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Original Research Article

Pesticide Residues and Organic Production

Osman Tiryaki*
Çanakkale Onsekiz Mart University, Faculty of Agriculture, Department of Plant Protection, 17020, Çanakkale, TURKEY

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ABSTRACT

This study focused on studies of pesticide residues in organic product. With increasing health and environmental awareness, organic farming has become an integral part of the agricultural policy in many countries. It is the less harmful to human and environment. The target of organic farm is not high quantity of production, but is the high quality. The market value of organic products in Europa was 45 billion € in 2010 and was 27.5 million $ in Turkey in 2009. Organic foods include less measurable residues than IPM-grown and conventionally grown food. Pesticide residues in organic products are primarily related to obstinate environmental contamination. Registered pesticides in organic farm are regulated by EC Regulation 889/2008. EU Reports on Pesticide Residues in Food published by EFSA based on 3 different market categories in 2010, 2012 and 2013. Residue data were evaluated in USA by 3 pesticide data programmes. For organic foods, there is no specific MRL list in Europa, USA and Turkey, but 0.010 mg kg^{-1} and 10% of the MRL has been applied for many years in Europa and 5% of the EPA tolerance in USA as well.

Keywords: Pesticide residues, Organic foods, EFSA, RASFF, MRL, IPM

INTRODUCTION

Organic farming (OF) is an agricultural production system which focusing on high quality products less harmful to human and environment. It is the fastest growing sector with health and environmental awareness. With health and environmental awareness, it is the fastest growing sector. In Europa, OF the land area over which OF is practiced increased from 3.6% to 5.5% in the period of 2005- 2011. While the size OF lands in Turkey was 60 000 ha in 2000, it increased to 383 782 ha in 2010 (Demiryürek 2011).

The use of pesticides is mostly banned in OF, few environmental friendly ones are registered. Synthetic chemicals that make up the highest percentage of all pesticides are prohibited (EC 2007 and 2008). Occurrence of prohibited pesticides may indicate illegal use of pesticide or mix-up of conventional and organic products. However, organic foods are grown, transferred and processed in an environment where pesticides and other artificial compounds are generally used. Unintentional contamination of organic foods may occur during grown, storing, transferring or processing without the guilt or organic producer' knowledge. Thus, residues in organic foods can either be indication of intentional use or unintentional contamination. For certification authorities, it is quite hard task to differentiate between these two residue sources (Speiser *et al.* 2013).

Pesticide residue analyses in foods and environment are significant control mechanisms. Analyses are performed both on conventional and organic products. They can also be performed in leaves and soil, for the purpose of organic inspection. Risk assessment based analyses far more efficient than common monitoring procedures.

There aren't MRL regulations for organic food in EU, but production and certification of it are regulated. EU legislation gives some advice related to the residues of pesticide (EC 2013). Pesticides registered in OF in EC 834/2007 (EC 2007), EC 889/2008 Annex II (EC 2008) and EU 2016/673 (EU 2016). Residue analysis results are published by the European Food Safety Authority (EFSA). The 2010 (EFSA 2013), 2012 (EFSA 2014) and 2013 (EFSA 2015) EU Reports on Pesticide Residues in Food were documented based on organic, conventional and Integrated Pest Management (IPM) based products. The registered pesticides in OF are regulated by two regulations in Turkey, compatible with Organic Farming Law (Official Gazette 2005 and 2010).

The aim of this study is to review pesticide residue analyses (PRA), legislations and regulations in OF in Europa, USA and Turkey.

* Corresponding author:osmantiryaki@yahoo.com

RESIDUE ANALYSES IN ORGANIC INSPECTION IN EUROPA

PRA are significant control mechanisms but it doesn't take place of whole inspection. Some pesticides degrade rapidly; all kinds of fraud can't detected well by analyses. So PRA may complement other inspection techniques, e.g., visual observations.

Causes of Pesticide Residues in Organic Products

Causes of residues are categorized into 4 groups; (A) cause cannot be defined, (B) contamination without farmer's knowledge, (C) inadequate care, (D) intential use, or mix-up of organic and conventional foods. Farmers are penaltied based on these causes.

Sampling Methodology in Organic Farming

Sampling methodology is very important factor in PRA in OF and sampling should be performed according to a risk assessment that focused on; (i) use of pesticide in common agriculture, (ii) agronomic situations such as high risks for pest' damages, (iii) observations for the past cases of fraud or pollution. Sampling procedures should be focused on risks (EAHC 2011). This is also requirement in the Reg. 392/2013 II (EC 2013). High risks were identified for the following situations (Speiser *et al.* 2013):

(i) High risks are identified for the organic and conventional farming on the same farm (parallel production). Where one family follows OF, and other ones follows usual farming, there are contamination risks, even if such plantations are separated.

(ii) The intentional use of pre-emergence herbicides was assessed a huge risk, since it is hard to prove by the analyses.

(iii) Application drift was considered to be another main risk. For example, because of the small plot size of vineyards and the huge spraying-drift in neighboring vineyards. It is difficult to differentiate between residues caused by application drift from neighboring farm and residues indicating intentional use in the organic farm.

(iv) Similarly in grain storing, there may be contamination risk with residues of insecticide. They could be also caused by contamination and/or by intentional use.

Sampled Materials

There is little information on pesticide residues in leaves or soil, whereas it is crucial to analyse leaves or soil. Generally, plant materials should be sampled with soil, since most pesticides strongly bind to soil particles or rapidly degrade in soil. Following situations are very important in sampling procedures:

(i) If there is discoloured leaves or uncommon growth in the weeds, sampling of these plant materials and analyses for herbicide residues should be performed.

(ii) Untypically bare soil (total absence of weeds), it may be sign of total herbicide usage, and soil should be sampled instead.

(iii) If the whole crops are healthy and there is no any pest symptom, residue analysis of fruit and/or foliage are necessary.

(iv) If the persistent organic pollutants (POPs), such as, DDT, HCB, dieldrin, are suspected in the soil, analysis of soil samples is necessary (Kilercioğlu *et al.* 2015).

(v) Pumpkin seeds strongly absorb persistent organic pollutants from the soil (so it is used for phytoremediation purposes) and thus may include pesticides, even if these residues are less than limit of quantification (LOQ) in the soil. In this situation, analysis of seeds is the only alternative.

(vi) If the intentional use of a pesticide is suspected, foliage and soil sampling as well as the spraying equipment should be sampled. In case of parallel production, there is no meaning to analyse the spraying equipment.

(vii) Sampling procedure for pesticide residue analysis should be performed according to 2002/63/EC (EC 2002). Necessary amount of laboratory sample and analytical portions based on sampled product are very important (Tiryaki 2016).

PESTICIDE RESIDUE ANALYIS RESULTS IN ORGANIC PRODUCTS

There are some regulations and legislation on organic production and inspection in EU and Turkey. They don't give any advice on the assessment of residue results. There is no MRL for organic products, thus interpretation of analytical results is very important.

Interpretation of Guidelines and Legal Regulations for PRA in Organic Product

In 2001, German Organic Processors and Traders Association (Bundesverband Naturkost Naturwaren Herstellung und Handel e.V. BNN) adopted a guideline to assess residues of pesticide in organic foods (BNN 2012) which is the oldest regulation with regard to pesticide residues in organic products. BNN member companies accepted MRL value of 0.010 mg kg^{-1}, called "orientation value". This orientation value is widely adapted by European organic sector, Swiss organic Farmers Associations (Bio Suisse) and Switzerland Migros Bio.

International Federation of Organic Agriculture Movements (IFOAM) is the huge authorization of the organic sector in the world. The guideline of IFOAM EU-group (IFOAM's European branch) follows the BNN MRL value, but it is named as "action level" (IFOAM EU 2012).

Pesticide residues guideline of European Organic Certifiers Council (EOCC) also follows the BNN's orientation value, but it is also named as "action level". In EOCC task force, residues in discussion paper, the handling of applying a MRL for organic foods are also argued (EOCC 2012). The MRL is known as "critical level*"*. EOCC task force recommended 10% of the MRL value for critical level.

The organic market in the USA has tolerated residues in organic foods up to 5% of the convential MRL value (EOCC 2012). In Italy, official MRL is specified as 0.01 mg kg^{-1} for organic foods (EAHC 2011). Wallonia guideline (Belgium) stated that if the residue exceeds the 1.5 X LOQ, the certification authority may judge as pesticide used and plant product cannot be accepted as organic. However, this situation is not valid if the organic producer prove to the inspection authority that the residues caused by external contamination (EAHC 2011).

The Guidance Note for Control Bodies on EU organic test procedure in the United Kingdom indicates that if a residue is resulted from activities that are not consistent with organic actions, product cannot be accepted as organic. However, the inspection authority may decide as organic, on condition that residue is at a trace level and caused by unintentional contamination (Speiser *et al*. 2013).

The registered pesticides in organic farm are regulated by two regulations in Turkey, compatible with Organic Farming Law. In case of using a substance listed in plant protection products allowed to be used in OF, The substance should not leave any residues over the products and should not have any negative impacts on environment (Official Gazette 2005). The time passed between the latest veterinary drug medication to an animal and production of an organic produce from these animals should be twice as much in OF as in conventional farming. Such a duration is 48 hours in case any time period was not specified (Official Gazette 2010).

Concepts of Orientation Values and Critical Levels

There are two different approaches in the regulations. In "orientation value", the residue is considered to be the cause of doubt, which needs further inspection. In "critical level", a certain residue cause to automatic de-certification, without any examinations. Categorization of it and marketing decision are shown in Table 1 (Speiser *et al*. 2013).

Table 1. Categorization of analytical results (adapted from Speiser *et al.* 2013).

Case	Residue Concentration	Decision
1	residue below MRL	marketing as organic is possible
2	residue exceeds MRL	no marketing as organic is possible
3	residue below 0.01 mg kg^{-1}	marketing as organic is possible
4	residue exceed 0.01 mg kg^{-1} , but below 10% MRL	preliminary blocking of marketing*
5	residues of more than 1 compounds **	preliminary blocking of marketing*
6	residues in few lots of one producer**	preliminary blocking of marketing*
7	residue exceed 10% MRL***	no marketing as organic is possible

*must be either confirmed or cancelled when investigations are finished. **regardless of concentration
***exception: residue is below 0.010 mg kg^{-1}, then case 3 is applied, even if residue exceeds 10% MRL

Residue Assessments of Leaves, Soil and Other Agricultural Materials

The existing assessment guidelines focused on foods, and not to leaves, soil or other agricultural materials. Similarly for foods, a separate guideline is necessary for them.

Residue Assessments of POPs in Soil

Soil may somehow contaminated with POPs, which were used in the past. Although they are prohibited in most country (e.g. Turkey and EU), the most care should be taken if risk plants (Cucurbitaceae) are planted on contaminated farms. Cultivation may be prohibited in the high POPs polluted fields.

Residues of POPs in organic products are more significant, because of the negative public impression to them. If the producer has planted a risk plant with the knowledge of contamination by POP, it is decided as insufficient care. If the producer does not know that the farm polluted by POPs, this is assumed that it is not farmer‘s mistake and POP residues for organic marketing up to 0.01 mg kg^{-1} level was tolerable.

Application Drift or Illegal Use of Pesticide in Organic Farm

Discrimination between drift and illegal use is very important in the concept of residues. The reason of the residues, whether drift from neighbor farm or intentional use of pesticides, is important. Positioning of primary samples, when drift from a neighboring farm is doubted has vital importance (Figure 1). Two samples should be taken. First sample is taken along the edge of neighboring conventional farm on the side from where there is drift and the second one from center of the organic field at a distance where drift is unexpected. Primary samples within one blue circle should be mixed. If the residue level at the edge of the conventional farm is more than in the center of organic field, it is assumed that the residues are resulted from application drift. Some conclusions are drawn in Table 2 (Speiser *et al.* 2013).

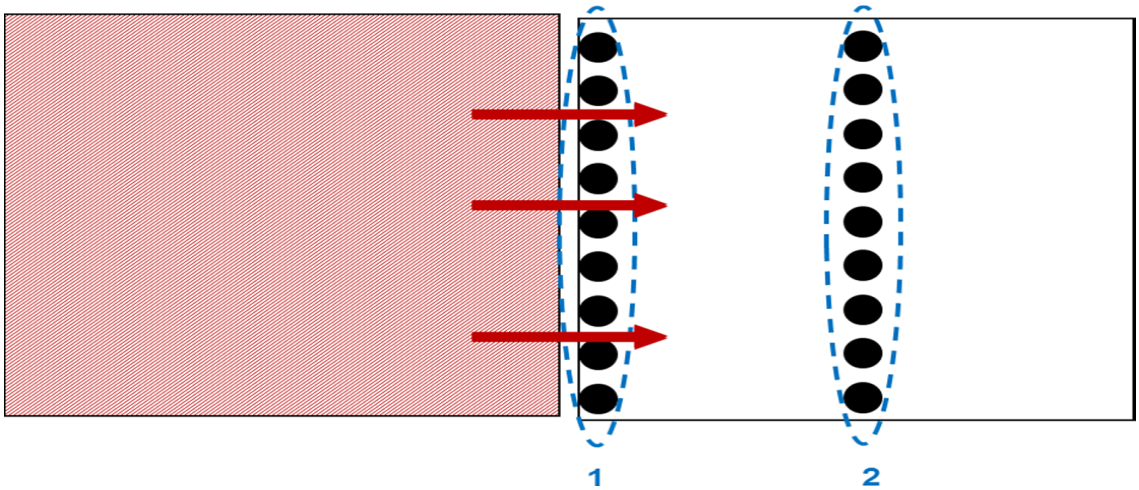

Figure 1. Primary sample arrangement. Black dots=primary sample; red= neighboring, conventional field; red arrow=suspected distance of drift (Speiser *et al.* 2013).

Table 2. Discrimination between drift and illegal use (Speiser *et al.* 2013).

Ratio of residue edge/center	Conclusion
edge/center ≥ 4	Drift is the reason of residues
4 > edge/center > 1	Drift may be reason of residues. If possible, more evidence is needed to demonstrate that drift is not the reason of residues.
edge/center ≤ 1	Drift is not the reason of residues. Illegal use is a possible cause of residues

PESTICIDE RESIDUE REPORT IN ORGANIC PRODUCT IN EUROPA

EFSA published report of the control activities results with regard to residues of pesticide in food carried out in 2010, 2012 and 2013 in the EU Member States.

Pesticide Residue Report of Organic Product in 2010

A total of 157 pesticide analyses were carried out in 7 plant-originated food groups in the 2010 EU-coordinated control program. 3571 organic samples (from 28 reporting countries) were analyzed (Figure 2). For all foods, with the exception of animal products), MRL exceedance rate of the conventionally grown crops (other productions in the figure) were higher than the organic foods.

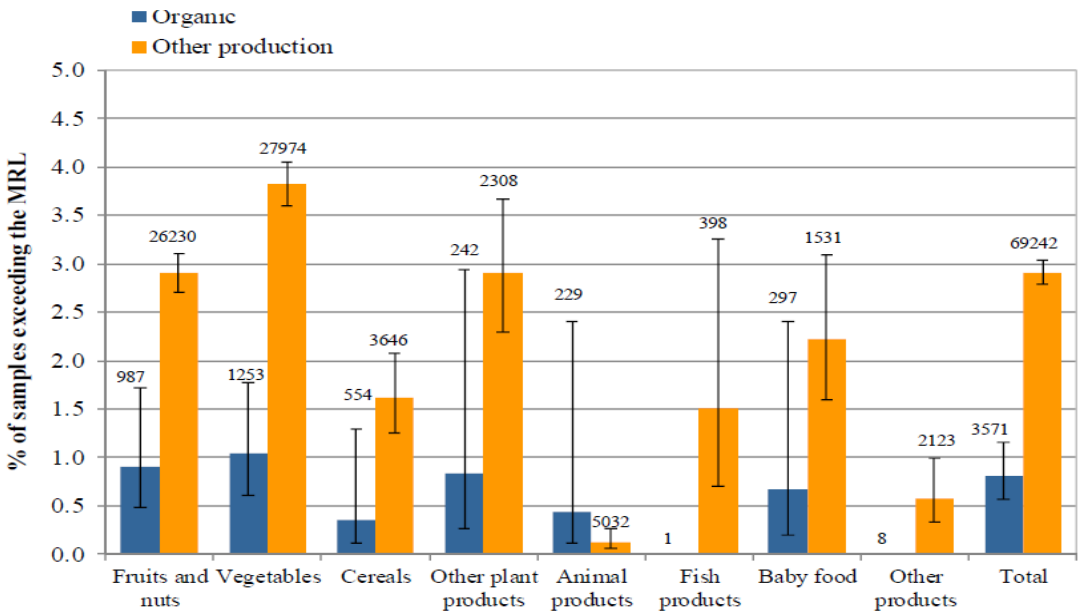

Figure 2. MRL exceedance rate for conventional and organic foods (It is displayed sample numbers on top of bars) (EFSA 2013).

MRL exceedance rate for the organic nuts and fruit (0.9%) was lower than for the conventionally grown nuts and fruit (2.9%). These values were 1.0% and 3.8%, respectively, for vegetables. Overall, rate of MRL exceedance for organic products was 0.8%. The number of found pesticides above the LOQ in organic samples was 131. Twenty six of them were found in at least 5 samples. Only one of 26 pesticides is allowed in OF (EC 2007, EC 2008). The 25 pesticides are related to environmental contamination or to banned pesticides.

Since accreditation has a vital importance in PRA (Tiryaki 2017), several countries used accredited laboratories, but in 6 countries used non-accredited ones.

Pesticide Residue Report of Organic Product in 2012

Residue analyses of 78390 samples were performed in 2012 (EFSA 2014). 5.8% of the total number of samples (4576) was organic samples. Frequencies of MRL exceeding residues in organic product were less than conventional grown products (Figure 3).

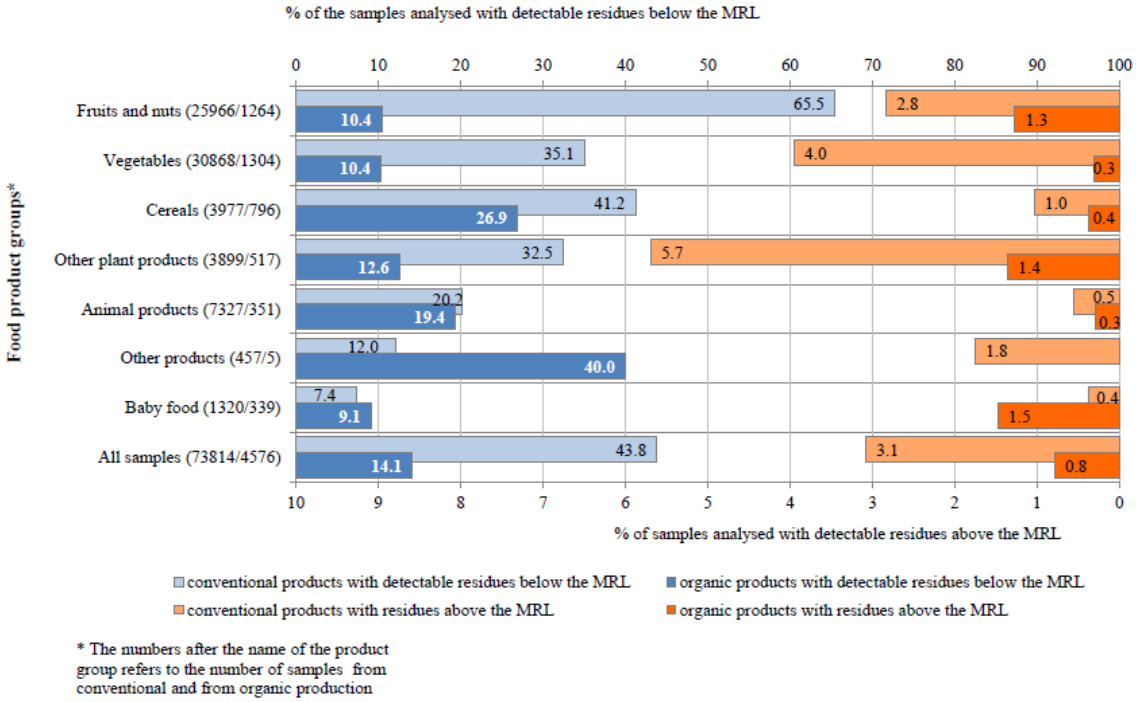

Figure 3. MRL exceedance rate for conventional and organic foods and samples containing detectable residues (EFSA 2014).

MRLs exceedance rate were 0.8 % and 3.1 % in organic samples and conventional grown samples, respectively. There was no detectable residue at the percentage of 85.1% and 53.1% in organic foods and conventional grown products, respectively.

A total of 136 pesticides were found above the LOQ in organic product; 37 of them were found less than 0.01 mg kg^{-1}. Most frequently found pesticides are shown in Figure 4. Spinosad and copper are permitted in OF, so the residues of these compounds are not related to agricultural practices not allowed in OF. HCB, DDT and dieldrin residues are mostly caused by environmental pollutions in soil, because of the usage of them in the past (Tiryaki and Temur 2010). In some commodities, detected bromide ion and dithiocarbamates are not linked to pesticides usage. BAC (benzalkoniumchloride) and DDAC (dicecyldimethylammoniumchloride) are disinfectant. Figure 4 indicated that pesticides not permitted for OF were used or that contaminations of organic foods were related to procedure of handling, packaging or processing.

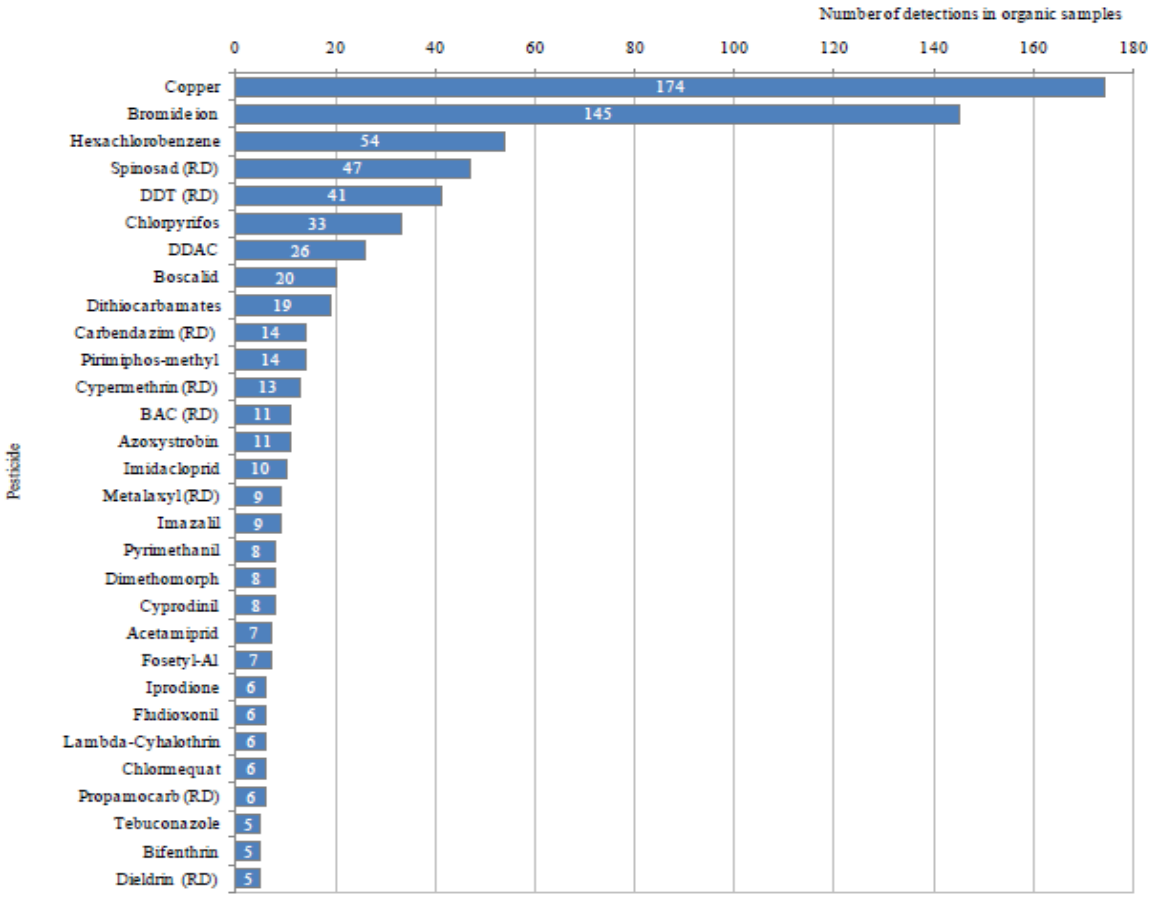

Figure 4. Most frequently detected pesticides in organic product (at least 5 determinations) (EFSA 2014).

Details on organic sample residues above the MRL are given in Table 3. The 35 organic products contained above the MRL. The most frequent residues over MRL were reported for BAC and DDAC. MRL of 0.01 mg kg^{-1} is applicable for both compounds.

Pesticide Residue Report of Organic Product in 2013

Total 80967 samples were analyzed in 2013 and 4620 of them were from organic products. In 15.5% of organic food, pesticide residues were lower than MRL, but 0.8% of the samples contained residue above the MRL.134 pesticides were detected in these organic product. For all food samples, detection rate and MRL exceeding rate were lower for organic samples than for conventional product, except for baby food (Figure 5).

Table 3. Information for organic product containing residues above the MRL (EFSA 2014).

Pesticide/commodity		Number of detection exceeding the MRL	Range of measured residue levels, mg kg^{-1}	MRL, mg kg^{-1}
DDAC,12[(a)]	Dry Apricot	1	0.094	0.01[*(b)]
	Bananas	7	0.073-0.292	0.01*
Imidacloprid,3[(a)]	Tea leaf	1	0.067	0.05*
Dimethoate 2[(a)]	Apples	1	0.11	0.02*
Copper	Pine nuts	2	30.1 - 33.6	30.0
Acetamiprid	Honey	1	0.097	0.05*
Biphenyl	Grapefruit	1	0.016	0.01*
Propargite	Table olives	1	0.04	0.01*
Cyfluthrin	Wheat	1	0.026	0.02*
Cypermethrin	Passion fruit	1	0.056	0.05*
Quintozene	Tea leaves	1	0.11	0.1*
Thiophanate-M	Dry herbal infusions	1	0.11	0.1*
Dichlorvos	Barley	1	0.014	0.01*
Diflubenzuron	Wheat	1	0.17	0.1

*: Limit of quantification, (a): Number of samples above the MRL, (b): Fresh apricot MRL is 0.01 mg kg^{-1}

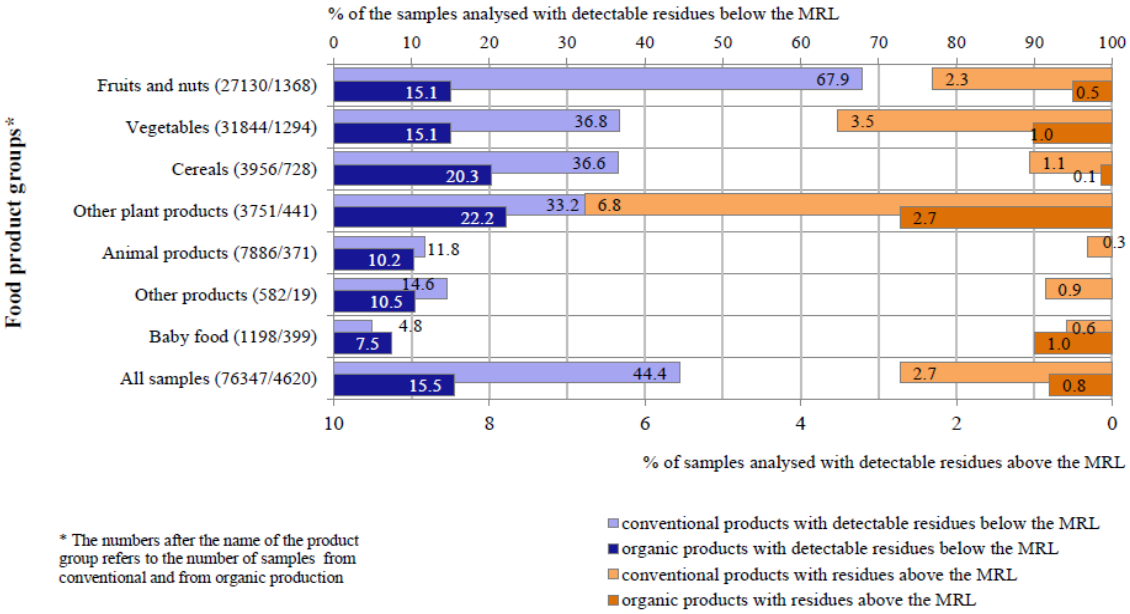

Figure 5. Detection rate and MRL exceeding rate for conventional and organic products (EFSA 2015).

The detected pesticides were associated with allowed pesticides for OF, POPs or residue of compounds that are not linked to pesticides usage but which may come from natural substances. 40 pesticides s were identified in organically produced baby food.

Table 4. Information for organic baby food residues above the MRL (EFSA 2015).

Compound	Number of organic sample above		Residue, mg kg^{-1}	Comment
	LOQ	MRL		
DDAC	7	4	0.008–0.1	Used for machine disinfections
BAC	4	3	0.01–0.099	See comment on DDAC.
Chlorpropham	2	2	0.039-0.044	Used for suppressing of potato sprouting. Approved in the EU.
Difenoconazole	1	1	0.011	Approved fungicide

Ten of them contained exceeding the MRL. Some of pesticide residues higher than MRL on organic baby food samples are reported in Table 4. According to 2013 monitoring program, Member States should take at least one organic sample for each of 12 food products in focus.

In 2010, 2012 and 2013 EFSA report it was indicated that there was no MRL regulations for organic foods in EU. Thus, the same MRLs for conventional foods were set by the Regulation No 396/2005 (EC 2005). In this case, extra production and labelling measures must be taken which includes important restrictions on the use of chemicals (EC 2007, EC 2008).

PESTICIDE RESIDUE REPORT IN ORGANIC PRODUCT IN USA

Pesticide residue data was assessed to identify and quantify differences between conventional, organic and IPM-grown vegetables and fruits. Residue analytical data for foods from these 3 market sources were compared using following 3 test programs data;

I. Pesticide Data Program (*PDP*) of USDA (USDA 2000),
II. California Department of Pesticide Regulation (*DPR*) (California EPA 1999),
III. The private tests by the Consumers Union (*CU*) (CU 1998).

Table 5. The number of samples contained pesticide residues in fresh food tested by PDP (Baker *et al.*2002).

Product	Number of Organic			Number of IPM (Conventional)*		
	Sample	Positive	Positive %	Sample	Positive	Positive %
All fruits	30	7	23	71(12612)	35(10392)	49(82)
All vegetables	97	22	23	124(13959)	56(9093)	45(65)
All fresh food	127	29	23	195(26571)	91(19485)	47(73)

* Conventional values are in the parenthesis

PDP and DPR data programs tested widely fresh fruits and vegetables whereas CU tested only 4 foods: apples, peaches, green peppers, tomatoes.

Conventionally grown products and IPM-grown product consistently had about one-half and about one-third as many residues as found in organic products. IPM and conventionally grown samples had more multiple residues than organic samples. Generally, organic samples' residue concentrations were less than in the other two market sources for 3 data sets. The residue content of IPM-grown products higher than organic samples, but less than conventionally grown products.

Table 5 shows the frequency of pesticide residues in fresh food tested by PDP from 1994 to 1999. The number of PDP tested samples was 26893 in the 6 years. 127 and 195 of them were organic and IPM-grown product, respectively; the remainders were classified as conventionally grown. About 73% of the all conventionally grown samples included at least one pesticide residue. The percentages of sample containing one or more residues were 82% and 65% for fruit s and of vegetables, respectively. Same values, respectively, were 47%, 49% and 45% for IPM-grown, and 23%, 23% and 23% for organic samples. Peaches and strawberries had more residues in both conventionally and organically grown samples.

If banned organochlorine compounds (OCs) are excluded from the comparison, the figures change, especially for vegetables (Table 6). When OCs excluded, the percentages of positive fraction for organic vegetables drops to 9%,

Table 6. The number of samples contained pesticide residues in fresh food tested by PDP, without banned OCs residues (Baker *et al.*2002).

Product	Number of Organic			Number of IPM (Conventional)*		
	Sample	Positive	Positive %	Sample	Positive	Positive %
All fruits	30	7	23	71 (12612)	35(10287)	49 (82)
All vegetables	97	9	9	124(13959)	54 (8465)	44 (61)
All fresh food	127	16	13	195(26571)	89(18752)	46 (71)

* Conventional values are in the parenthesis

whereas conventionally and IPM grown vegetable show only slight decrease. There is no change for fruits in any market sources. Overall, decreases % of positive organic samples from 23 to 13%. It means that residues in organic products are related to POPs.

Comparison of the frequency of pesticides found in conventional and organic products tested by the DPR from 1989 to 1998 were shown in Table 7. The DPR tested 67154 food samples. Of those, 1097 were identified as organically grown, of which 6.5% contained at least one residue and 66057 samples were classified as conventionally grown, of which 31% contained at least one residue.

According to CU data programs, or all 4 foods combined, 79%, 51% and 27% of samples had one or more residues in conventional, IPM and organic samples, respectively (Table 8). These overall differences and also differences between the percent positive for conventional and organic grown product of all 4 individual foods were significant ($p < 0:001$).

Multiple residues of pesticide are found in commonly widely consumed fresh foods. The number of samples with multiple pesticide residues in 3 market claim by 3 data programs were compared (Table 9). In CU tests, 62% of conventional product, 44% of IPM grown product and only 6% of organic samples contained multiple residues, whereas PDP values were 46%, 24% and 7%, respectively. In DPR tests, percent of the detected multiple residues were 1.3% and 12% for organic and conventional samples, respectively. These differences were significant ($p < 0:001$).

Table 7. Residues in conventional and organic product (DPR data) (Baker *et al.* 2002).

Year	Number of sample	Number of Organic			Number of Conventional		
		Sample	Positive	Positive%	Sample	Positive	Positive %
1989	9387	196	7	3.6	9191	2060	22.4
1990	8275	194	5	2.6	8081	1660	20.5
1991	7443	82	5	6.1	7361	1856	25.2
1992	7307	40	4	10.0	7267	2271	31.3
1993	6056	22	0	0.0	6034	2165	35.9
1994	5465	45	2	4.4	5420	1838	33.9
1995	5498	41	3	7.3	5457	1943	35.6
1996	6070	144	20	13.9	5926	2190	37.0
1997	5635	155	15	9.7	5480	2025	37.0
1998	6018	178	10	12.8	5840	2402	41.1
All Years	67154	1097	71	6.5	66057	20410	30.9

Table 8. Frequency of residues in fresh fruits and vegetables by CU testing (Baker *et al*.2002).

Product	Number of Organic			Number of IPM (Conventional)*		
	Sample	Positive	Positive %	Sample	Positive	Positive %
Apple	20	7	35	20 (20)	19(20)	95(100)
Peach	12	4	33	5(13)	3(11)	60(85)
Total fruits	32	11	34	25(33)	22(31)	88(94)
Pepper	10	0	0	6(14)	0(10)	0(71)
Tomato	25	7	28	14(21)	1(13)	7(62)
Total vegetables	35	7	20	20(35)	1(23)	5(66)
Total for 4 foods	67	18	27	45(68)	23(54)	51(79)

* Conventional values are in the parenthesis

Table 9. Samples including multiple pesticides by market category in 3 data program (Baker *et al*.2002).

Data set	Number of Organic			Number of IPM (Conventional)*		
	Sample	Positive	Positive %	Sample	Positive	Positive %
PDP(20 crop)	127	9	7.1	195(2657)	46(12102)	23.6(45.5)
DPR(19 crop)	609	8	1.3	n.a.(34003)	n.a. (4055)	n.a. (11.9)
CU(4 crop)	67	4	6.0	45(68)	20(42)	44.4(62)

n.a = Not applicable

The residue content of organic products were less than IPM and conventionally grown products. Similarly organic samples had less multiple residues than conventional or IPM product. These differences were significant. All the residues were belong to synthetic and conventional pesticides. Many of synthetic residues are unavoidable. Unavoidable contamination was set as 5% of the applicable EPA MRL. Most residues of pesticides found in positive organic samples in all 3 test programs were less than this level and tested samples were sold as organic under that standard (Baker *et al.*2002).

INDIVIDUAL STUDIES ON PESTICIDE RESIDUES IN ORGANIC FOOD

A several studies have been performed with regard to pesticide residues in organic product. In a study, residues in strawberries grown both as organic and IPM and in soils were analyzed by GC-MS/MS, LC-MS/MS. Strawberries, using OF and IPM practices, were sampled in the first week of May on 2009 and 2010 from a plot near the center of Portugal. There were no pesticides residues in strawberries and soils from OF practices, but 9 pesticides were detected in IPM grown samples, and slightly higher residue were found in the soils. All results were below EU MRL legislation (Virginia *e t al*. 2014).

Szekacs *et al.* (2015) summarized pesticide residue results in soil surface and ground water in Hungary in 1990–2015 periods. Residues also monitored in surface water at regions of Organic Agriculture. Due to high level of diffuse pesticide contamination observed in the national survey, a separate monitoring study, focused on detection of POPs in soil and water in OF, and their effects on OF, was performed between 2006 and 2008. They concluded that OF was not free from pesticide residues because of (i) drift from pesticide treated fields; (ii) pesticide residues in irrigation water; (iii) POPs from treatments prior to OF; (iv) illegal pesticide application. They have observed that pesticide contamination levels determined in OF fields were on the average one order of magnitude lower than in intensively cultivated fields.

In a review work was performed by Groza *et al.* (2012) on general aspects about pesticide residues in fruits and comparison was made between OF and conventional farming. They concluded that most people carry pesticide residues in their bodies, but the level can be drastically reduced by the adoption of an organic diet. Studies showed that organic foods generally contain lower residue levels and contain more minerals and vitamins and a more balanced protein profile. OF, with its restrictions of synthetic pesticides, seems to offer a low residue and alternative to conventional methods.

In another study, it has reported lower residue contents in organic products as compared to conventional products. A residue survey, carried out in Italy, reported 10-fold lesser contamination in organic products (2.6%) as compared to conventional (27%) products. 0.8% and 8.8% multiple residues reported in organic and

conventional samples, respectively. US data stated that conventionally grown products recorded about 3 fold as many residues as organic products (Oates and Cohen 2009).

Pussemier *et al.* (2006) reviewed residue results for the period of 1995-2001 in Belgium. Residues were found in 49% of conventional food and 12% of organic food.

In Turkey, although there aren't MRL regulations in organic production, a few papers published on this issue. One of them is an original study carried out by Turgut *et al*.(2011) with regard to pesticide residues in table grapes. Grapes were sampled from 99 different vineyards in Aegean region: 20 from IPM farms, 10 from OF, and 69 farms using conventional farming. Residue analyses of 27 pesticides were performed by QuEChERS analytical method. The most frequently detected pesticides were lambda-cyhalothrin, deltamethrin, chlorpyrifos-methyl, and chlorpyrifos, with the number of sample of 22, 15, 15 and 12, respectively. The residues were found just in conventional farm. The number of samples above MRL was 2 for both Chlorpyrifos-methyl and Lambda-cyhalothrin. There were no residues in IPM applied farm and OF.

Bilgin *et al.* (2008), analysed the residues of 258 pesticides in different processed flours, which are obtained from organically grown wheat, by Luke method. The pesticides were from organochlorines, organophosphorus, strobulin fungicides, n-metyhl carbamates, synthetic pyrethroids, benzimidazoles and pyridylmethalamines groups. All of the pesticide residues were not higher than MRL.

Tosun and Kaya (2010) reviewed some studies with regard to residues in organic and conventional food. Mostly study revealed that pesticide residues were just found in conventional farms, whereas no or less pesticides were found in OF. They concluded that residue of pesticides found in many organic products were releated to POP.

CONCLUSIONS

Nowadays pesticide residues are the most important component of food safety. The use of pesticides during vegetation cause residues in fresh foods. In every country, the aim of residue monitoring studies is to prove that vegetables and fruits are safe with regard to pesticide residues. It was shown that organic products included less measurable pesticide residues than IPM-grown and conventionally grown food in EFSA reports, USA's pesticide data programs and individual residue studies. Organic samples have less multiple residues than IPM and conventional foods. Organic diet provides an immediate protective effect against pesticides residues. There is no specific MRL regulation in the world for organic foods, but 0.010 mg kg^{-1} and 10% of the MRL has been applied in EU and 5% of the EPA tolerance in the USA as well. At European level, Regulation No 834/2007 and Regulation No 889/2008 define a list of pesticides that are allowed in OF. Risk-based sampling plan is important for PRA in OF. For example, positioning of primary samples, when there is a suspicion of application drift from a neighboring farm, has a vital importance. A lot of studies showed that the residues found in many organic products are related to POPs coming from agro-ecosystem. Visual checks alone are not regarded as enough proof for organic product safety. Pesticide residue analyses help to increase the efficiency and the organic control system's guarantee, to prove the integrity and quality of OF. Residue analysis should also be performed by accredited laboratories.

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