Pesticide residues determination in food premises in Bench-Maji zone, Southwest Ethiopia

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Abstract

Pesticides are very important risk factors in human life causing chronic human health effects. Pesticides are commonly used across the globe to enhance human endeavors. In Ethiopia, pesticides are widely used by local farmers and governmental organizations for pests control purpose. However, majority of pesticides are not specifically targeting the pest. As a result, pesticide residues in food items have been a concern to the consumers and environment they live in. Therefore, this study was aimed to determine the amount of organo-chlorine and organo-phosphate pesticide residues in cereal crops in Bench-Maji Zone, Ethiopia. Experimental study design was employed to determine the amount of pesticide residues and cereal crops were bought from the local farm sites and market of purposively selected sites. The samples were extracted using a Quick, Easy, Cheap, Effective, Rugged and Safe extraction and clean up method. Finally, the extracted samples were injected into Gas chromatography tandem Mass Spectrometer and the types, and concentrations of pesticide residues were analyzed using linear regression equation that obtained from calibration curves. The highest concentration of Endosulfan sulfate (0.076 $mgkg^{-1}$) was detected in rice, followed by Dimethoate (0.068 $mgkg^{-1}$) and p,p'-DDE (0.087 $mgkg^{-1}$) in Sorghum and common millet, respectively in the samples obtained from Gurafarda site. The highest concentration of p,p'-DDT (0.133 $mgkg^{-1}$) was detected in common millet, followed by Aldrin (0.082$mgkg^{-1}$) and Dimethoate (0.077$mgkg^{-1}$) in Sorghum and common millet, respectively in the samples obtained from North-Bench site. In addition, Aldrin detected in rice, sorghum and common millet obtained from the three sites was a residue of above the maximum residual limits set by Codex Alimentarius regulations and European Union. The finding shows that the detection of pesticide residues in cereal crops in samples obtained from the study area. It is an indication of the widespread use of pesticides in cereal crops production. Therefore, strict supervision of pesticide application in the fields, regulation of informal veterinary drug store and implmentation of integrated vector management strategy are recommended.

1. Introduction

Pesticides are toxic substances envisioned for averting, abolishing or controlling pests throughout the production, processing, transporting and marketing of food (Jardim et al. 2014; Pano-Farias et al. 2017). This comprises vectors of human and animal illnesses, undesirable kinds of floras or animals (Maksymiv 2015). The usage of chemicals in modern agricultural practices is observed as an essential portion of the achievement of the farming industry. Nevertheless, utmost of the pesticides applied to agrarian lands might influence non-target creatures and pollute soil and aquatic media (Prieto Garcia et al. 2012; Ogunfowokan et al. 2012; S. P, I. B, and S 2020). In current centuries there have been an growing worry that pesticides create a risk to the overall inhabitants through residues in food supply (Margni et al. 2002).

Greatest pesticides used in farming nowadays are synthetic organic substances that deed by interfering with a vigorous metabolic procedure in the creatures to which they are embattled (Chaturvedi, Sharma, and Chaturvedi 2013; Sarwar 2015). The community health belongings of pesticides have extensive been recognized and the unwanted effects of substance pesticides have been known as a severe public health worry throughout the ancient periods (Sarwar 2015). Rendering to a market study report, around 5,684 million pounds of pesticides (active ingredients) are smeared per annum all over the universe. Numerous of these substances are mutagenic and related to the growth of cancer or might lead to birth defects (Ahmed and Zaki 2009).

Giri et al. (2002) reported genotoxic effects of Malathion, Cypermethrin and Carbosulphan in chromosomal aberration (sister chromatid exchange) and sperm abnormality in mice as potential germ cell mutagens. The health effects of pesticides that can be divided into acute poisoning and chronic effects (Buczyńska and Szadkowska-Stańczyk 2005). Acute pesticide poisoning is any illness or health threats appearing shortly after a single or multiple doses of pesticide (Khurana 2018). This includes a wide range of reactions in different target organs like neurological, dermal or respiratory. Chronic poisoning occurs gradually after prolonged exposure to pesticides (Tukura, Usman, and Mohammed

2013). Increasing development of cancer and reproductive abnormalities has been seen in people who have gone through a long-term exposure to pesticides (Apiwat Tawatsin, Usavadee Thavara 2015; Uddin et al. 2015).

A cytogenetic investigation accompanied by Rita and coworkers (1987) on men coupled with the squirting of pesticides in grape garden discovered a significant upsurge in a chromatid disruptions and gaps in genes in the peripheral blood cells. Nevertheless, the possible poisonousness of residues still continued a problem of disagreement. Even though it is thought that adipose tissue performances as a defensive reservoir (Fosu-Mensah et al. 2016).

Dichlorodiphenyltrichloroethane (DDT) is one of the utmost universal and the persistent organic contaminant agro-chemicals with extensive negative influences on biodiversity and public health all over the sphere (Darko and Acquaah 2008). It is occupied up from the soil by floras, destroys utmost invertebrates, predominantly insects, and amasses in the fatty tissues of animals, comprising human being, and leads to disturbances of regular breeding, predominantly in faunas that are tall up the food chain such as birds of prey, and in mammals that are predators (Laxmishree and Nandita 2017). DDT is originate virtually all over the sphere, even faraway from anywhere it has been used as an insecticide (Wahab et al. 2016).

Meanwhile the 1980s, international community through the United Nations Environment Program has established for governing, or somewhat banning the usage of DDT excepting under exceptional conditions, is well-known as the Stockholm Convention on persistante organic polutantes (POPs). All industrialized countries have nowadays entirely banned the usage of DDT (Ortega Barriga et al. 2016; Apiwat Tawatsin, Usavadee Thavara 2015; Margni et al. 2002; Wahab et al. 2016).

Ethiopia has as well established a National Implementation Plan to remove or minimalize the usage of these substances. Nevertheless, it is still allowable to usage DDT for governing the malaria carrying a mosquito by squirting of households once or twice a year. These squirting movements are not ad hoc. They are scheduled to provide extreme safety to persons existing in a regions where there are unvarying epidemics of malaria (Bahru, Hailemariam Barkea, and Sali 2018).

As a consequence, pesticide residues in food stuffs have been a worry to the environment and consumer clusters of their wide-ranging usage (Thompson et al. 2017). Greatest pesticides particularly, the organo-chlorines are very resistant to microbial degradation (Centre for Genomic Pathogen Surveillance 2020; Ruiz-Toledo et al. 2018; Veljanoska-Sarafiloska et al. 2011). They can consequently gather in human body fats and the surroundings affectation complications to public health (Munyinda, Michelo, and Sichilongo 2015; Genuis, Lane, and Birkholz 2016; Sharma and Singhvi 2017). In Ethiopia, from 1950s to about 2014, DDT has been squirted out-of-doors (for farming usage) as well as at home for malaria resistor by decreasing the mass and durability of vector mosquitoes by means of indoor residual squirting (IRS). Current investigation conducted in Jimma zone reports certain banned pesticides (DDT and Endosulfan) were distinguished in the pepercorn samples (Mekonen, Ambelu, and Spanoghe 2014).

Further investigation conducted in Gurage zone revealed that farmers who cultivate the *catha edulis* vegetable in the specified areas of Gurage zone had been using the DDT and squirting it on their *catha edulis* herb to control diverse pests and the study shown that the mean concentrations of the first DDT metabolite, 4, 4'-DDD and the second DDT metabolite, 4, 4' of *catha edulis* samples were greater than maximum acceptable residual limits (Bahru, Hailemariam Barkea, and Sali 2018).

Cereal grains are the most important food grains because they are the chief source of food for the majority of the world's population. They provide about 60% of the calories and 50% of the proteins to the human race (Uddin et al. 2015; Wahab et al. 2016). In Ethiopia, farmers have been widely used pesticides to achieve production efficiency in cereal crops. To date, there is no study has been carried out to ascertain safety of cereal crops from both organo-chlorine and organophosphate pesticide residues. Therefore, the main objective of this study was to determine organo-chlorine and organo-phophate pesticide residues in selected cereal crops in Bench Maji zone, Ethiopia.

2. Materials And Methods

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2.1. Description of the study area

The study was conducted in Bench Maji Zone. It is one of the 16 zones in South Nation Nationality regional State located 585 kms away from Addis Ababa, the capital of Ethiopia, in Southwest direction. According to 2013 Ethiopia census projection for 2014-17, the total population of the zone was 786,421 out of which 388,038 were female and 398,383 were male. It has one urban and eghit rural districts, 246 the smallest administrative units (229 rural and 17 urban). The zone has one University Teaching Hospital, 40 health centers and 182 health posts (Mekonnen, Geremaw, and Asefa 2020). Geographically, Bench-Maji Zone is located between 5°.33′ to 7°. 21′North latitude and 34.88° to 36°.14′ East longitude of the equator. The zone comprises of altitudes ranging from 1200 to 1959 meters above sea level. Besides, the mean annual temperature of the zone ranges between 15-27°C and the mean annual rainfall ranges 1500-1800 mm. According to the land utilization data of the zone, 11,383 hectares land is used for rice cultivation, 2,060 hectares for wheat production and 52,410 hectares for corn production, 3,014.75 hectares of land is for common millet production and 18,140 hectares for sorghum cultivation.

2.2. Study design and period

Experimental study design was employed to determine the types and concentration of organo-chlorine and organophosphate residues from selected cereal crops (Rice, Corn, Sorghum and Common millet) in 3 major cereal crops cultivating districts (Gurafarda, South Bench and North Bench sites) in Bench- Maji zone. The study was conducted from first of June to 30th December, 2019.

2.3. Sample collection

The samples were collected from Bench-Maji zone purposively selected three sample sites namely Gurafarda, South Bench and North Bench woredas (districts), where cereal crops are cultivated within the zone at large. Cereal crops (Corn, Sorghum, Rice and Common millet) were bought from the local farms of each Woreda. From each Woreda again three sites were selected. From each site 10 samples (one kg of each crop sample) were taken randomly and homogenized to represent the bulk sample. The bulk sample of each site was placed in net polyethylene sheets until sample preparation and analysis were done (Mekonen, Ambelu, and Spanoghe 2014; Bahru, Hailemariam Barkea, and Sali 2018). The data handling and measurements were made as per Food and Agriculture Organization and WHO Procedural Manuals(FAO 2009; WHO 209). Moreover, sample labels were properly completed.

2.4. Sample preparation and analysis

Sample extraction for determination of pesticides: Extraction was started with 5 g of cereal crop sample. After oven drying and grounding by mortar, 1 g of the powder was mixed with 5 ml of NaOH, sonicated for 3 minutes, and then left for 30 minutes at room temperature. Three extraction cycles were performed on the original sample with 4 ml of extraction solvent in each cycle acetone/ethylacetate/n-hexane (1:2:1) for three minutes vortex followed by two minutes centrifugation at 2000 g. The three extracts were combined and dehydrated with 1 g of sodium sulfate, filtered, and then reduced to 5 ml at room temperature (Wahab et al. 2016; Uddin et al. 2015; Mekonen, Ambelu, and Spanoghe 2014).

QuEChERS methods protocols: A portion of the sample was extracted using a QuEChERS Extraction Salt and Acetonitrile (0.1% Chromatographic Grade Acetic Acid in Chromatographic Grade Acetonitrile both obtained from Sigma Aldrich) and centrifuged. The supernatant was treated using QuEChERS Dispersive Kit to remove interferences in the matrix and centrifuged. 0.5 mL of the supernatant was taken and 1 µl of the sample was injected to the GC-MS system (GC-7890B, MS-5977A model). The sample chromatogram was evaluated against a calibration curve obtained from a 7 point calibration made using pure analytical standards (Chromatographic Grade obtained from Sigma Aldrich) for quantization purposes (Prieto Garcia et al. 2012; Mekonen, Ambelu, and Spanoghe 2014; Bahru, Hailemariam Barkea, and Sali 2018).

2.6. Data Analysis

The pesticides residue data was analyzed statistically using Origin pro version 8.0 computer software packages. Analysis of variance (ANOVA) was used to assess the significance difference between the mean values Organo-chlorine and Organo-Phosphate pesticide residues in sample cereal crops. Possibilities less than 0.05 ($p < 0.05$) was considered statistically significant and the analyzed data was presented by using tables (Mekonnen, Haddis, and Zeine 2020) [42]. All the mean values of organo-chlorine and organophosphate pesticide residues were compared with maximum pesticides residual limits in food samples prescribed by Codex alimentary and European Union standards (FAO 2015; (FAO) and (WHO) 2009).

3. Results

A total of four cereal crops (corn, rice, common millet and sorghum) were investigated for the presence of seventeen pesticide residues. The investigated pesticide compounds were p,p'-DDT, p,p'-DDE, Chlordane, Hexachlor benzene, β-Lindane, Lindane, α-Lindane, Aldrin, hexachlorepoxide, α-Endosulfan, β-Endosulfan, Endosulfan Sulfate, Methoxychlor, Heptachlor, Dimethoate, Chlorpyrifos and Profenofos.

Validation result

As presented in Table 1, the percentage recoveries of the pesticides standard were found to be acceptable ranging from 71.2% for β- endosulfan to 112.3% for lindane, which indicates that the reproducibility of the method was satisfactory. The limits of detection pesticides standard were ranged between 0.008-0.902 $mgkg^{-1}$ and limits of quantification varied from 0.027 to 3.022 $mgkg^{-1}$.

Table 1: Percentage recoveries and validation information of pesticides standards used for this study.

Pesticides standard	Percentage Recovery (%)	Limits of Detection ($mgkg^{-1}$)	Limits of Quantification ($mgkg^{-1}$)
p,p’-DDE	90.5	0.010	0.033
p,p’-DDT	85.7	0.016	0.054
Chlordane	101.6	0.108	0.362
endosulfan salfate	72.4	0.008	0.027
α-endosulfan	98.1	0.078	0.261
Hexachlor benzene	81.3	0.241	0.807
β-Lindane	73.9	0.512	2.705
Lindane	112.3	0.016	0.054
α-Lindane	82.3	0.193	0.647
Aldrin	89.4	0.020	0.067
Hexachlorepoxide	78.8	0.902	3.022
Methoxychlor	91.2	0.038	0.127
Heptachlor	81.4	0.193	0.647
Dimethoate	94.8	0.018	0.060
Chlorpyrifos	88.0	0.310	1.039
Profenofos	71.5	0.032	0.107
β- endosulfan	71.2	0.205	0.687

Calibration curvatures have been created for quantification. Linearity has been detected entirely alongside the region of concentration considered subject on the target pesticide substances. The calibration curvatures were gotten by inoculating eight diverse concentrations of the pesticide standards in a variety of 4-300ng/ml. The regression coefficient (r^2) was > 0.997 for all the pesticides the under investigation. Calibration curves of the analyzed pesticides revealed acceptable linearity over designated concentration variety with regression correlation coefficients (r^2) ranging from 0.997 for p,p'- DDE, to 0.999 for Endosulfan sulfate.

Analysis of pesticide residues

Four organo-chlorine pesticide residues namely, p,p’-DDT and its metabolite (p,p’-DDE), Endosulfan salfate, and Aldrin and one organophosphate pesticide residue (i.e. Dimethoate) were detected from food samples collected from the sample sites. p,p’-DDT and p,p’-DDE were the most frequently detected contaminants in all food items obtained from Gurafarda site as shown in Table 2. Pesticide residues varied from 0.011±0.003 to 0.018±0.005 $mgkg^{-1}$ in corn, 0.035±0.013 to

0.076±0.025 $mgkg^{-1}$ in rice, 0.037±0.005 to 0.068±0.042 $mgkg^{-1}$ in sorghum and common millet were 0.039±0.030 to 0.087±0.006 $mgkg^{-1}$. Highest concentration of Endosulfan sulfate (0.076 $mgkg^{-1}$) was detected in rice, followed by Dimethoate (0.068 $mgkg^{-1}$) and p,p'-DDE (0.087 $mgkg^{-1}$) in sorghum and common millet, respectively.

Table 2: Concentration ($mgkg^{-1}$) of pesticide residues in assessed food items from Gurafarda site.

Pesticide residues	Food items			
	Corn	**Rice**	**Sorghum**	**Common millet**
p,p'-DDT	0.018±0.005	0.046±0.020	0.048±0.007	0.062±0.027
p,p'-DDE	0.011±0.003	0.035±0.013	0.054±0.009	0.087±0.006
Endosulfan salfate	ND	0.076±0.025	0.047±0.013	0.039±0.030
Aldrin	ND	0.06±0.033	0.037±0.005	0.042±0.008
Dimethoate	ND	0.065±0.023	0.068±0.042	0.080±0.018

Table 3 illustrated that, the crop samples analyzed in North-Bench site, Dimethoate was less frequently detected in corn. Highest concentration of p,p'-DDT (0.133 $mgkg^{-1}$) was detected in common millet, which indicates the recent use of the pesticide DDT in the study area.

Pesticide residues varied from 0.045 to 0.066 $mgkg^{-1}$ in corn, 0.040 to 0.077$mgkg^{-1}$ in rice, 0.031-0.082 $mgkg^{-1}$ in sorghum and 0.018-0.133 $mgkg^{-1}$ was detected in common millet. Highest concentration of p,p'-DDT (0.133 $mgkg^{-1}$) was detected in common millet, followed by Aldrin (0.082$mgkg^{-1}$) and Dimethoate (0.077$mgkg^{-1}$) in Sorghum and common millet, respectively.

Table 3: Concentration ($mgkg^{-1}$) of pesticide residues in assessed food items from North-Bench site

Pesticide residues	Food items			
	Corn	**Rice**	**Sorghum**	**Common millet**
p,p'-DDT	0.064±0.023	0.059±0.26	0.031±0.011	0.133±0.069
p,p'-DDE	0.066±0.039	0.058±0.027	0.044±0	0.057±0.007
Endosulfan salfate	0.045±0.003	0.061±0.034	0.049±0.018	0.018±0.002
Aldrin	0.065±0.028	0.040±0.02	0.082±0.007	0.027±0.002
Dimethoate	ND	0.077±0.028	0.04±0.013	0.039±0.006

As illustrated in Table 4, Dimethoate was detected in about 50% samples of the food items obtained from South-Bench site. It was only detected in rice (0.060 $mgkg^{-1}$) and sorghum (0.051 $mgkg^{-1}$). The average residues concentration were varied from 0.056 to 0.059 $mgkg^{-1}$in corn, 0.035 to 0.057 $mgkg^{-1}$ in rice, 0.051 to 0.130 $mgkg^{-1}$ in sorghum and 0.038 to 0.074 $mgkg^{-1}$ in common millet. Highest concentration of Aldrin residue (0.130 $mgkg^{-1}$) was detected in sorghum.

Table 4: Concentration (mg/kg^{-1}) of pesticide residues in assessed food items from South- Bench site

Pesticide residues	Food items			
	Corn	Rice	Sorghum	Common millet
p,p'-DDT	0.056±0.042	0.035±0.013	0.075±0.022	0.038±0.016
p,p'-DDE	0.059±0.023	0.057±0.023	0.078±0.018	0.074±0.022
Endosulfan salfate	0.081±0.004	0.065±0.023	0.059±0.036	0.044±0.020
Aldrin	0.074±0.025	0.069±0.027	0.130±0.146	0.045±0.017
Dimethoate	ND	0.060±0.030	0.051±0.021	ND

Comparison of pesticide residue with the maximum residue limit (MRL)

Table 5, 6 and 7 are summarizes the comparisons of average mean concentration of detected residues with MRLs established by the European Union (EU) and the Co-dex Alimentarius regulations. As indicated in the Table 5, the comparisons of residue concentration in food samples obtained from Gurafarda site, aldrin detected in rice, sorghum and common millet were a residue of above the MRLs set by Codex Alimentarius regulations [37] and European Union (EU) [41], while the Dimethoate residue detected in rice, sorghum and common millet were contained a residue of above the MRLs set by European Union (EU). In addition, p,p'-DDT in common millet and Endosulfan sulfate in rice exceeded corresponding MRLs set by European Union.

Table 5: Comparisons of average mean concentration of pesticide residues with European Union and Codex Alimentareous standards from Gurafarda site.

Pesticide residues	Food items											
	Corn	MRLs		Rice	MRLs		Sorghum	MRLs		Common millet	MRLs	
		CA	EU		CA	EU		CA	EU		CA	EU
p,p'-DDT	0.018	0.1	0.05	0.046	0.1	0.05	0.048	0.1	0.05	**0.062**	0.1	**0.05**
p,p'-DDE	0.011	0.1	0.05	0.035	0.1	0.05	**0.054**	0.1	**0.05**	**0.087**	0.1	**0.05**
Endosulfan sulfate	ND	NA	0.05	**0.076**	NA	**0.05**	0.047	NA	0.05	0.039	NA	0.05
Aldrin	ND	0.02	0.01	**0.06**	**0.02**	**0.01**	**0.037**	**0.02**	**0.01**	**0.042**	**0.02**	**0.01**
Dimethoate	ND	NA	0.01	**0.065**	NA	**0.01**	**0.068**	NA	**0.01**	**0.080**	NA	**0.01**

MRLs = maximum residue limits; NA = not available; ND = not detected; CA= Codex Alimentarius; EU= European Union

The average concentration of p,p'-DDT and p,p'-DDE residues detected in all food samples obtained from North-Bench site were above the MRLs established by European Union and p,p'-DDT and Endosulfan sulfate residue detected in common millet and rice were also above the MRLs established Codex Alimentarius standards and European Union, respectively as shown in Table. The average concentration of Aldrin residue detected in all food samples obtained from this site was above the MRLs established by Codex Alimentarius standards and European Union. The only organophosphate (Dimethoate) detected in three food samples (i.e. rice, sorghum and common millet) obtained from North-Bench site was also above the MRLs established by European Union.

Table 6: Comparisons of average mean concentration of pesticide residues with European Union and Codex Alimentareous standards from North-Bench site.

Pesticide residues	Food items											
	Corn	MRLs		Rice	MRLs		Sorghum	MRLs		Commonmillet	MRLs	
		CA	EU		CA	EU		CA	EU		CA	EU
p,p'-DDT	**0.064**	0.1	**0.05**	**0.059**	0.1	**0.05**	0.031	0.1	0.05	**0.133**	**0.1**	**0.05**
p,p'-DDE	**0.066**	0.1	**0.05**	**0.058**	0.1	**0.05**	0.044	0.1	0.05	**0.057**	0.1	**0.05**
Endosulfan sulfate	0.045	NA	0.05	**0.061**	NA	**0.05**	0.049	NA	0.05	0.018	NA	0.05
Aldrin	**0.065**	**0.02**	**0.01**	**0.040**	**0.02**	**0.01**	**0.082**	**0.02**	**0.01**	**0.027**	**0.02**	**0.01**
Dimethoate	ND	NA	0.01	**0.077**	NA	**0.01**	**0.04**	NA	**0.01**	0.039	NA	**0.01**

MRLs = maximum residue limits; NA = not available; ND = not detected; CA= Codex Alimentarius; EU= European Union

The average concentration of p,p'-DDT and p,p'-DDE residues detected in all food samples obtained from South- Bench site were above the MRLs established by European Union as indicated in Table 7. Moreover, Endosulfan salfate residue was detected in three food items namely; corn, rice and sorghum. It was above the MRLs established by European Union. The average concentration of Aldrin residue detected in all food samples obtained from this site was above the MRLs established by Codex Alimentarius standards and European Union. Dimethoate residue detected in 50% if the food sample was above the MRLs established by European Union.

Table 7: Comparisons of average mean concentration of pesticide residues with European Union and Codex Alimentareous standards from South- Bench site.

Pesticide residues	Food items											
	Corn	MRLs		Rice	MRLs		Sorghum	MRLs		Commonmillet	MRLs	
		CA	EU		CA	EU		CA	EU		CA	EU
p,p’-DDT	**0.056**	0.1	**0.05**	0.035	0.1	**0.05**	**0.075**	0.1	0.05	**0.038**	0.1	**0.05**
p,p’-DDE	**0.059**	0.1	**0.05**	**0.057**	0.1	**0.05**	**0.078**	0.1	0.05	**0.074**	0.1	**0.05**
Endosulfan sulfate	**0.081**	NA	0.05	**0.065**	NA	**0.05**	**0.059**	NA	0.05	0.044	NA	0.05
Aldrin	**0.074**	**0.02**	**0.01**	**0.069**	**0.02**	**0.01**	**0.130**	**0.02**	**0.01**	**0.045**	**0.02**	**0.01**
Dimethoate	ND	NA	0.01	**0.060**	NA	**0.01**	**0.051**	NA	**0.01**	ND	NA	0.01

MRLs = maximum residue limits; NA = not available; ND = not detected; CA= Codex Alimentarius; EU= European Union.

4. Discussion

In the present study, four organochlorine pesticide residues namely, p,p’-DDT and its metabolite (p,p’-DDE), Endosulfan salfate, Aldrin and one organophosphate pesticide residues (i.e. Dimethoate) were detected from food samples collected from sample sites. p,p’-DDT and p,p’-DDE were the most frequently detected contaminants in all food items. The chlorinated pesticides such as DDT and endusulfan were mostly used for malaria control in Ethiopia (Bahru, Hailemariam Barkea, and Sali 2018). This might be due to cross contamination or from their persistent nature remain in the nearby environment(Munyinda, Michelo, and Sichilongo 2015) [43].

In this study, p,p’-DDT and p,p’-DDE residues were detected in all food samples obtained from the three sites. This could be due to pesticides with tall volatility can be captivated by the leaves of non-target harvests from side to side spray drift and can similarly be engaged up by yield roots under dry soil situations (Fosu-Mensah et al. 2016). Additional probable method by which the adulteration might rise is through polluted surfaces because of storing and dissemination practices. The result of the present study is reliable with a investigation conducted in Jimma zone (Ethiopia) which stated that the amount of DDT in coffee pulp is significantly different (p-value < 0.01) from other food items excluding for red pepper (Mekonen, Ambelu, and Spanoghe 2014). Even though, DDT is formally banned for agrarian use in Ethiopia, pollution of food still happens. This pollution could be described by indoor squirting of DDT for malaria avoidance and by illegitimate usage from outdated pesticide stocks (Bahru, Hailemariam Barkea, and Sali 2018; Mekonen, Ambelu, and Spanoghe 2014). Additionally, it could be as a result of tenacious behaviour of organo-chlorine pesticide deposit triumph in the adjacent soil and water segment (Munyinda, Michelo, and Sichilongo 2015).

The only organophosphate (Dimethoate) was detectected in corn obtained from the sample sites. This is due to the fact that organophosphate compounds have the advantage of being more rapidly degraded in the environment than organo-chlorine compounds (Prieto Garcia et al. 2012)[6]. Generally, lower concentrations Dimethoate residue was less frequently detected in all food items obtained from the three sites was above the MRL of cereals established by European Union (FAO 2015; (FAO) and (WHO) 2009).

The commonly consumed food items in Bech-Maji zone shows lower concentrations of p,p-DDT pesticide residues except the p,p’-DDE residue was higher concentration reported from Jimma zone, Ethiopia (Mekonen, Ambelu, and Spanoghe 2014). This difference might be belonging to the fact that Jimma zone is a tall possible capacity in farming and there is a opportunity of organo-chlorine pesticide usage in the former. Alternative reason might be percolating and surface run-off pesticides. Furthermore, greater residues might effect from past usage and erstwhile environmental pollution, predominantly from those composites representing environmental persistence and gathering of outdated pesticides proximate the study zone (Bahru, Hailemariam Barkea, and Sali 2018).

The comparisons of residue concentration in food samples obtained from Gurafarda showed that aldrin detected in rice, sorghum and common millet were above the MRLs set by Codex Alimentarius regulations (FAO 2015) and European Union ((FAO) and (WHO) 2009), while the Dimethoate residue detected in rice, sorghum and common millet were contained above the MRLs set by European Union (EU). In addition, p,p’-DDT in common millet and Endosulfan sulfate in rice exceeded corresponding MRLs set by European Union ((FAO) and (WHO) 2009).

The average concentration of p,p’-DDT and p,p’-DDE residues detected in all food samples obtained from North-Bench site were above the MRLs established by European Union and p,p’-DDT and Endosulfan sulfate residue detected in common millet and rice were also above the MRLs established by Codex Alimentarius standards and European Union, respectively. Similar result reported when compared to the study done in Jimma zone, Ethiopia which showed that DDT which was expressed as the total sum of its metabolites: p,p’-DDE, p,p’-DDD, o,p’-DDT and p,p’-DDT, was above the MRL set by Codex Alimentarius (Eueropean Union 2008) in the two commonly consumed cereals corn and teff. The reason might be due to illegal use of pesticides in the production of staple crops in the study area or there may be contamination from the environment (Mekonen, Ambelu, and Spanoghe 2014).

5. Conclusion And Recommendations

Four cereal crops were investigated for the presence of seventeen pesticide residues. Out of them, only five pesticide residues were detected. Four organochlorine pesticide residues namely, p,p’-DDT and its metabolite (p,p’-DDE), Endosulfan salfate, and Aldrin and one organophosphate pesticide residues (i.e. Dimethoate) were detected from food samples collected from the three areas. p,p’-DDT and p,p’-DDE were the most frequently detected contaminants in all food items obtained from Gurafarda and North-Bench sites. Dimethoate was detected in 50% samples of the food items obtained from South- Bench site.

Tighter regulation in the production of cereal crops and implementation of integrated pest management methods should be needed. Additionally, further monitoring studies must be performed to improve food safety and protect consumers’ health. In Ethiopia, there is no maximum residue limits set by the concerned bodies. Therefore, establishment of the national maximum residue limits is recommended. In addition, the use of OP and OC pesticides are commen in cereal crops production, hence monitoring of this chemicals should be done at regular interval to determine the extent of the release of these compound’s to environmental compartment and food products. Moreover, consumption survey and consumer risk assessment on residues in food items are recommended.

List Of Abbreviations

CA Codex Alimentarius

DDT Dichlorodiphenyltrichloroethane

EU European Union

MRLs Maximum Residue Limits

NA Not Available

ND Not Detected

OC Organo-Chlorine

OP Organo-Phosphate

POPs Persistent Organic Pollutants

QuEChERS Quick, Easy, Cheap, Effective, Rugged and Safe

WHO World Health Organization

Declarations

Availability of data and materilas

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

BM, JS and SN were wrote the protocol, participated in data collection and experimental work, BM and JS were analyzed the data and wrote the manuscript. BM and SN were performed manuscript edition. All authors read and approved the final manuscript.

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Ethical approval

Not applicable: our study does not use any animal or human tissue.

Consent to participate

Not applicable

Consent to publish

Not applicable

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