THE EFFECTS OF PESTICIDES ON THE HEALTH OF PEASANT COCOA FARMERS IN MUNYENGE, SOUTH WEST CAMEROON

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ABSTRACT

There is a significant increase in the use of pesticide and these chemicals have potential adverse effects on human health. This study aimed to investigate the effects of exposure to pesticides on the liver, heart and lungs functions of 296 cocoa farmers with more than 1 year experience. One hundred non-farmers were recruited as a control group to compare levels of alanine aminotransferase (ALT) and aspartate aminotransferase (AST). The results indicated that AST and ALT were significantly (P<0.05) increased in pesticide-exposed workers compared with control. However, there was a positive correlation between AST and ALT among exposed group. Increase in chemical applications was positively correlated with increase in the levels of AST and ALT in the blood. Munyenge farmers require more attention on pesticide use so as to limit the health hazards caused by the side effects of these chemicals.

Keywords: alanine aminotransferase, aspartate aminotransferase, Cameroon, Munyenge

INTRODUCTION

Pesticides are ubiquitous in the environment and have significant economic, environmental and public health impact. Their usage has played a significant role in raising the yields of crops from agricultural land around the world. Cocoa was introduced to Cameroon by the German colonial administration in the western coastal areas, including around Mount Cameroon, in 1886 (Ardener, 1996). During this time, the Germans introduced a range of plantation crops from around the world into Cameroon through the Victoria (now Limbe) Botanic Garden, at the foot of Mount Cameroon. The Trinitario variety of cocoa they introduced was from Venezuelan and West Indian planting material, with distinctive red-podded trees. The result is cocoa with unusually high fat content and a red-colored powder (Jagoret, 2011). The Trinitario variety, called “German”, is still planted around Mount Cameroon today. In South and East Cameroon, Trinitario trees were mixed with Amelonado from Fernando Po, Equatorial Guinea. Amelonado cocoa was first introduced to the Central and West African region through Principe (1822), Sao Tome (1830) and Fernando Po (1854). Cocoa plantations on Fernando Po relied on imported labor from West Africa, and with the exception of Cameroon, Amelonado cocoa spread throughout the region when cocoa laborers returned home (Wood, 1991).

Cocoa is grown mainly in two areas in Cameroon; the coastal zone and the Center South, East regions. The coastal zone of the country extends from the area around mount Cameroon to Kribi. Attitude is generally below 400 m except in area around mount Cameroon. The main annual rainfall pattern is between 2000 mm to 5000 mm. The mean temperature varies from 22°C to 29°C. The second most important area covers the Center, South and Eastern provinces. The attitude ranging between 500 m and 850 m. The mean temperature is around 25°C and mean annual rainfall between 1500 mm and 2000 mm (Mahob *et al*., 2014).

Cameroon is the sixth largest producer of cocoa in the world, most of it being grown in the humid, forested south of the country. Since 1994, farmers have sold their cocoa on the international market. Processed cocoa products such as paste and butter account for around 15% of cocoa export earnings. In many African countries, economic and agricultural policies promote the use of pesticides compared to non-chemical-based pest control measures. In the cash crop sector in particular, the adoption of less chemical-dependent crop protection methods by the farming community takes place on a relatively lower scale (Adesina and Zinnah, 2003).

Cocoa remains the main cash crop to more than 75% of the population in Cameroon. Its production is mainly by peasant farmers who, even though they are the main producers of the high demand crop, do not earn sufficient income to meet their needs and maintain a moderate standard of living. They are left to suffer, which endangers the cocoa sector and their entire livelihood (AFTA, 2005).

The effectiveness of pesticides derives from their ‘kill function’ which in turn is related to their level of toxicity. As a result, pesticides are thus necessarily by nature made to be toxic, else they would not be effective. As toxic products, they are biocides that kill pests but inadvertently negatively affect human health. The negative effects of pesticides on human health and productivity have been documented by several authors including Rola & Pingali (1993) and Antle *et al*. (1998). Given that labor is one of the most important factors in agricultural production especially in developing countries, pesticides necessarily lower aggregate potential output through their negative impact on the health of household members and farm workers.

Chemicals with various side effects are left in the hands of these farmers to fight pests with little or no knowledge on the use of these chemicals by them. Due to this negligence, it was thought very necessary to evaluate the various chemicals used by these cocoa farmers and their health implications on them. The liver enzyme has broad substrate specificity, including a variety of pesticide oxidations. Many researchers tried to correlate various enzymes with the harmful effects of pesticides, especially in the case of ALT**,** AST and ALP (Vrioni *et al*., 2011; Dias *et al*., 2013). However, very little work has been done on this aspect in Cameroon. Therefore, analysis of blood samples of agriculture workers compared with control was done to find 1) Type of pesticides application and its effect on liver functions. 2) The impact of pesticide exposure on liver enzymes among different age group 3) Correlation between liver enzymes and age and number of pesticide application.

MATERIALS AND METHODS

Study Area

Munyenge is a populated rural place and is located in South-West Region, Cameroon. The estimated terrain elevation above sea level is 206 metres. It is located around Latitude: 4°24'18" Longitude: 9°16'11.64. Munyenge is found in the Muyuka Sub-Division of the Fako Division. It is located behind the Mount Cameroon with very rich volcanic soil and the main occupation is farming. The main cash crop cultivated is cocoa and the local farmers receive little or no subvention from the government (personal communication). This area is characterized by bad road which is almost inaccessible by cars and trucks in the rainy season. Accessibility is possible at onset and during the dry season and beginning of the rainy season.

Education is not a priority in the place as many of the people prefer petit trade and farming to education. Portable water is not readily available in Munyenge and the small water catchments from the mountain are sources of water for drinking and domestic use. Apart from farming many small off-licenses can be found littered throughout the entire town where farmers after selling their products empty their pockets. Access to good healthcare in Munyenge is still a myth and the small health centre located there is poorly equipped with very few health workers to attend to the health needs of the population.

Study Design

This was a non-probability study whereby all farmers who were willing and signed the consent form were recruited. Structured questionnaire was used to evaluate farmers' knowledge on pesticide use after which, blood sample were collected from each farmer into a tube with no anticoagulant. 296 cocoa farmers consented for the study and were recruited. The blood collected was separated and used to test for liver and kidney functioning of these farmers after many years of exposure to these chemicals during spraying. The questionnaire was written in English and administered in English and Pidgin English by the research assistants under the supervision of the first author.

The interviews covered the following themes: (1) the type and source of pesticides used in cocoa farming, (2) frequency of pesticide application in a cropping season, (3) the use of protective gear when applying pesticides, (4) any cases of pesticide poisoning experienced by cocoa farmers, and (5) individual knowledge on the negative effects of pesticide use on the environment among others. Data for this baseline survey were collected between October and December 2017.

Ethical Issues

The study was approved by the institutional review board of the School of Health and Human Services, Saint Monica University, Buea. Administrative clearance and authorization was obtained respectively from the Delegation of Public Health South West Region Buea (R11/MINSANTE/SWR/RDPH/PS/996/149) as well as the Buea District Health Services (FW2/L/MINISANTE/RDPHSW/DHS/BUEA/75), permitting us to carry out research in any area of the Fako Division. Authorization was also obtained from the district and community leaders in the various towns. At an individual level, verbal consent was received from each participant before data collection. The principles of privacy and confidentiality were upheld.

Pesticide Classification and Characterisation

Pesticides widely used by these farmers were broadly classified based on the target pest, mainly grouped into herbicides, insecticides and fungicides, (Damalas, 2011). Based on chemical properties, pesticides can also be categorized into organochlorines (OC), organophosphates (OP), carbamates, dithiocarbamates, pyrethroids, phenoxyl, triazine, amide, and coumadin compounds. Pesticides can also be classified based on their mechanism of action. For example, OC, OP and pyrethroid insecticides are designed as neurotoxins. Phenoxyl herbicides are plant hormone analogues. Some pesticides are disruptors of normal metabolism and physiological processes, such as triazine and urea herbicides (Sinning, 1992; Oettmeier, 1999); (Proudfoot *et al*., 2006). There are also pesticides, such as dithiocarbamate fungicides and amide herbicides, which are disruptors of energy production and inducers of oxidative stress (Keifer and Firestone, 2007).

The acute toxidromes of pesticides in humans are mainly due to pesticide neurotoxicity, including interference with neural conduction by targeting voltage-gated ion channels or Na+/K+ ATPase, interference with neural transmission by inhibiting acetylcholine esterase, stimulating respiratory sensory neurons or initiating pro-inflammatory signals (Louis *et al*., 2008). At high dose exposures, OC, OP and pyrethroids can affect both the central neural system (CNS) and peripheral neural system (PNS) in mammals (Keifer and Firestone, 2007). In summary, farmers, their families and other persons who used chemical pesticides regularly are at greatest risk of achieving toxic levels in their bodies. The danger is spread out to larger areas, as the pesticides:

- Are carried in the wind
- Leave residues on produce
- Remain inside produce and animals
- Run off into open water, contaminating public water supply as well as fish and other seafood

Anyone who uses pesticides or is present when pesticides are sprayed is at risk for dangerous exposure. The pesticides can enter the body through skin, eyes, mouth and nose.

Sample Collection

5 ml syringes were used to collect blood samples by venipuncture during the study into non-anticoagulant tubes. About 3 ml each of blood samples were collected and into a non-anticoagulated tube and kept upright in a fresh environment for separation by the use of a rag. This was to enable separation of red blood cells (RBC) from the white blood cells (WBC).

Separation of Serum from Erythrocytes

The collected blood samples were kept in an upright manner and the erythrocytes were separated from the plasma naturally after coagulation with 8 hours. The coagulated erythrocytes were immediately separated by pouring the serum into a labeled 2 mL ependorf tube and transported to the laboratory and frozen for work to be done the next day. 20 samples were thawed and run daily for ALT and AST each.

Organs Functioning Tests

The frozen sera were used to determine the functioning of the liver, kidney, heart and muscles as a result of exposure to chemicals by farmers during spraying. Quantitative determination of alanine aminotransferase GPT (ALT) and aspartate aminotransferase GOT (AST) were done for major organs (liver, heart, muscle and kidney) tests. This was done using the method as described by CHRONOLAB. These enzymes are found in low concentration in the blood and when the organs, liver, heart, muscles and kidney are destroyed, they are present in high concentration in the blood.

Data Analysis

Raw data were coded, entered, and analyzed using the statistical package for social science SPSS version 20 for Windows (SPSS, Inc, NC, USA). A chi-square test was used for each group of variables to test for statistical significance. The significant levels were set at $P \leq 0.05$. The results were then presented in tables and charts separately for each group of variables, from which inferences were drawn.

RESULTS

Characteristics of the Study Population

The summary of the socio-demographic characteristics of the study population is shown in tables 1 & 2. Chemicals used by these cocoa farmers were herbicides, insecticides and fungicides and the active ingredients are shown on the table. Most of the farmers were male 97.3% and most of the farmers were of the age range 30-49 (32.4%). The least represented were of the age range greater than or equal to 50 years, 40 (10%). The educational levels of the farmers were also sought and it was found that majority of them 220 (74.3%) were holders of the First School Leaving Certificate (FSLC) while the minority, 8 (2.7%) were holders of tertiary certificates. See table 2 for details.

Table 1: Chemicals use by Cocoa Farmers in Munyenge

Name of Pesticide	Active Ingredients	Frequency of Application
Herbicide	Glyphosate paraquat, glufosinate-ammonium, diuron, MSMA, 2.4 D, diuron, metsulfuron-methyl	Monthly
Insecticide	Mocarp, Gamalin, imidacloprid, diazinon, bifenthrin + acetamiprid	Once a week
Fungicide	metalaxyl + copper oxide, copper oxide, Bordeaux mixture, dimetomorph + copper oxide	Once a week on the pods

Table 2: Demographic Characteristics of Cocoa Farmers

Demographic variables of respondents	Frequency (N=)	Percentage (%)
Sex of Respondent		
Male	288	97.3
Female	8	2.7
Age Range of farmers		
20-29	64	21.6
30-39	96	32.4
40-49	96	32.4
≥50	40	13.5
Educational Level		
FSLC	220	74.3
O/L	40	13.5
A/L	28	9.5
Tertiary	8	2.7

FSLC=Primary school certificates, O/L=Secondary school certificate, A/L=Secondary high school Certificate

Longevity of the Cocoa Farmers in the Farming Activities and Chemical Handling

Table 3: Correlating Farming Experience and the use of Agrochemicals by Cocoa Farmers

Educational Level of Farmers	Frequency (f)	Percentage (%)	Knowledge on side effects f(%)	Protection during spraying f(%)	Observed effects of chemicals f(%)
1-10	192	64.9	140(72.9)	88(45.8)	12(6.25)
11-15	16	5.4	16(100)	8(50)	0
16-20	28	9.5	16(57.1)	16(57.1)	0
≥21	60	20.2	32(53.3)	32(53.3)	12(20)
Total	296	100	204(68.9)	144(48.6)	24(8.1)
P-Value			0.044	0.194	0.035

Farming experience was classified thus in years 1-10, 11-15, 16-20 and >20. It was observed that farmers who had 1-10 years' experience were the highest in representation 192(64.9%) and the least represented were farmers who had 11-15 years' experience 16(5.4%). 204 (68.9%) of the farmers had knowledge on the side effects of the agrochemicals used while only 144 (48.6%) of the farmers protected themselves during spraying or during the use of these chemicals. Farmers who had ≥21years' experience had the highest side effects and the difference was statistically significant at P=0.035. See table 3 for details.

Health symptoms reported by pesticide applicators (Cocoa farmers)

Some farmers indicated that they always have the following symptoms after spraying their farms with the chemicals. These symptoms are cough, sneezing, catarrh, skin rash, headache and others. From these, it was found that 21% of them said that they experience headache, after spraying, accounting for the highest frequency of signs and symptoms of the various chemicals. The least side effects by farmers were skin rash and sneezing (13%). These symptoms as reported by farmers range from mild to severe cases that may take days for them to stabilize. See figure 1 for details.

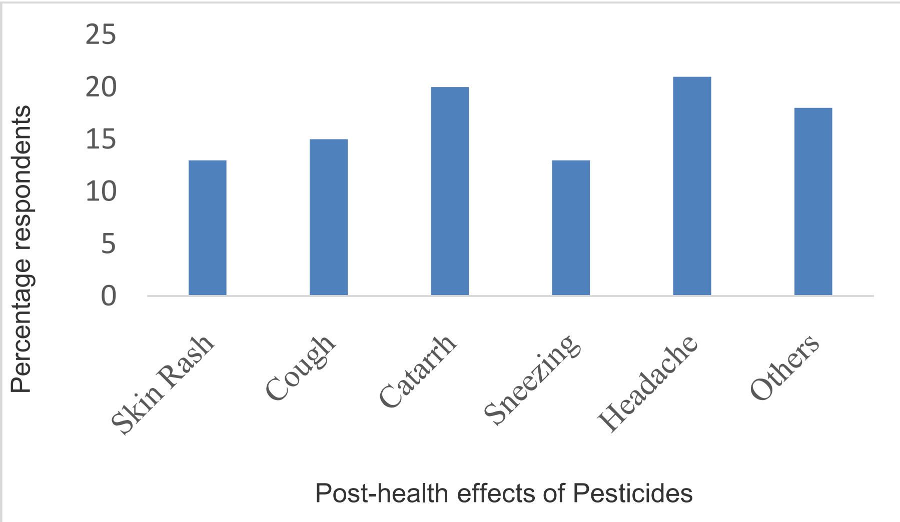

Figure 1: Post Health Monitoring Effects of Agrochemicals

Educational Level of the Cocoa Farmers and Chemical Effects

Farmers with tertiary level of education had the best knowledge on the side effects of the chemical use and showed no side effect while those who had FSLC had the least knowledge on the side effects of the chemicals and showed highest side effects. The difference between the side effects of the chemicals with respect to level of education was statistically significant at P=0.029. See table 4 for details.

Table 4: Correlating Farmers' Educational Level and observed effects of chemicals

Educational Level of Farmers	Frequency (f)	Knowledge on side effects f (%)	Protection during spraying f (%)	Observed effects of chemicals f (%)
FSLC	220	148(67.3)	116(52.7)	24(10.9)
O/L	40	28(70.0)	12(30.0)	0
A/L	28	20(71.4)	16(57.1)	0
Tertiary	8	8(100)	0.0	0
Total	296 (100)	204(68.9)	144(48.6)	24(8.1)
P-Value		0.287	0.180	0.029

Bio-Medical Tests of Pesticide Exposure of Farm Workers

Table 5 correlates the duration of chemical use and the level of ALT and AST in the blood of the farmers. It was found that a greater proportion of farmers with greater than 21 years farming experience had abnormally high level of ALT and AST in their blood 4(26.7%) and 12(20.0%) respectively. In overall, it was found that 40(13.5%) and 36(12.2%) had abnormally high levels of ALT and AST respectively.

Table 5: Farming Experience and the ALT and AST Levels in the Blood

Farming Experience	ALT Conc. Range (μ/L) in blood Frequency (%)		AST Range (μ/L) Frequency (%)	
Years	7-56 -Normal	> 56-High	10-40-Normal	>40 -High
1-10	168(87.5)	24(12.5)	172(89.6)	20(10.4)
11-15	16(100)	0.0	16(100)	0.0
16-20	28(100)	0.0	24(87.5)	4(14.3)
≥21	44(73.3)	4(26.7)	48(80.0)	12(20.0)
Control	100 (100%)	-----	100%	-----
Total	256(86.5)	40(13.5)	260(87.8)	36(12.2)

N.B Control fell within the normal ranges of ALT and AST.

DISCUSSION

Cocoa farmers depend so much on chemicals in their farms and many of these chemicals have been banned due to their detrimental effects. From the study, the chemicals studied were classified as herbicides, insecticides and fungicides based on their targets. Herbicides were the least used of all the pesticides by these farmers. This might have been due to the fact that the leaves of these cocoa plants fall and prevent underneath growth. This was also explained by Sonwa *et al*. (2008) in his studies on production constraints in cocoa agroforestry in Central Africa. It was found that more males were represented than females. This might have been due to the fact that this work needs more energy and females were left to prepare food for their husbands and participated fully during harvesting. Many of these cocoa farmers were First School Leaving Certificate (FSLC) holders (74.3%) and the least of them had tertiary certificate. This might have been due to the fact that many of them with the FSLC had no other job but to turn to farming while those who had higher certificates had 'white colar jobs' and preferred those jobs to cocoa farming.

The years spent in farming by these farmers were sought and classified in to 1-10, 11-15, 16-20 and ≥21. Signs and symptoms of the effects of pesticides were also investigated with respect to farming experience. It was found that those who spent longest time in cocoa had highest signs and symptoms (20.0%). These signs and symptoms experience by these farmers after spraying were nausea, skin itches and redness, catarrh, cough, vomiting, vertigo and painful eyes. Some experienced one or more of the above signs and symptoms of the chemical poisoning/attack. This might have been due to long and periodic exposure to these chemicals by farmers. In the same light, those who showed signs/symptoms of chemical attacks were all holders of FSLC. This might have been due to the fact that these low-educated farmers might not have been able to read the leaflets of these chemicals and so, never followed instruction which exposed them to attack. Mahob *et al*. (2014) explained in similar manner that cocoa farmers became responsible for buying and applying pesticides on their farms because in 1990 Cameroon government stopped subsidies due to economic crises. The buying, distribution and application of pesticides chemicals were left at the mercy of the uneducated and lowly educated farmers. Ndoumbe-Nkang *et al*. (2004), Babin *et al*. (2010) also explained that in the early 80s, the state was responsible for the purchasing and distribution of chemicals to farmers and retailers had no means to operate. He also explained that during this period banned chemicals were screened to make sure that those supplied to the farmers were biologically friendly with very mild side effects. These days in Cameroon, farmers get chemicals at random with little or no checks and because of these, instruments and spraying frequencies are not standardized. This might have been the reasons for the side effects experienced by farmers in Munyenge who are left alone by the government of Cameroon.

The relationship between farming experience, chemical use and the concentration of ALT and AST in the blood was sought. Those who spent longest time in the use of pesticides had abnormally high concentration of ALT and AST in their blood. This might have been due to the fact that these pesticide are moderately poisonous and accumulation in the systems might have led to organs (heart, liver, kidney, and muscles) damaged. When these organs are damaged, they release high concentration of ALT and AST in the blood because these enzymes are normally found in these organs. This is also explained in the work of Awad *et al*. (2014) who worked on the influence of exposure to pesticide on liver enzymes and cholinesterase levels in male agric workers in Egypt. Many works have been done in human and mice similar to this. An increased risk of liver dysfunction was observed in Air Force veterans responsible for the aerial spraying of herbicides in Vietnam, the effect being due primarily to increased AST, ALT, or LDH (Michalek *et al*., 2001). ‘‘In vitro’’ studies have found that glyphosate and paraquat are able to inhibit certain enzyme activities: ALT, AST, lactate dehydrogenase (LDH), and acetyl cholinesterase (AChE) (El-Demerdash *et al*., 2001). Experimental studies in rats have reported significant changes in all these enzyme activities after suchronic administration of mancozeb in a dose-dependent manner (Kackar *et al*., 1999). Gomes *et al*. (1999) reported that exposure of rats and mice to OPs led to increased levels of serum ALT and AST. Azmi *et al*. (2006) reported that a significant increase in the enzyme levels (ALT, AST and ALP) in different fruit and vegetable farm-station workers exposed to pesticides. Podprasart et al. (2007) in similar studies on the activities of paraquat and glyphosate reported that some pesticides, such as paraquat and glyphosate, cause inhibition in the activity of serum AST and LDH, while other pesticides (OPs, organochlorines, and pyrethroids) are able to cause inhibition of LDH.

CONCLUSIONS

From this study, it was revealed that the enzymes; AST and ALT activities in serum and red blood cells, are influenced by pesticide exposure. It was also found that most farmers were not aware of the health hazards caused by the inappropriate handling of pesticides. Awareness needs to be created on use of personal protective measures among farmers, while handling pesticides.

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