Available online on 15.09.2023 at ijmspr.com

International Journal of Medical Sciences and Pharma Research

Open Access to Medical Science and Pharma Research

Open Access **Research Article**

Literature Study: Overview of Cholinesterase Enzyme Activity in Horticultural Farmers Exposed to Organophosphates and Carbamates

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Article Info:

Article History:

Received 21 June 2023
Reviewed 04 August 2023
Accepted 26 August 2023
Published 15 September 2023

Cite this article as:

Lestari D, Astutik Y, Literature Study: Overview of Cholinesterase Enzyme Activity in Horticultural Farmers Exposed to Organophosphates and Carbamates, International Journal of Medical Sciences & Pharma Research, 2023; 9(3):1-6

DOI: http://dx.doi.org/10.22270/ijmspr.v9i3.66

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Abstract

Pesticides are chemicals used to control pests and animals that cause damage to crops. Organophosphate and carbamate pesticides have the potential to cause poisoning for humans, including horticultural farmers. Farmers who experience poisoning will experience metabolic disorders of the enzyme cholinesterase in the blood. To determine the activity of the enzyme cholinesterase due to exposure to organophosphates and carbamates can use the Tintometer kit and Spectrophotometer. This scientific paper is made with a literature study method that discusses cholinesterase enzyme activity in horticultural farmers based on internal factors including gender, age, and knowledge then external factors including spraying frequency, working period, use of PPE, and length of spraying. This literature study used 18 journals in the publication year 2013 - 2023. Based on the results of the journal literature review, the danger of pesticide poisoning which results in a decrease in the activity of the enzyme cholinesterase in the blood of farmers will increase the longer farmers are exposed to organophosphate and carbamate pesticides. The decrease in cholinesterase enzyme activity in horticultural farmers based on internal factors in farmers with age, gender, and low knowledge level. For external factors, there was a decrease in cholinesterase enzyme activity in farmers with a spraying frequency of >2 times a week, a working period of more than 5 years, farmers who used incomplete PPE and farmers who sprayed pesticides for more than 3 hours per day.

Keywords: Organophosphate, Carbamate, Enzim Cholinesterase

INTRODUCTION

Collaboration and technological innovation in agriculture and plantations have been widely applied by horticultural farmers to increase productivity and profitability. However, despite this, farmers still always deal with pests that become obstacles in crop production and cultivation so that spraying pesticides is an effort made by farmers to control and kill pests[1] (Pratama et al., 2021). The uncontrolled use of pesticides due to the cover blanket system method, results in consistent exposure to farmers. Nationally in 2019 there were 334 cases of pesticide poisoning with 147 cases of agricultural pesticides as the causative group. Organophosphates and Carbamates are the types of pesticides most commonly used by farmers. these two types of pesticides have anti-cholinesterase properties that can suppress cholinesterase activity in red blood cells and synapses.

Cholinesterases are a family of enzymes that catalyze the hydrolysis of the neurotransmitter acetylcholine (ACh) into choline and acetic acid, a reaction necessary to allow cholinergic neurons to return to a resting state after activation. ACh functions as a carrier and messenger in preganglionic sympathetic and parasympathetic neurons and also acts as a nerve conductor in all parasympathetic-containing organs of the adrenal medulla.

ACh is synthesized through a single-step reaction catalyzed by the enzyme choline acetyltransferase biosynthesis and the presence of this enzyme is a "marker" that the neuron is cholinergic. ACh is released from the neuron during neurotransmission and binds to nicotinic and muscarinic ACh receptors on the postsynaptic membrane, conveying signals from the nerve. The postsynaptic membrane is home to AChE, which stops signal transmission by hydrolyzing ACh. The pre-synaptic nerve absorbs the choline freed from ACh breakdown once again, and choline acetyltransferase uses it to combine with acetyl-CoA to make neurotransmitters (Colovic et al., 2013).

In organophosphate and carbamate pesticide poisoning, the hydrolysis reaction of Ach into choline and acetic acid will be inhibited where the active side of the cholinesterase enzyme that should bind to acetylcholine will bind to the active substances of organophosphates and carbamates. This results in the accumulation of acetylcholine at muscarinic, nicotinic, & CNS synapses (Balqis et al., 2019).

MATERIALS AND METHODS

This research is written using the literature review method which aims to compile, tabulate and compare research results, then summarize the entire research. Journal searches in the research conducted using keywords, year ranges, and sorting according to relevance specify and expand during searches to make it easier when determining which journals to review. In this study, the journal search used keywords namely "pesticide poisoning in farmers" and "organophosphate & carbamate pesticides" the search for journals reviewed in this study was sourced from journals related to the research topic using the Google Scholar, Neliti, and ResearchGate databases.

RESULTS

The results of research on the description of cholinesterase enzyme activity in farmers exposed to organophosphates and carbamates based on literature studies are as follows

1. Overview of Cholinesterase Enzyme Activity Based on Internal Risk Factors Gender

No.	Author - Year	Method	Gender	Result AchE			Conclusion
				Normal	Abhormal	n	
1	(Hermawan et al., 2018)	Tintometer Kit Lovibond 2000	Female	0	2	2	No relation
			male	10	36	49	
2	(Wicaksono et al., 2018)	-	Female	3	1	4	No relation
			male	14	20	34	
3	(Amalia, 2019)	-	Female	-	-	-	No relation
			male	-	-	-	
4	(Saragih, 2019)	-	Female	17	8	25	No relation
			male	4	1	5	
5	(Utami et al., 2021)	Tintometer Kit Lovibond 2000	Female	20	1	21	No relation

Of the five journals searched, it was found that the gender that experienced the most decrease in cholinesterase enzyme activity was male with a percentage of the number of farmers who experienced a decrease in cholinesterase enzyme as much as 67% of the total respondents. In his research, Hermawan (2018) stated that this happened because of the lack of maximum data collection of respondents. Where in this gender variable only 2 female respondents were obtained and 46 male respondents so that the statistical test found that gender was not associated with cholinesterase levels in the blood of farmers.

2. Overview of Cholinesterase Enzyme Activity Based on Internal Risk Factors Age

No.	Author - Year	Method	Age	Result AchE			Conclusion
				Normal	Abhormal	n	
1	(Yuantari, 2020)	Tintometer Kit Lovibond 2000	Productve	40	1	41	No relation
			Not productibe <25 years	2	2	4	
2	(Ipmawati et al., 2016)	-	<25 years	9	5	14	No relation
			≥25 years	40	38	78	
3	(Purnomo, 2021)	Fotometrik	Productive (>15 dan <64 years	42	33	75	No relation
			Less productve <15 dan >64 years	7	4	11	
4	(Tutu et al., n.d.)	-	<48 years	6	10	16	No relation
			>48 years	3	11	14	
5	(Wicaksono et al., 2018)	-	<40 years	19	10	9	No relation
			>40 years	8	11	19	
6	(Utami et al., 2021)	Tintometer Kit Lovibond 2000	<36 years	44	2	46	No relation

Of the six journals searched, it was found that the age that experienced the most decline in cholinesterase enzymes was productive age with a percentage of the number of farmers who experienced a decrease in cholinesterase enzymes as much as 40% of the total respondents. According to the International Labor Organization (ILO) quoted by Darmawan and quoted again by Utami (2021), it is explained that younger workers (those under 20 years of age) have cholinesterase activity that tends to decrease faster than older workers, especially if exposed or exposed to pesticides which can exacerbate the effects of poisoning. The longer a person works with pesticides, the more exposure they receive, which reduces the efficacy of their immune system and impairs their body's ability to fight toxic substances. This effect increases with age.

3. Overview of Cholinesterase Enzyme Activity Based on Internal Risk Factors Level of Knowledge

No.	Author - Year	Method	Knowledge	Result AchE			Conclusion
				Normal	Abhormal	n	
1	(Ipmawati et al., 2016)	-	Good	31	17	48	Related
			Not so good	18	26	44	
2	(Purnomo, 2021)	Fotometrik	Good	5	0	5	Related
			Not so good	44	37	81	
3	(Hermawan et al., 2018)	Tintometer Kit Lovibond 2000	Good	7	22	29	Related
			Not so good	3	27	30	
4	(Tutu et al., n.d.)	-	Good	4	14	18	No relation
			Not so good	5	7	12	
5	(Tika & Cahyati, 2019)	-	Good	13	3	16	Related
			Not so good	12	22	34	
6	(Wicaksono et al., 2018)	-	Good	12	10	22	No relation
			Not so good	5	11	16	
7	(Yushananta, 2020)	Good	129	43	172		No relation
		Not so good	89	28	117		

Of the seven journals searched, it was found that a decrease in cholinesterase enzyme activity occurred mostly in farmers with a poor level of knowledge with a percentage of the number of farmers who experienced a decrease in cholinesterase enzymes as much as 47% of the total respondents. One of the main determinants of behavior is the level of knowledge. Cholinesterase activity in the blood will be influenced by farmers' knowledge about pesticides, their use, and pesticide management because this affects the use of pesticides by farmers (Ipmawati et al., 2016). Farmers who do not have knowledge about pesticides are more likely to be poisoned than farmers who have knowledge about pesticides (Purnomo, 2021).

4. Overview of Cholinesterase Enzyme Activity Based on External Risk Factors Spraying Frequency

No.	Author - Year	Method	Spray frequency	Result AchE			Conclusion
				Normal	Abhormal	n	
1	(Ipmawati et al., 2016)	-	≤ 2 times / week	35	2	37	Related
			> 2 times / week	14	41	55	
2	(Purnomo, 2021)	Fotometrik	< 2 times / week	7	0	7	Related
			> 2 times / week	42	37	79	
3	(Hermawan et al., 2018)	Tintometer Kit Lovibond 2000	< 2 times / week	7	26	33	No relation
4	(Tutu et al., n.d.)	-	≤ 2 times / week	7	5	12	Related
			> 2 times / week s	2	16	18	
5	(Tika & Cahyati, 2019)	-	Low	16	7	23	Related
			High	9	18	27	
6	(Utami et al., 2021)	Tintometer Kit Lovibond 2000	≤ 2 times / week	26	3	29	No relation
			> 2 times / week	83	1	84	
7	(Yushananta, 2020)	Fotometrik	≤ 2 times / week	99	18	117	Related
			> 2 times / week	119	53	172	

Of the seven journals searched, it was found that the decrease in cholinesterase enzyme activity occurred mostly in farmers with a spraying frequency of > 2 times / week with a percentage of the number of farmers who experienced a decrease in cholinesterase enzyme as much as 41% of the total respondents. Based on the review of the journal Ipmawati et al., (2016) the possibility of pesticide poisoning farmers will increase along with the increasing number of agricultural land that began spraying. The length of time farmers spend spraying also affects how often they spray, therefore, the more often farmers spray their fields, the greater the risk of pesticide poisoning. Purnomo's research (2021) states that spraying too often can cause the cholinesterase enzyme to decrease.

5. Overview of Cholinesterase Enzyme Activity Based on External Risk Factors of Working Period

No.	Author - Year	Method	Length of period	Result AchE			Conclusion
				Normal	Abhormal	n	
1	(Yuantari, 2020)	-	< 20 Years	17	0	17	No relation
			≥ 20 Years	25	3	28	
2	(Ipmawati et al., 2016)	-	≤ 1 Years	35	6	41	Related
			> 1 Years	14	37	51	
3	(Purnomo, 2021)	-	< 5 Years	5	0	5	Related
			≥ 5 Years	44	37	81	
4	(Hermawan et al., 2018)	Tintometer Kit Lovibond 2000	Not at risk	8	15	23	Related
			At risk	2	23	25	
5	(Tutu et al., n.d.)	-	New	5	4	9	Related
			Old	20	21	41	
6	(Tika & Cahyati, 2019)	-	Good	12	10	22	No relation
			Not so good	5	11	16	
7	(Mastra, 2019)	-	< 5 Years	2	1	3	Related
			≥ 5 Years	6	21	27	
8	(Istinah, 2018)	-	New	9	28	37	Related
			Old	22	27	49	
9	(Utami et al., 2021)	Tintometer Kit Lovibond 2000	≤ 10 Years	44	1	45	No relation

Of the nine journals searched, it was found that the decrease in cholinesterase enzyme activity occurred mostly in farmers with a working period of >5 years with a percentage of the number of farmers who experienced a decrease in cholinesterase enzyme as much as 48% of the total respondents. The amount of pesticide buildup that enters the body correlates with the length of time farmers work. In general, the longer farmers spray continuously and over a longer period of time, the greater their chances of being poisoned and experiencing more severe poisoning (Ipmawati et al., 2016).

6. Overview of Cholinesterase Enzyme Activity Based on External Risk Factors for PPE Use

No.	Author - Year	Method	PPE	Result AchE			Conclusion
				Normal	Abhormal	n	
1	(Yuantari, 2020)	-	Complete	4	0	4	No relation
			Incomplete	38	3	41	
2	(Purnomo, 2021)	-	Use	32	5	37	Related
			No use	17	32	49	
3	(Yushananta, 2020)	Photometric Kinetic Test	Complete	100	9	109	Related
			Incomplete	118	62	180	
4	(Tutu et al., n.d.)	-	Complete	7	3	10	Related
			Incomplete	2	18	20	
5	(Tika & Cahyati, 2019)	-	Complete	15	8	23	No relation
			Incomplete	10	17	27	
6	(Mastra, 2019)	-	Complete	4	6	10	Related
			Incomplete	4	16	20	
7	(Istinah, 2018)	-	Complete	12	4	16	Related
			Incomplete	19	51	70	
8	(Utami et al., 2021)	Tintometer Kit Lovibond 2000	Good	84	1	85	Related

Of the eight journals searched, it was found that the decrease in cholinesterase enzyme activity occurred mostly in farmers with incomplete use of PPE with a percentage of the number of farmers who experienced a decrease in cholinesterase enzyme as much as 49% of the total respondents. It has been proven that using the right PPE and using it in appropriate conditions can reduce the risk of pesticide exposure for workers who spray pests. In accordance with applicable laws and regulations, PPE is a tool that can protect workers because it can protect workers from various risks and hazards that may arise in the workplace. Farmers' health is maintained by the use of appropriate PPE, so as to reduce the risk of exposure to hazardous pesticides.

7. Overview of Cholinesterase Enzyme Activity Based on External Risk Factors Spraying Duration

No.	Author - Year	Method	PPE	Result AchE			Conclusion
				Normal	Abhormal	n	
1	(Ipmawati et al., 2016)	-	≤ 3 Hours	45	4	49	Related
			> 3 Hours	4	39	43	
2	(Tutu et al., n.d.)	-	≤ 4 Hours	7	4	11	Related
			> 4 Hours	2	17	21	
3	(Mastra, 2019)	-	Low	24	23	47	No relation
			High	1	2	3	
4	(Saragih, 2019)	-	≤ 5 Hours	16	1	17	Related
			> 5 Hours	5	8	13	
5	(Mathematics, 2016)	-	≤ 3 Hours	8	22	30	No relation
			> 3 Hours	-	-	-	
6	(Istinah, 2018)	-	Good	11	9	20	Related
			Bad	20	46	66	

Of the six journals searched, it was found that a decrease in cholinesterase enzyme activity occurred in farmers with a length of spraying time >3 hours / day with a percentage of the number of farmers who experienced a decrease in cholinesterase enzyme as much as 52% of the total respondents. research conducted by Mutiara (2019) which states there is a relationship between the length of spraying with cholinesterase activity. In line with research conducted by Ipmawati (2016), Tutu (2020), Istianah (2018), and Saragih (2019). The above research is not in line with research conducted by Budiawan (2013) and Mastra (2019) who found no relationship between the length of spraying and the decrease in cholinesterase enzyme activity in farmers. In his research, Budiawan (2013) stated that there are other factors that can also affect the length of spraying such as the use of personal protective equipment (PPE) by farmers. Most farmers only wear hats, long-sleeved shirts, long pants, and trousers, regardless of the importance of using PPE. Mastra (2019) who also stated that the use of pesticides in a short time can already make farmers sick or experience a decrease in cholinesterase enzyme activity.

8. Overview of cholinesterase enzyme activity by examination method

No.	Author - Year	Method	Result AchE		n
			Normal	Abnormal	
1	(Penuh, 2018)	Tintometer Kit Lovibond 2000	21	9	30
2	(Horimu et al., 2017)	Tintometer Kit Lovibond 2000	28	6	34
3	(Nurillah, 2020)	Photometric Kinetic Test	4	1	5
4	(Purnomo, 2021)	Photometric Kinetic Te	49	37	86
5	(Nasyuddin, 2013)	Tintometer Kit Lovibond 2000	8	42	50
6	(Yushananta, 2020)	Photometric Kinetic Te	218	71	289
7	(Rahmawati & Soenjono, 2014)	Tintometer Kit Lovibond 2000	8	7	15
8	(Hermawan et al., 2018)	Tintometer Kit Lovibond 2000	10	38	48

Of the eight journals searched, it was found that many researchers used the Tintometer Kit method with a percentage of 62% of the total literature. And the photometric kinetic test method with a spectrophotometer with a percentage of 37% of the total literature to analyse cholinesterase enzyme activity. Based on 18 journals searched, 6 journals used the Tintometer kit method, 3 journals used the photometric kinetic test method, and 9 other journals did not include the method used in analysing the cholinesterase enzyme.

CONCLUSION

1. There is no relationship between gender and cholinesterase enzyme activity in horticultural farmers.
2. There is no relationship between age and cholinesterase enzyme activity in horticultural farmers.
3. The results of the literature study from 7 journals searched, 5 journals stated that there was a relationship while the other 2 journals stated that there was no relationship between cholinesterase enzyme activity and risk factors for knowledge level.
4. The results of the literature study from 7 journals searched, 5 journals stated that there was a relationship while the other 2 journals stated that there was no relationship between cholinesterase enzyme activity and the risk factor of spraying frequency.
5. The results of the literature study from 9 journals searched, 6 journals stated that there was a relationship while the other 3 journals stated that there was no relationship between cholinesterase enzyme activity and the risk factor of working period.
6. There is a relationship between the use of PPE and cholinesterase enzyme activity in horticultural farmers.
7. The results of the literature study from 6 journals searched, 4 journals stated that there was a relationship while the other 2 journals stated that there was no relationship between cholinesterase enzyme activity and the risk factor of spraying duration.
8. Tintometer kit and photometric kinetic test are the most widely used methods to determine cholinesterase enzyme activity.

ACKNOWLEDGEMENTS

Thank you to institution Health Polytechnic Ministry of Health Jakarta III

CONFLICT OF INTEREST: None declared

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