low
Medium
High

Table 4. The risk range description

Risk	Description	Action
15-25	High	A high risk requires immediate action to control the hazard as detailed in the hierarchy of control.
5-12	Medium	A medium risk requires a planned approached to controlling the hazard and applies temporary measures if required.
1-4	Low	Acceptable and further reduction may not be necessary.

RESULTS AND DISCUSSION

In order to supervise the workplace hazard efficiently, the relative risk determined in Table 5 showed the essential actions that need to be encountered. There were three work activities involved in fruits ripening process which have a potential to initiate hazards towards farmers, fruit traders, farm workers and fruit stall workers and three categories of hazards were identified. The work activities were carbide wrapping, ripening process and fruits checking after ripening process is over while the hazards categories associated with the work activities were chemical, work environmental and safety. It was found that most of the high risks were related with the noxiousness effect of CaC_2 such as skin irritation, eyes irritation and inhalation irritation and this condition needs instant action with the intention to control the hazards.

The types of control proposed in this study in order to eliminate the hazards were engineering control, administrative control and personal protective equipment (PPE) control. For engineering control, the use of proper container to store the CaC_2 block and the segregation of the hazard's source in a well-ventilated room or in an open area can reduced the hazards while for administrative control, the recommendation on safe work procedure and supervision of workers on the recommended quantity used of CaC_2 (0.3-10g) of carbide for each kilograms of yields) (Rohani 1999) and proper storage of chemical after used were suggested. PPE control (application of mask and glove) were also advised due to the health impact of the chemical hazards to the farmers.

The knowledge gap that exist in this study was noticed through interview with the respondents and observation and it was found that most of the respondents have a very low information on recommended quantity of CaC_2 used which was 24%. They were also showed depleted knowledge on the effect of CaC2 to health which was 25.5%. Apparently, the low percentage of knowledge on carbide will lead to a practice gap where only 37% and 35% were using glove and mask, respectively when handling carbid.

Table 5. HIRARC for the use of CaC_2 for ripening purpose

Hazard identification				Risk analysis				Risk control
No	**Work activity**	**Hazard**	**Effect**	**Existing control**	**Likelihood (L)**	**Severity (S)**	**Risk ranking**	**Recommended control measures**
1	Carbide wrapping	Confined spaces without proper ventilation	Accumulation of carbide dust	Carried out wrapping activity at opened space or in a room with ventilation	4	3	12	Wear mask and glove to avoid the carbide dust entering the nose
		Hot weather	Dehydrate	None	3	1	3	Provide adequate drinking facilities
		Flammable chemical	Cause fire	CaC_2 was kept by tied the packaging using rubber band after every use	2	4	8	Kept in a tight container every time after use and apply safe work procedure
		Irritation chemical	Irritate eyes, skin and inhalation	None	5	3	15	Wear appropriate mask and glove
2	Ripening process	Confined spaces without proper ventilation	Accumulation of phosphine gas	The fruit basket was covered with newspaper	4	4	16	Located the fruit basket in an opened area or in a well-ventilated room
		Flammable chemical	Cause fire	Use appropriate quantity of CaC_2	1	4	4	Supervise the recommended quantity used (0.3-10g of carbide for each kilograms of yields) and apply safe work procedure
		Irritation chemical	Skin corrosion and eyes irritation	None	3	3	9	Wear appropriate glove
		Irritation chemical	Skin corrosion and eyes irritation	None	3	3	9	Wear appropriate glove
		Toxic chemical	Inhalation	None	5	3	15	Wear appropriate mask
3	Fruits checking after ripening process is over	Flammable chemical	Cause fire	Use appropriate quantity of CaC_2	1	4	4	Follow the recommended quantity which is 0.3-10g of carbide for each kilograms of yields
		Irritation chemical	Skin corrosion and eyes irritation	None	3	3	9	Wear appropriate glove
		Toxic chemical	Inhalation	None	5	3	15	Wear appropriate mask

High

Medium

Low

CONCLUSION

HIRARC can be counted as preventive actions because when hazard has been identified and analysed, and its associated risks are assessed, the appropriate control is suggested and applied (DOSH Malaysia, 2008). The working practice can be transform to a positive way from the corrective action taken. HIRARC is conducted when there is an indication of significant threat posed by substantial hazards or when there is a need to evaluate if the current controls are insufficient. The process involves four steps which are work activities classification, hazard identifications, risk analysis, and suitable controls taken (DOSH Malaysia, 2008). Other than that, it is important to decide on suitable corrective or preventive measures to ensure that the risks are satisfactorily controlled (DOSH Malaysia, 2008). The finding of this study would be beneficial to the policy maker especially for the development of standard operating procedure (SOP) on the safe handling of carbide to ensure the quality of human health especially farmers in a good state. The information that can be incorporated in the SOP are MSDS of CaC_2 and Phosphine, route of exposure, PEL or OEL for CaC_2 and Phosphine, the recommended quantity of CaC_2 should be used for ripening and the use of PPE when handling CaC_2. Furthermore, it is also beneficial to farmer community where awareness on the health impact of carbide to health can be improved and thus, encourage them to apply PPE when handling carbide.

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