Exploratory study on pesticide residues on fresh vegetables from markets in Uganda

Commissioned by the Agricultural Counsellor of the Dutch Ministry of Agriculture, Nature and Food Quality, based in Kampala, Uganda

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This research was funded by the Dutch Ministry of Agriculture, Nature and Food Quality (project number BO-43-113-038).

Wageningen Environmental Research
Wageningen, November 2023

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Report 3303
ISSN 1566-7197

Ronner, E., Van der Poel, M., Van Reemst, L., 2023. *Exploratory study on pesticide residues on fresh vegetables from markets in Uganda; Commissioned by the Agricultural Counsellor of the Dutch Ministery of Agriculture, Nature and Food Quality, based in Kampala, Uganda.* Wageningen, Wageningen Environmental Research, Report 3303. 36 pp.; 2 fig.; 4 tab.; 12 ref.

Deze studie onderzoekt het gebruik van bestrijdingsmiddelen en de voedselveiligheid in de tuinbouwsector van Oeganda. De studie analyseerde 726 bestrijdingsmiddelencomponenten op drie groenten van zes markten in drie regio's in Oeganda. Er werden 19 verschillende bestrijdingsmiddelen gevonden, met Acetamiprid, Profenofos en Cypermethrin als meest voorkomende residuen. In tomaten kwamen de meeste residuen voor, in witte kool de minste. Sommige residuen overschreden de Codex Alimentarus en EU maximumresidugehalten, waaronder Methamidophos, dat verboden is voor gebruik in Oeganda. Cypermethrin overschreed de limieten voor acute toxiciteit. Aanbevelingen zijn onder andere betere informatie in lokale talen, overheidsfinanciering voor handhaving van de regelgeving en capaciteitsopbouw, publiek-private partnerschappen voor exportnaleving, duidelijke productetikettering, verder onderzoek met een grotere steekproefgrootte en koppelingen met bestaande initiatieven voor gewasbescherming.

This study assessed pesticide use and food safety in Uganda's horticultural sector, analyzing 726 pesticide components on three vegetables from six markets across three regions in Uganda. It found 19 different pesticide components, with Acetamiprid, Profenofos, and Cypermethrin being the most common residues. Tomatoes had the highest residue occurrence, while cabbage had the least. Some exceeded Codex Alimentarus and EU maximum residue levels, including Methamidophos which is banned for use in Uganda. Cypermethrin surpassed acute toxicity limits. Recommendations include better information in local languages, government funding for regulation enforcement and capacity building, public-private partnerships for export compliance, clear product labeling, further research with a larger sample size, and linkages to existing pest management initiatives.

Keywords: pesticide residues, fungicides, insecticides, horticulture, Africa

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Wageningen Environmental Research Report 3303 | ISSN 1566-7197

Photo cover: Laurie van Reemst

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Verification

Report: 3303
Project number: BO-43-113-038

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Executive Summary

This study aimed to assess the use of pesticides in the horticultural sector in Uganda, with a focus on food safety. The study analysed 726 pesticide components in fresh vegetables from six markets across three regions in Uganda. A total of 60 samples were collected from the selected markets, consisting of tomatoes, cabbage, and green peppers. The samples were analysed for pesticide residues by an accredited laboratory in the Netherlands.

In total, 19 different pesticide components were detected out of the 726 tested. Acetamiprid, Profenofos, and Cypermethrin were the most frequently found residues. Tomatoes exhibited the highest occurrence of pesticide residues, with 16 different residues found in 18 out of 20 samples. Green peppers had 12 different residues in 17 out of 20 samples, while only one cabbage sample contained three pesticide residues. On average, two to three types of residues were found per tomato sample, and two on green pepper. Most cabbage samples did not contain any pesticide residues.

The study assessed the exceedance of maximum residue levels (MRLs) set by the Codex Alimentarius and the European Union (EU). The MRL Codex thresholds were exceeded in three cases for tomato, five for green pepper, and one for cabbage. These cases included residues of Methamidophos, which is banned for use in Uganda and in the EU, and of unregistered products such as Acephate, Clothianidin, and Cyromazine although their exceedance of MRL values was limited. Some samples exceeded EU thresholds, necessitating better information for potential exports. Cypermethrin surpassed Acute Reference Dose limits (referenced to consumption patterns for tomato and green pepper in the Netherlands), indicating acute toxicity. Mancozeb residues, despite its common use, were not studied, necessitating further investigation.

While the study had an exploratory character due to a limited coverage of markets, vegetables, and samples per vegetable, the study gives insights in potential avenues for follow-up, as well as the potentially most problematic vegetables and pesticide components. Recommendations based on this study are:

1. **Improved information provision in local languages**: Provide information to farmers and agro-dealer on pesticide risks and safety measures in local languages. This aims to raise awareness and encourage the correct application of pesticides, particularly focusing on Highly Hazardous Pesticides.
2. **Government funding for regulation enforcement and testing capacities**: Allocate government funds to strengthen regulatory enforcement, improve laboratory diagnostic capabilities, and invest in training and development for regulatory agencies.
3. **Public-private partnerships for SPS compliance in export markets**: Foster collaboration between the public and private sectors to ensure compliance with Sanitary and Phytosanitary (SPS) controls, especially for exports. Implement traceability systems and explore alternatives to organophosphate pesticides for export-oriented produce.
4. **Cost-savings through better instructions and product labelling**: Provide farmers and agro-dealers with clear and accurate instructions for pesticide use, including proper dosages and relevant crops/pests/diseases to reduce unnecessary pesticide expenses. Consider conducting follow-up studies to identify specific areas for improvement.
5. **Verification and expansion of study findings**: Conduct further research with a larger sample size to validate and expand upon the initial study findings. This can help identify regional priorities and inform policy changes if necessary. Collaboration with Uganda National Bureau of Standards (UNBS) for pesticide analysis is also recommended.
6. **Link to ongoing pest management initiatives**: Leverage existing initiatives like from MAAIF, Trademark East Africa and CABI. Incorporate Integrated Pest Management and biological alternatives into these programs to reduce pesticide reliance and promote sustainable farming practices.

1 Introduction

Wageningen University and Research (WUR) conducted a study, commissioned by the Embassy of the Kingdom (EKN) of the Netherlands in Kampala, Uganda, to explore the opportunities for organic agriculture in Uganda. The organic agriculture sector in Uganda is relatively small at present, and geared towards export, while the majority of smallholder farmers practice farming with limited use of external inputs. As part of the study, a scoping exercise was conducted which showed that while the use of mineral fertilizer in Uganda is still among the lowest in the world, the use of pesticides is increasing steadily. Moreover, the use of inputs is particularly high in certain sectors, especially the horticultural sector. This led to a focus of the study on the horticultural sector, with a specific attention for food safety in relation to the use of pesticides.

A collaboration with the EKN-funded HortiMAP project was sought, to complement ongoing activities to strengthen horticultural value chains in general, and to improve food safety in particular, as the latter was also indicated as a priority for HortiMAP. After consultations with HortiMAP's project partners (Technoserve and Wageningen Centre for Development Innovation), the idea of a study focusing on actual measurement of pesticide residues on fresh fruits and vegetables (FFV) on markets across the project's intervention areas was considered useful. This study would complement an ongoing study on consumer perceptions around food safety.

While a few studies on pesticide residues on FFV in Uganda had been conducted in Kampala (Ssemugabo et al., 2022), Wakiso district (Atuhaire et al., 2017), Kampala and Mbale (Rikolto, 2020) and Kabale (Ngabirano and Birungi, 2022), these studies were limited in terms of the amount of pesticides components analysed (e.g. DDT, glyphosate are missing), and in terms of geographical location (one or two locations only) and/or sample size.

In this study, we therefore analysed 60 FFV samples for the presence of residues of 726 pesticide components, including older and more recent pesticides. Samples were taken from central markets of six towns across Uganda. The study aimed to indicate which pesticides are of particular concern, how many of these pesticides surpass critical thresholds, and how widespread this concern is (e.g. in a particular fruit or vegetable, in a particular region, or across the country or crops). This study gives a first insight in the range of pesticides that is currently applied by farmers, and provides clues for follow-ups on the producer-side as well.

Therefore, this study contributes to:

1. Enhancing stakeholders' awareness on food safety issues (and hence to encourage demand for safe food and improve consumer health)
2. Improving pest management advice to farmers and agro-dealers (which pesticides to use, which ones to avoid, frequency/ timing of spraying, etc.), and
3. Developing policy recommendations with respect to food safety, such as pesticides that could be phased out, restricted, etc.

2 Methods

2.1 Sampling strategy

HortiMAP supports markets in three regions of Uganda, namely Kigezi, Victoria Crescent and Mbale/Mt. Elgon (Figure 1).

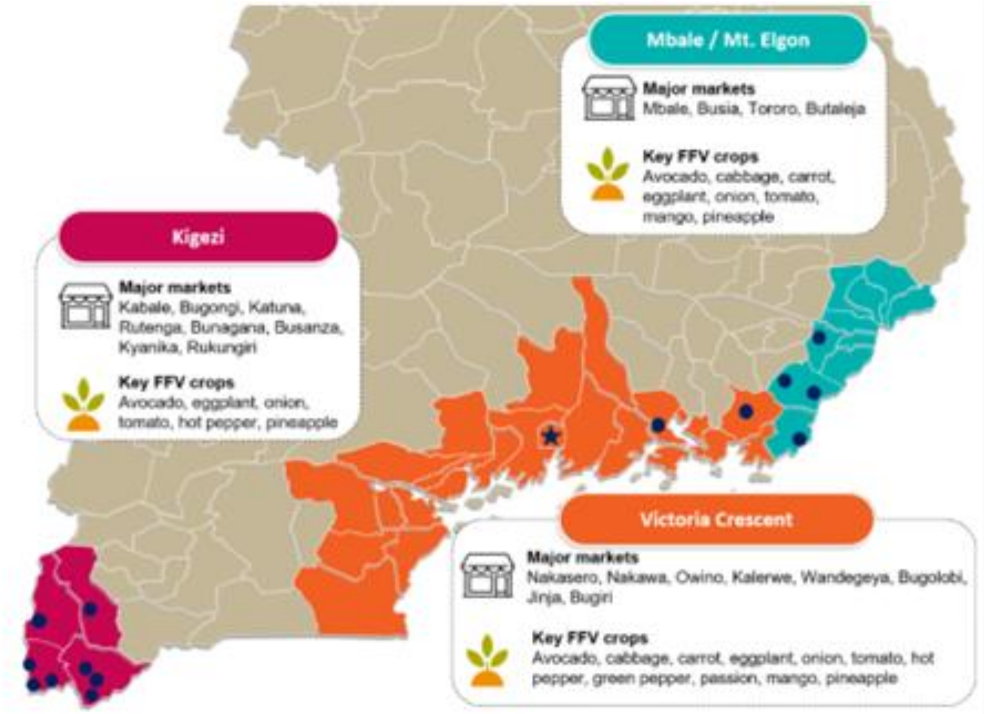

Figure 1 *Geographic focus of the HortiMAP programme.*

This study selected two markets in Central, two in Eastern and two in Southwestern Uganda. In each region, the central markets in two major towns were selected:

- Central: Kampala (Kalerwe market) and Jinja
- Eastern: Mbale and Tororo
- Southwest: Kabale and Kisoro

Based on the assessment of the frequency of consumption as well as the frequency of spraying, done in the "*Food safety risks in fruits and vegetables supplied in Kampala and Mbale towns of Uganda*" study conducted by Rikolto, the following vegetables were selected for sampling:

1. Tomato (Solanum lycopersicum)
2. Cabbage (Brassica oleracea var. capitata)
3. Green pepper (Capsicum annum)

A total of 60 samples were collected, totalling to 10 samples per market, consisting of 3-4 samples per vegetable. This led to 20 samples per vegetable divided over 6 markets.

2.2 Sampling protocol

Staff members from Technoserve were engaged as technicians for the sampling of the vegetables in the selected markets. Samples were taken on the 13th of December 2022.

Each sampler selected ten stalls in the market, and at each stall bought 1 kg of one of the selected vegetable. The stalls were picked from different sides of the market, giving a good representation of the circumstances in the market (stalls on the inside, on the outside, and stalls where he/she would typically go as a consumer). The 1 kg bought was put in a plastic bag, with a pre-printed label on both the inside and outside of the bag, which clearly indicated the market name, the type of vegetable and the sample number. The vendor was asked to place the vegetable in the bag, to ensure that the sampler did not touch the vegetable to avoid cross-contamination.

The collected samples from each market were transported to Kampala by the samplers themselves, by bus. All samples were collected in Kampala and sent on to the Cropnuts laboratory in Nairobi, Kenya, on the same day by car. Cropnuts forwarded the samples by air to Normec Groen Agro Control, their accredited partner laboratory for pesticide residue analyses in the Netherlands.

A permit to export the samples for the purpose of this research was received from MAAIF as well as a clearance to import the samples into Kenya. Moreover, the Nagoya protocol was followed to adhere to access and benefit-sharing obligations of the Convention on Biological Diversity.

2.3 Sample analysis

Samples were analysed on 21st and 22nd of December 2022 by Normec Groen Agro Control. The analysis included 726 pesticide components (pesticides, and their metabolites which form in the chemical breakdown process of the pesticide). The analysed components included older and more recent pesticides, covering the most widely used products. Glyphosate was analysed separately as it requires a different method (see Annex 1 for details). Mancozeb, a commonly used fungicide in Uganda, was not included in the standard analysis, and was not requested for specifically. Hence, Mancozeb and its metabolites were not part of the analysis.

For the detection of pesticide residues, an extraction method was used that is based on the QuEChERS method, according to Crop Nutrition Laboratory Services Ltd. The methods used for analysis were LC-MSMS (A090, A104 & A178, own method) and GC-MSMS (A088, A104 & A178, own method).

The laboratory also provided a comparison of the residue level detected with the Maximum Residue Limit (MRL). The MRL (in mg/kg) is the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly. The laboratory used MRLs based on EU standards (MRL (EU)), as set by the EU member states, the EU council and the European Food Safety Authority. We added a comparison with MRLs based on the Codex Alimentarius[1] (MRL codex). MRLs from the Codex Alimentarius are set by the Joint Meeting on Pesticide Residues (JMPR), which is a group of experts that meets annually to harmonize the requirement and the risk assessment of pesticide residues and is administered by the UN FAO and WHO.

Additionally, the laboratory results included a comparison with the Acute Reference Dose (ARfD). This is an estimate of the amount of a component in food and/or drinking water, expressed on a body-weight basis, that can be ingested in a period of 24h or less, without appreciable health risk to the consumer. For the calculation of the ARfD, the Pesticide Residue Intake Model (PRIMo) version 3.1 was used. This model, developed by the European Food Safety Authority, is based on national food consumption figures and unit weights provided by Member States of the European Union. It is intended to be used in the context of

[1] Codex Maximum Residue Limits for Pesticides and Extraneous Maximum Residue Limits adopted by the Codex Alimentarius Commission up to and including its 44th Session (November 2021)" Codex Pesticides Residues in Food Online Database, FAO, URL: Pesticide Database | CODEXALIMENTARIUS FAO-WHO.

regulations from the European Commission (including the EU MRL), as an assessment tool for both short-term (acute) and long-term (chronic) exposure to pesticide residues via food,. For the short-term risk assessment the Acute Reference Dose (ARfD) is used. The long-term risk assessment is based on comparing the exposure values with the daily acceptable intake (ADI) values, which are usually lower than the ARfD values. Exposure is calculated separately with the PRIMo model for each pesticide. Cumulative exposure resulting from more than one pesticide is not considered, as well as the uncertainty related to dietary exposure calculations.

While the ARfD is based on dietary patterns of fruits and vegetables for European consumers, and cumulative exposure is not considered, we still consider this comparison valuable for the Ugandan context because it 1) indicates roughly which levels could also be considered problematic for Ugandan consumers, despite expected potential differences in consumption patterns, and 2) indicates which residue levels are (not) accepted when export to the EU is considered.

3 Results

3.1 Occurrence of pesticide residues

In the 60 samples which were tested, 19 different pesticide components were found, out of the 726 pesticide components tested. Figure 2 shows the percentage of samples on which the specific component was found, based on the sample size of n=20 per crop, for tomato, green pepper and cabbage. Out of these 19 components, 15 were insecticides, while the remaining four were fungicides.

For the insecticides, Acetamiprid had the highest rate of occurrence (on 45% of the samples for tomato and green pepper) followed by Profenofos (on 45% of the samples for tomato and 30% for green pepper), and Cypermethrin (on 40% of the samples for tomato and 30% for green pepper) were found relatively often. For the fungicides, Propamocarb was found the most, on 20% of the tomato and 10% of the green pepper samples.

Tomato had the largest occurrence of pesticide residues: 16 different residues were found, on a total of 18 out of 20 samples. On green pepper 12 different residues were found on a total of 17 out of 20 samples. On only one of the cabbage samples, three pesticide residues were found: Profenofos, Cypermethrin and Omethoate, all three of them being insecticides. The other 19 cabbage samples did not contain any of the 726 pesticide residues. On average, two to three different types of residues were found on each tomato sample, ranging from 0-7 per sample. On green pepper on average two types of residues were found, ranging from 0-5 per sample, and for cabbage all samples except one had no pesticide residues.

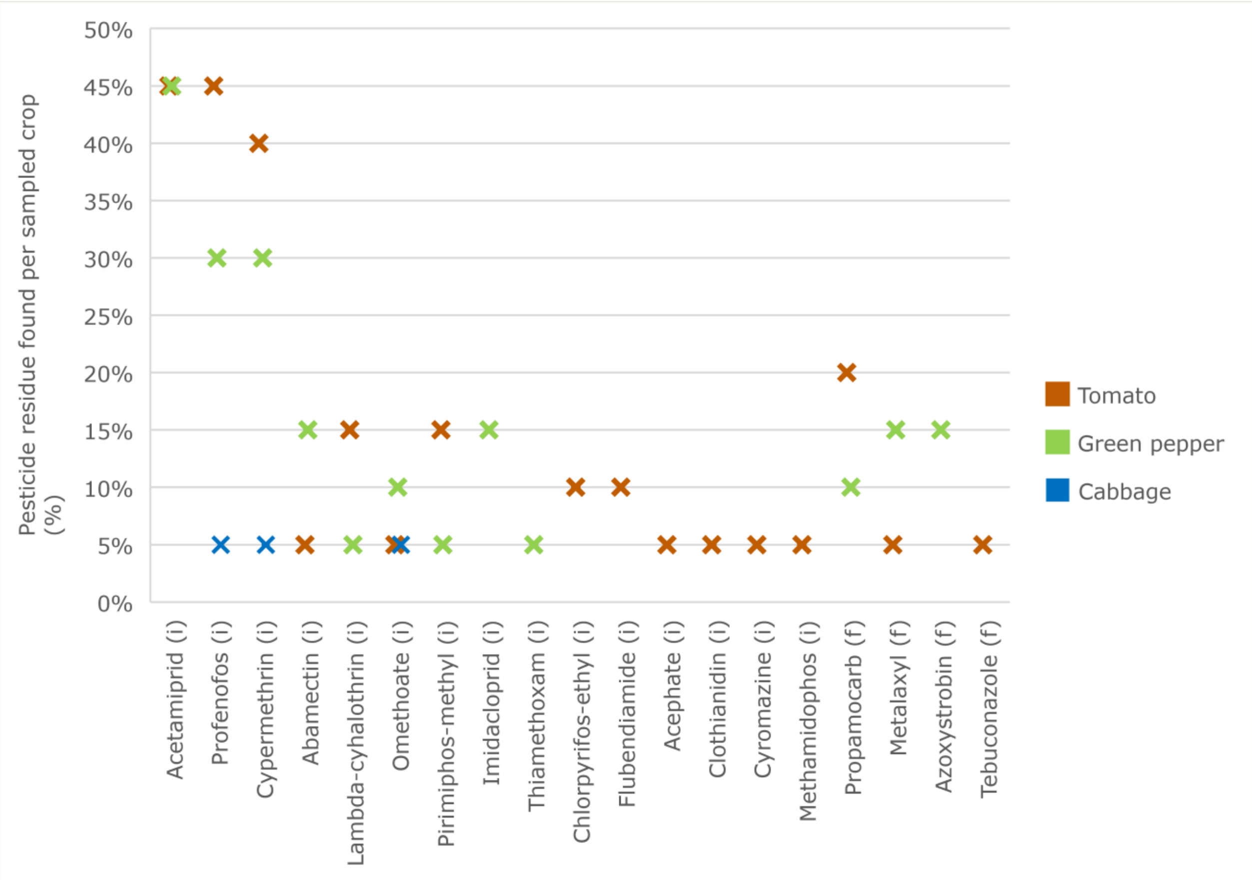

Figure 2 *Occurrences of pesticides residues on tomato (n=20), cabbage (n=20) and green pepper (n=20). Pesticides are split into insecticides (i) and fungicides (f).*

3.2 Exceedance of threshold values

Tables 1, 2 and 3 show the detection of residues on respectively tomato, green pepper and cabbage, as well as the number of samples that exceeded the MRL Codex and MRL EU threshold values for each residue. Annex 2 provides an overview of individual components which are either banned, registered or unregistered in Uganda[2], and/or allowed for use in the European Union[3].

Two components found in the analysis are banned for use, both in Uganda and in the EU: Methamidophos and Omethoate. This means that practically, no residues of this component are allowed to be found. Methamidophos was found on one tomato sample. Omethoate was found on all three vegetables: on one sample of tomato, two samples of green pepper and one sample of cabbage. However, while Omethoate is banned as a product, it is more likely that the residues of Omethoate found are in fact a metabolite of Dimethoate, which is registered for use in Uganda. Products with Dimethoate are quite common in Uganda (Ngabirano & Birungi, 2022), while products with Omethoate are rare (H. de Putter, personal communication).

Three components found in the analyses are unregistered for use in Uganda: Acephate, Clothianidin and Cyromazine. An above-threshold detection only occurred for Acephate in one tomato sample; exceeding the MRL EU value only.

Since the MRL values differ between the international Codex and EU standards, three samples exceeded the MRLs of the Codex Alimentarius for tomato, while eight samples exceeded the MRLs for the EU. For green pepper this was respectively five (Codex) and nine (EU) samples. For cabbage, only one sample exceeded both thresholds.

For tomato, next to the exceedance of the MRL Codex values for Methamidophos and Omethoate on one sample each, the MRL Codex threshold was exceeded in one sample for Propamocarb (Table 1). The MRL EU for this component was not exceeded however, because of its higher threshold value. The MRL EU values were exceeded for Pirimiphos-methyl in three samples and for Chlorpyrifos-ethyl in two samples. The latter product is banned for use in the EU, yet registered in Uganda. For green pepper, in addition to the exceedance for Omethoate, the MRL Codex was exceeded for Abamectin in three samples (Table 2). The MRL EU values were exceeded in six samples for Profenofos (banned in the EU but registered in Uganda) and one sample for Pirimiphos-methyl. For cabbage, the MRL Codex and EU values were only exceeded in one sample for Omethoate (Table 3).

The last column of tables 1 and 2 indicate the number of times a residue found on the sample exceeded the Acute Reference Dose (ARfD). None of the components exceeded the ARfD, except for Cypermethrin in three samples of tomato and two samples of green pepper. This is in contrast with the indicated MRLs, as none of the samples exceeded the MRL for Cypermethrin. The ARfD for cabbage was not given in the lab results.

For a number of fungicides, residues were found on tomato and green pepper, yet their application is not particularly useful in these crops. For instance, Metalaxyl and Propamocarb in green pepper, and Tebuconazole in tomato. Though thresholds were not exceeded, this indicates that better instructions to producers on their use and applicability to certain crops and diseases are needed; for instance by inspecting the labels of these formulated products to check if these show directions for use in the mentioned crops, and revise them where needed.

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2 Register of Agricultural chemicals registered, MAAIF, URL: Chemical-Register-Feb-2022.pdf (agriculture.go.ug).

3 EU pesticides database on active substances, URL: https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/active-substances.

Table 1 *Residue concentrations exceeding maximum residue limits (MRLs) and acute reference dose (ARfD) for tomato samples (n=20). Values found per sample can be found in Annex 3.*

			Tomato			
Component	**Total count**	**MRL codex (mg/kg)**	**# samples > MRL codex**	**MRL EU (mg/kg)**	**# samples > MRL EU**	**# samples > ARfD PRIMO NL**
Acetamiprid	9	0.2	0	0.5	0	0
Profenofos	9	10	0	10	0	0
Cypermethrin	8	0.2	0	0.5	0	3
Propamocarb	4	2	1	4	0	0
Pirimiphos-methyl	3	0.5	0	0.01	3	0
Lambda-cyhalothrin	3	0.3	0	0.07	0	0
Chlorpyrifos-ethyl	2	1	0	0.01	2	0
Flubendiamide	2	2	0	2	0	0
Abamectin	1	0.05	0	0.09	0	0
Acephate	1	1	0	0.01	1	0
Methamidophos	1	0.01	1	0.01	1	0
Omethoate	1	0.01	1	0.01	1	0
Clothianidin	1	0.05	0	0.04	0	0
Cyromazine	1	1	0	0.6	0	0
Metalaxyl	1	0.5	0	0.3	0	0
Tebuconazole	1	0.7	0	0.9	0	0
Total			*3*		*8*	*3*

Table 2 *Residue concentrations exceeding maximum residue limits (MRLs) and acute reference dose (ARfD) for green pepper (n=20). Values found per sample can be found in Annex 3.*

			Green Pepper			
Component	**Total count**	**MRL codex (mg/kg)**	**# samples > MRL codex**	**MRL EU (mg/kg)**	**# samples > MRL EU**	**# samples > ARfD PRIMO NL**
Acetamiprid	9	0.2	0	0.3	0	0
Profenofos	6	3	0	0.01	6	0
Cypermethrin	6	2	0	0.5	0	2
Abamectin	3	0.005	3	0.07	0	0
Azoxystrobin	3	3	0	3	0	0
Imidacloprid	3	1	0	0.9	0	0
Metalaxyl	3	1	0	0.5	0	0
Omethoate	2	0.01	2	0.01	2	0
Propamocarb	2	3	0	3	0	0
Pirimiphos-methyl	1	0.5	0	0.01	1	0
Lambda-cyhalothrin	1	0.3	0	0.1	0	0
Thiamethoxam	1	0.7	0	0.7	0	0
Total			*5*		*9*	*2*

Table 3 *Residue concentrations exceeding maximum residue limits (MRLs) for cabbage (n=20). The acute reference dose was not exceeded by any of the residues. Values found per sample can be found in Annex 3.*

			Cabbage			
Component	**Total count**	**MRL codex (mg/kg)**	**# samples > MRL codex**	**MRL EU (mg/kg)**	**# samples > MRL EU**	**# samples > ARfD PRIMO NL**
Omethoate	1	0.01	1	0.01	1	-
Cypermethrin	1	1	0	1	0	-
Profenofos	1	0.05	0	0.01	0	-
Total			*1*		*1*	-

3.3 Detection of pesticide residues on different markets

Residues of Acetamiprid, Profenofos and Cypermethrin were found on samples taken from (almost) all markets (Table 4). Six out of ten samples in Tororo contained Acetamiprid, and five out of ten samples in Kabale contained Profenofos. Residues of the unregistered components were found on three markets (Tororo, Kampala and Kabale); the banned component Methamidophos was found on one sample in Tororo. Two samples each in Jinja and Tororo had Omethoate. The largest diversity of components was found on Tororo, Kampala, Kabale and Jinja markets (n=26, n=18 and n=17 and n=15 respectively). Kisoro and Mbale had residues of 9 and 6 different components respectively.

Table 4 *Number of samples with pesticide residue components detected per market (with a total of n=10 samples taken on each market) as well as the division over the different crops.*

Component	Tororo	Kampala	Kabale	Jinja	Kisoro	Mbale
Acetamiprid	6	1	3	4	2	2
Profenofos	2	3	5	3	3	-
Cypermethrin	2	3	3	3	3	1
Propamocarb		4	2	-	-	-
Abamectin	4	-	-	-	-	-
Lambda-cyhalothrin	1	-	2	-	-	1
Metalaxyl	1	-	-	3	-	-
Omethoate***	2	-	-	2	-	-
Pirimiphos-methyl	-	4	-	-	-	-
Azoxystrobin	3	-	-	-	-	-
Imidacloprid	3	-	-	-	-	-
Chlorpyrifos-ethyl	-	-	-	-	1	1
Flubendiamide	-	-	1	-		1
Acephate*	1	-	-	-	-	-
Clothianidin*	-	-	1	-	-	-
Cyromazine*	-	1	-	-	-	-
Methamidophos**	1	-	-	-	-	-
Tebuconazole	-	1	-	-	-	-
Thiamethoxam	-	1	-	-	-	-
Total # of samples with residues detected	**7/10**	**7/10**	**5/10**	**7/10**	**6/10**	**4/10**
Tomato	4/4	4/4	3/3	3/3	2/3	2/3
Green pepper	3/3	3/3	2/3	3/3	4/4	2/4
Cabbage	0/3	0/3	0/4	1/4	0/4	0/3

* Unregistered in Uganda, **Banned in Uganda, *** Banned in Uganda, yet could be a metabolite of Dimethoate which is registered in Uganda.

4 Discussion and conclusions

In this study we assessed the occurrence of pesticide residues on 60 samples of tomato, green pepper and cabbage on six markets in three different regions of Uganda. We also compared the residue level found with MRLs as established in the Codex Alimentarius and by the EU member states. The study had an exploratory character due to a limited coverage of markets and different types of vegetables (no fruits), and a limited number of samples per vegetable. Yet, the study gives us insights in potential avenues for follow-up, as well as the potentially most problematic vegetables and pesticide components.

Out of the 726 pesticide components and metabolites analysed, residues were found from 19 different components and metabolites. For tomato and green pepper, 18 and 17 out of 20 samples respectively contained some residues. For cabbage, only one sample out of 20 contained residues. From the different residues found, the MRL Codex thresholds were exceeded in three cases for tomato, five for green pepper, and one for cabbage.

From the components that exceeded the MRL Codex, Methamidophos is the most notable. This insecticide is marked as Highly Hazardous Pesticide and is banned in Uganda, as well as more and more worldwide. The pesticide has been banned for long in the EU already. Omethoate falls in the same category, yet it cannot be concluded from this study whether an actual product with Omethoate was sprayed, or whether this concerned a metabolite of Dimethoate. This would require tracking up to farm level, to find out which product was used at spraying.

In addition to these banned products, the MRL Codex thresholds were exceeded in one sample of tomato for Propamocarb, and in three samples of green pepper for Abamectin. The former is fungicide against late blight, the latter a broad-spectrum insecticide (i.e. not specifically targeted to a certain insect but effective against all insects, including natural enemies and honey bees). Both pesticides are registered for use in Uganda, yet the exceedance indicates that either the sample was sprayed with a too high dose, or neglecting the pre-harvest interval.

The ARfD (referenced to consumption patterns for tomato and green pepper in the Netherlands) was exceeded for Cypermethrin in five samples. This implies acute toxicity (illness) when these tomatoes or peppers are consumed in a large portion. The exceedance is especially remarkable because both MRLs were not exceeded. The latter resulted in a follow-up with the Netherlands Food and Consumer Product Safety Authority, to check whether the MRL should not be lowered (a lengthy process, with no response yet). Cypermethrin is a broad-spectrum insecticide, and because of its wide use it is often no longer effective due to resistance among insects. As a response, farmers tend to use Cypermethrin more and more often, in higher doses than recommended. The general advise, for this reason, is to use insecticides only when necessary, and to use products as specific as possible while avoiding broad-spectrum insecticides, and to regularly alternate with products from other Mode of Action groups (Cypermethrin belongs to the pyrethroid Mode of Action group) to prevent this problem.

Several other samples showed exceedance of MRL EU threshold values. This indicates that in case farmers consider export of these vegetables to the EU, better information on alternatives for these products or on the prescribed use of the products is required (e.g. to be used on which crops, in which dose and complying with the pre-harvest interval).

Some of these products are banned in the EU. For instance, a number of insecticides detected included broad-spectrum products from the organophosphate group (Profenofos, Chlorpyrifos Acephate, Omethoate). Products from this group are older and more poisonous than pyrethroids. Organophosphates show an even higher risk of insect resistance than pyrethroids. All the organophosphates are banned in the EU, because newer and less poisonous alternatives are available. Other components belong to the neonicotinoids group (Acetamiprid, Thiomethoxam, Imidacloprid and Clothianidin), which are effective against sucking insects such as white flies, aphids and thrips), but they are also very poisonous to bees. Hence, they are banned in the EU for environmental reasons.

In comparison, a study by Ssemugabo et al. (2022) screened a total of 160 fruits and vegetables samples, collected from farm to fork in Kampala Metropolitan Area, for a total of 93 pesticides residues. This study detected 57 different pesticides on watermelon, passion fruit, tomato, cabbage and eggplant. In their study, the components Fonofos, Fenithrothion and Fenhexamid exceeded EU MRL values for some samples, including tomato and cabbage. These components were not detected in our study. Moreover, they found a possibility of chronic health risk to consumers based on hazard quotients (HQs, derived from comparing the estimated daily intake to the ADI values) for 18 pesticides, including Cypermethrin, Omethoate and Profenofos. ARfD values were not considered.

While specifically tested for Glyphosate (a herbicide that is currently highly debated because of its potential health risks) we did not find any Glyphosate residues in the sample analysis. Glyphosate is a non-specific systemic herbicide, which means that contact with glyphosate could also have negative effects on crop growth. Hence, most likely, if crops would have gotten in touch with Glyphosate through uptake via leaves and, to a lesser extent, possibly via roots they die off and their fruits would not reach the market.

Despite the widespread use of Mancozeb in Uganda, this pesticide was not included in the standard analysis and not requested for specifically (an unfortunate oversight). This pesticide often leaves visible residues on crops like tomato and surely plays a role in consumer perceptions of food safety. We did find residues of Metalaxyl, a fungicide which is only available in a formula with an additional broad-spectrum fungicide like mancozeb. However, no exceedance of any MRL was found for Metalaxyl. Similarly, a study conducted in Central Uganda found detectable amounts of Mancozeb on all tomato samples taken, though none of the average concentrations exceeded the MRL Codex (Kaye et al., 2015). Also Ssemugabo et al. (2002) detected Dithiocarbamates (Mancozeb, Maneb, Dithane, Thiram, Metam sodium and Propineb) in their study, but no average concentrations on tomato and cabbage samples exceeded the MRL values. It is unclear whether residue concentrations on individual samples did exceed threshold levels, as this data was not presented. In contrast, Atuhaire et al. (2017) found an exceedance of the MRL Codex for Mancozeb on 14% of their tomato samples, taken from markets in Wakiso district, Uganda.

The varying results in these studies indicate the need for better insights in actual residue levels of (metabolites of) Mancozeb on individual samples, and whether or not they exceed thresholds to inform consumer health risks. Additionally, sample collection and handling are done differently in the various studies and this might influence the findings, especially when the half-life of a pesticide is short. For representative results, samples therefore need to be handled and analysed as quick as possible.

5 Recommendations

1. Improved information provision to farmers and agro-dealers in local languages

Two Highly Hazardous Pesticides (HHPs) were found, that are banned for use in Uganda (Omethoate and Methamidophos). It is worth exploring to what extent these products are still found on the market and used by farmers. Measures to better enforce the ban by regulatory agencies (or the phasing out of these products) can be explored. A Country Situation Analysis on HHPs in Uganda (AUPWAE, 2021) indicated the challenges to phase out HHPs, which include limited knowledge and low community sensitization on threats from pesticides and safety measures for correct application. Moreover, insufficient information and outreach materials regarding HHPs translated into local languages limits adoption of best practices. Better information provision, in local languages, to farmers and agro-dealers on the risks of HHP products could therefore be a first step.

2. Government funding for enforcement of regulations and strengthening of testing capacities

Conversely, a study on pesticide use and risk exposure in Ugandan smallholder farming found that farmers are generally well-aware of the risks associated to pesticide use, but typically do not have the options for correct pest control (Andersson and Isgren, 2021). While farmers are concerned about the impacts around their use, they largely access pesticides through unauthorized supply channels, while technical support is lacking. Poor regulation enforcement and market liberalization has led to the establishment of a large informal market with cheap, poor-quality and sometimes counterfeit products. Government intervention is needed in this respect. Measures identified by Trademark East Africa (2022) include updating of legal frameworks, strengthening of laboratory diagnostic and analytical capacities among different ministries, departments and agencies, and increased public spending on staffing, skill development and funding to regulatory agencies.

3. Public-private partnerships for compliance with Sanitary and Phytosanitary controls for export

The study detected a number of residues from organophosphates, which are currently registered in Uganda yet largely banned in the EU. When export of produce to the EU is considered, these pesticides are therefore not allowed, and exporters therefore need to discuss alternatives with producers. Besides, because newer and less poisonous alternatives are available with lower risks of resistance, gradual phasing out could be explored for the longer term. The introduction of a traceability system with farm registration and labelling of produce could help to track and trace issues with specific pesticides when they arise. In the short term, such traceability system could be an option for international export products, while in the long run a similar system for the national market would be highly beneficial for food safety. Cooperation between public and private sector should ensure compliance with and reduce the unit costs for the required Sanitary and Phytosanitary (SPS) controls (Trademark East Africa, 2022). Improved compliance with SPS controls would also improve Uganda's position in emerging export markets like in the Middle East, or in cross-border trade within the East African Community.

4. Cost-savings for producers through better instructions and product labelling

A number of pesticides was used in too high doses (in the case of Cypermethrin), or on crops where no effects are to be expected (different fungicide products in tomato and green pepper). Farmers could save money when they use the right products on the right crop, in the right dose. Also, when resistance against certain products drives farmers to spray in higher doses, they could benefit from improved information on alternative products. This requires better instructions to farmers and agro-dealers on the correct application of different types of products, as well as better labelling of products (for which crops, with which purpose, with clear directions for use). To support this, a potential follow-up study could include sampling at farmers' field at harvest in combination with a spraying logbook from the farm, to get a better picture of what farmers use, and at which specific point instructions need to improve (incorrect/ unclear product label, lack of knowledge from the agro-dealer, farmers are unable to read instructions, reasons for farmers to ignore instructions, etc.).

5. Verification of study findings in a wider scope

Although no widespread exceedance of thresholds was detected, certain products require further attention to produce safe and healthy food for consumers in Uganda. This includes an extension of the analysis to (metabolites of) Mancozeb. Also, to verify the results from our exploratory study or to extend conclusions to different markets or fruits/ vegetables, a study with a larger sample size would be recommendable. Different considerations could play a role in such a study: strategically, results from markets in Kampala would probably get the most attention from policy makers, if any high-level changes in regulations need to be made. Alternatively, widespread testing across markets in Uganda would give more information on what type of markets or regions show more and less problematic results, and hence what regional priorities should be. And finally, for discussions with agro-dealers and producers, (smaller) markets that have a direct link with producers could be of most interest, as improved recommendations and guidelines for use could be directly discussed with the actors involved. As the Uganda National Bureau of Standards (UNBS) seeks accreditation for their laboratory for pesticide analyses, a cooperation with UNBS would foster the development and capacity of their laboratory.

6. Link to ongoing initiatives on effective pest management

Uganda’s Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) has implemented a two-year Sanitary and Phytosanitary Compliance Program in Uganda (50mln USD) in 2020 to address risks (including food safety) and challenges related to Uganda’s export trade in selected agricultural commodities including fresh fruits and vegetables (Trademark East Africa, 2020). Among other measures, improvements in pest & disease forecasting and quarantine to control the spread of pests have been implemented. This has resulted in substantial progress in the control of specific pests (such as the Fall Army Worm) and diseases (such as Banana Bacterial Wilt) (MAAIF, 2023). Such measures facilitate a reduced and more targeted use of pesticides.

MAAIF also collaborates with the Centre for Agriculture and Bioscience International (CABI), enabling crop protection experts to access crucial information on pest trends and management through an online portal. One of the key components of this collaboration is the interactive Plantwise Knowledge Bank, which is utilized by the Districts in coordination with the Crop Protection Department. Using the platform, experts can search for specific pests or crops and gain insights into the various pests that attack a particular crop. Additionally, the platform provides information on how to prevent, control, and manage these pests effectively. This valuable knowledge equips agricultural experts with the necessary tools to address pest-related challenges faced by farmers. The information is made accessible to smallholder farmers as well, through apps and mobile phone services and through training of governmental agricultural extension agents on how to use them.

An opportunity here is also to include knowledge on Integrated Pest Management (IPM) and biological alternatives for pest control into the knowledge bank. Relevant IPM and biocontrol strategies should be developed specifically for the Ugandan context, by MAAIF in collaboration with research institutes and other public and private actors. An IPM road map for Uganda is proposed (Wageningen University and Research, Greenhouse Horticulture), stipulating the current and desired situations as well as encountered obstacles and available resources. Currently, initiatives around biological pest control and IPM focus on peri-urban, commercial horticulture farmers. More specific ideas on how to transfer relevant principles to the bulk of smaller farmers that deliver their produce to local markets across Uganda could be developed.

Acknowledgements

We thank Paul Zomer (Wageningen Food Safety Research), Herman de Putter (Wageningen Plant Research), Edwin van der Maden (Wageningen Centre for Development Innovation) and Mechteld ter Horst (Environmental Risk Assessment) for their inputs on the set-up of the study and the interpretation of results. We also thank the HortiMAP/ Technoserve team for their involvement in the design of the study and coordinating the collection of samples from the different markets across Uganda.

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Annex 1 List of components analysed

ANALYSIS LIST PESTICIDES

Normec Groen Agro Control

Analysis list Fruit and vegetables, SPV A088, A104 & A178, GC-MSMS

Version 27, valid since 19-09-2022

List of components and their reporting limit in mg/kg

1,4-Dimethylnaphthalene		0.01
2,4,6-Trichlorophenol		0.01
2,4D-Methylester		0.01
2,6-Dichlorobenzamide		0.01
2-Phenylhydroquinone		0.01
Acetochlor		0.01
Acibenzolar-S-methyl		0.01
Aclonifen	Q	0.01
Acrinathrin	Q	0.01
Alachlor		0.01
Aldrin	Q	0.01
Allethrin		0.01
Ametoctradin		0.01
Ametryn		0.01
Aminocarb		0.01
Amiprophos-Methyl		0.01
Anthraquinone		0.01
Atrazine		0.01
Azaconazole	Q	0.01
Azinphos-ethyl	Q	0.01
Azinphos-methyl		0.02
Aziprotryne		0.01
Azoxystrobin	Q	0.01
Barban		0.01
Benalaxyl	Q	0.01
Benazolin-ethyl		0.01
Bendiocarb		0.01
Benfluralin	Q	0.01
Benfuracarb (as carbofuran)		0.01
Benodanil		0.01
Benzovindiflupyr		0.01
Benzoylprop-ethyl		0.01
Bifenazate	Q	0.01
Bifenox		0.01
Bifenthrin	Q	0.01
Biphenyl (=diphenyl)	Q	0.01
Bistrifluron		0.01
Bitertanol	Q	0.01
Boscalid	Q	0.01
Bromacil		0.01
Bromocyclen		0.01
Bromophos-ethyl	Q	0.01
Bromophos-methyl	Q	0.01
Bromopropylate	Q	0.01
Bromoxynil-methyl		0.01
Bromoxynil-octanoate		0.01
Bromuconazole	Q	0.01
Bupirimate	Q	0.01
Buprofezin	Q	0.01
Butachlor		0.01
Butralin	Q	0.01
Butylate		0.01
Cadusafos	Q	0.01
Captafol		0.01
Captan		0.01
Carbaryl	Q	0.01
Carbofuran	Q	0.01
Carbofuran-3-OH	Q	0.01
Carbofuran-phenol	Q	0.01
Carbophenothion	Q	0.01
Carboxin		0.01
Chinomethionate		0.01
Chlorbenside		0.01
Chlorbenzilate	Q	0.01
Chlorbromuron		0.01
Chlorbufam		0.01
Chlordane	Q	0.01
Chlordecone		0.01
Chlorfenapyr	Q	0.01
Chlorfenson		0.01
Chlorfenvinphos (α+β)	Q	0.01
Chlorfluazuron		0.01
Chlormephos		0.01
Chloro-3-Methylphenol		0.01
Chloroaniline (3-)	Q	0.01
Chlorobenzuron		0.01
Chloroneb		0.01
Chloropropylate	Q	0.01
Chlorothalonil	Q	0.01
Chlorothion		0.01
Chloroxuron	Q	0.01
Chlorpropham	Q	0.01
Chlorpyrifos-ethyl	Q	0.01
Chlorpyrifos-methyl	Q	0.01
Chlorthal-dimethyl	Q	0.01
Chlorthiophos		0.01
Chlorthiophos-sulfone		0.01
Chlozolinate	Q	0.01
Cinidon-ethyl		0.01
Cinmethylin		0.01
Climbazole		0.01
Clodinafop-propargyl		0.01
Clofentezin	Q	0.01
Cloquintocet-mexyl		0.01
Coumaphos		0.01
Crimidine		0.01
Crufomate		0.01
Cyanazine		0.01
Cyanofenphos		0.01
Cyanophos		0.01
Cycloate		0.01
Cyenopyrafen		0.01
Cyfluthrin	Q	0.03
Cyhalofop-butyl	Q	0.01
Cymiazole		0.01
Cypermethrin	Q	0.01
Cyphenothrin		0.01
Cyproconazole	Q	0.01
Cyprodinil	Q	0.01
Cyprofuram		0.01
Dazomet		0.01
DDD (o,p)	Q	0.01
DDD (p,p)	Q	0.01
DDE (o,p)	Q	0.01
DDE (p,p)	Q	0.01
DDT (o,p)	Q	0.01
DDT (p,p)	Q	0.01
DEET		0.01
Deltamethrin	Q	0.01
Demeton-O		0.01
Demeton-O-sulfoxide		0.01
Demeton-S		0.01
Demeton-S-methyl	Q	0.01
Demeton-S-methylsulfone		0.01
Desmetryn	Q	0.01
Diafenthiuron		0.01
Dialifos		0.01
Diallate		0.01
Diazinon	Q	0.01
Dichlobenil	Q	0.01
Dichlofenthion	Q	0.01
Dichlofluanid		0.01
Dichloroaniline (3,4-)		0.01
Dichloroaniline (3,5-)		0.01
Dichlorophen		0.01
Dichlorprop-2-ethyl-hexyl		0.01
Dichlorprop-methyl		0.01
Dichlorvos	Q	0.01
Diclobutrazol	Q	0.01
Diclofop-methyl		0.01
Dicloran	Q	0.01
Dicofol	Q	0.01
Dicrotophos		0.01
Dieldrin	Q	0.01
Diethofencarb	Q	0.01
Difenoconazole	Q	0.01
Difenoxuron		0.01
Diflubenzuron	Q	0.01
Diflufenican		0.01
Dimethachlor		0.01
Dimethenamid-P	Q	0.01
Dimethipin		0.01
Dimethirimol		0.01
Dimethoate	Q	0.01
Dimethomorph	Q	0.01
Dimethylvinphos		0.01
Dimoxystrobin	Q	0.01
Diniconazole	Q	0.01
Dinobuton		0.1
Dinoseb		0.01
Dinoterb		0.01
Dioxabenzofos		0.01
Dioxacarb		0.01
Dioxathion		0.01
Diphenamid	Q	0.01
Diphenylamine	Q	0.01
Dipropetryn		0.01
Disulfoton	Q	0.01
Disulfoton-sulfone		0.01
Ditalimfos	Q	0.01
DMSA		0.01
DMST		0.01
DNOC		0.01
Dodemorph	Q	0.01
Edifenphos		0.01
Endosulfan-alpha	Q	0.01
Endosulfan-beta	Q	0.01
Endosulfan-sulfate	Q	0.01
Endrin	Q	0.01
EPN	Q	0.01
Epoxiconazole	Q	0.01
EPTC		0.01
Etaconazole		0.01
Ethalfluralin		0.01
Ethiofencarb		0.01
Ethion	Q	0.01

Q: Accredited components (Dutch Accreditation Council (RvA), registration number L335)

* This component will only be reported on request

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ANALYSIS LIST PESTICIDES

Normec Groen Agro Control

Analysis list Fruit and vegetables, SPV A088, A104 & A178, GC-MSMS

Version 27, valid since 19-09-2022

List of components and their reporting limit in mg/kg

Component	Q	Limit
Ethofumesate		0.01
Ethofumesate, 2-Keto		0.01
Ethoprophos	Q	0.01
Ethoxyquin	Q	0.01
Etofenprox	Q	0.01
Etoxazole	Q	0.01
Etridiazole	Q	0.01
Etrimfos	Q	0.01
Famophos (Famphur)		0.01
Famoxadone		0.01
Fenamiphos		0.01
Fenarimol	Q	0.01
Fenazaquin	Q	0.01
Fenbuconazole	Q	0.01
Fenchlorphos		0.01
Fenhexamid		0.01
Fenitrothion	Q	0.01
Fenobucarb		0.01
Fenoxaprop-P		0.01
Fenoxycarb	Q	0.01
Fenpiclonil	Q	0.01
Fenpropathrin	Q	0.01
Fenpropidin		0.01
Fenpropimorph	Q	0.01
Fenson		0.01
Fensulfothion		0.01
Fensulfothion-sulfone		0.01
Fenthion	Q	0.01
Fenthion-sulfoxide	Q	0.01
Fenuron		0.01
Fenvalerate (incl. esfenvalerate)	Q	0.01
Fipronil	Q	0.005
Fipronil-carboxamid*		0.005
Fipronil-desulfinyl*		0.005
Fipronil-sulfide*	Q	0.005
Fipronil-sulfone	Q	0.005
Flamprop-M-isopropyl		0.01
Flamprop-M-methyl		0.01
Flonicamid	Q	0.01
Fluazifop-p-butyl		0.01
Fluazinam	Q	0.01
Flubendiamide		0.01
Fluchloralin		0.01
Flucycloxuron		0.01
Flucythrinate	Q	0.01
Fludioxonil	Q	0.01
Flufenacet	Q	0.01
Flufenoxuron	Q	0.01
Flufenzin		0.01
Flumethrin		0.01
Flumioxazine	Q	0.01
Fluometuron		0.01
Fluopicolide	Q	0.01
Fluotrimazole		0.01
Fluquinconazole	Q	0.01
Flurenol-butyl		0.01
Flurochloridone		0.01
Fluroxypyr-1-meptyl		0.01
Flusilazole	Q	0.01
Flutolanil	Q	0.01
Flutriafol	Q	0.01
Fluvalinate (tau-)	Q	0.01
Folpet		0.01
Fonofos	Q	0.01
Fosthiazate		0.01
Fuberidazole		0.01
Furalaxyl	Q	0.01
Furathiocarb	Q	0.01
Furmecyclox		0.01
Halfenprox		0.01
Haloxyfop-ethoxyethyl	Q	0.01
Haloxyfop-p-methyl	Q	0.01
HCH-alpha		0.01
HCH-beta		0.01
HCH-delta		0.01
HCH-gamma (Lindane)	Q	0.01
Heptachlor	Q	0.01
Heptachlor epoxide	Q	0.01
Heptenophos	Q	0.01
Hexachloro-1,3-butadiene		0.01
Hexachlorobenzene	Q	0.01
Hexaconazole	Q	0.01
Hexaflumuron		0.01
Hexazinone		0.01
Hexythiazox	Q	0.01
Imazalil	Q	0.1
Imazamethabenz-methyl		0.01
Indoxacarb (R+S)	Q	0.01
Iodofenphos		0.01
Ioxynil-methyl		0.01
Ioxynil-octanoate		0.01
Iprobenfos	Q	0.01
Iprodione	Q	0.01
Iprovalicarb	Q	0.01
Isazofos		0.01
Isodrin		0.01
Isofenphos		0.01
Isofenphos-methyl	Q	0.01
Isofenphos-oxon		0.01
Isoprocarb		0.01
Isoprothiolane		0.01
Isoproturon		0.01
Isoxadifen-ethyl		0.01
Karanjin*		0.01
Kresoxim-methyl	Q	0.01
Lambda-cyhalothrin	Q	0.01
Lenacil		0.01
Leptophos		0.01
Lufenuron	Q	0.01
Malaoxon		0.01
Malathion	Q	0.01
Mecarbam	Q	0.01
Mefenpyr-diethyl		0.01
Mepanipyrim	Q	0.01
Mephosfolan		0.01
Mepronil	Q	0.01
Metalaxyl/metalaxyl-M	Q	0.01
Metamitron		0.1
Metazachlor	Q	0.01
Metconazole	Q	0.01
Methabenzthiazuron		0.01
Methacrifos		0.01
Methidathion	Q	0.01
Methiocarb	Q	0.01
Metholachlor-S	Q	0.01
Methoprene		0.01
Methoprotryn		0.01
Methoxychlor	Q	0.01
Metobromuron	Q	0.01
Metolcarb		0.01
Metoxuron		0.01
Metrafenone	Q	0.01
Metribuzin	Q	0.01
Mevinphos	Q	0.01
Mirex	Q	0.01
Monalide		0.01
Monocrotophos		0.01
Monolinuron		0.01
Myclobutanil	Q	0.01
Naftol-1-α		0.01
Naled		0.01
Napropamide		0.01
Nicotine		0.01
Nitralin		0.01
Nitrapyrine		0.01
Nitrofen	Q	0.01
Nitrothal-isopropyl	Q	0.01
Norflurazon		0.01
Nuarimol	Q	0.01
Ofurace		0.01
Orbencarb		0.01
Oxadiargyl		0.02
Oxadiazon		0.01
Oxadixyl	Q	0.01
Oxycarboxin		0.01
Oxychlordane		0.01
Oxyfluorfen		0.01
Paclobutrazol	Q	0.01
Paraoxon		0.01
Paraoxon-methyl		0.01
Parathion-ethyl	Q	0.01
Parathion-methyl	Q	0.01
Pebulate		0.01
Penconazole	Q	0.01
Pencycuron	Q	0.01
Pendimethalin	Q	0.01
Pentachloraniline	Q	0.01
Pentachloranisole	Q	0.01
Pentachlorobenzene		0.01
Pentachlorophenol		0.01
Penthiopyrad		0.01
Permethrin	Q	0.01
Perthane		0.01
Phenmedipham		0.01
Phenothrin	Q	0.01
Phenthoate	Q	0.01
Phenylphenol-2	Q	0.01
Phorate		0.01
Phorate-sulfone	Q	0.01
Phorate-sulfoxide	Q	0.01
Phosalone	Q	0.01
Phosmet		0.01
Phosphamidon		0.01
Phthalimide (degr. folpet)		0.01
Picolinafen	Q	0.01
Picoxystrobin	Q	0.01

Q: Accredited components (Dutch Accreditation Council (RvA), registration number L335)

* This component will only be reported on request

ANALYSIS LIST PESTICIDES
Normec Groen Agro Control

Normec Groen Agro Control

Analysis list Fruit and vegetables, SPV A088, A104 & A178, GC-MSMS

Version 27, valid since 19-09-2022

List of components and their reporting limit in mg/kg

Piperonyl butoxide	Q	0.01
Pirimicarb	Q	0.01
Pirimicarb-desmethyl*	Q	0.01
Pirimiphos-ethyl	Q	0.01
Pirimiphos-methyl	Q	0.01
Prochloraz	Q	0.1
Procymidone	Q	0.01
Profenofos	Q	0.01
Profluralin	Q	0.01
Profoxydim-lithium		0.01
Promecarb		0.01
Prometryn		0.01
Propachlor		0.01
Propachlor-2-OH		0.01
Propanil		0.01
Propaphos		0.01
Propargite	Q	0.01
Propazine		0.01
Propetamphos		0.01
Propham	Q	0.01
Propiconazole	Q	0.01
Propoxur	Q	0.01
Propyzamide	Q	0.01
Proquinazid	Q	0.01
Prosulfocarb	Q	0.01
Prothiofos	Q	0.01
Prothoate		0.01
Pyracarbolide		0.01
Pyraclofos		0.01
Pyraflufen-ethyl	Q	0.01
Pyrazophos	Q	0.01
Pyrethrins (cinerin/jasmolin/pyrethrin)	Q	0.1
Pyribenzoxim		0.01
Pyridaben	Q	0.01
Pyridalyl	Q	0.01
Pyridaphenthion	Q	0.01
Pyrifenox	Q	0.01
Pyrimethanil	Q	0.01
Pyriproxyfen	Q	0.01
Pyroquilone		0.01
Quinalphos	Q	0.01
Quinoxyfen	Q	0.01
Quintozene	Q	0.01
Quizalofop-ethyl		0.01
Resmethrin		0.01
S 421		0.01
Sethoxydim		0.01
Silafluofen		0.01
Silthiofam		0.01
Simazine	Q	0.01
Spirodiclofen	Q	0.01
Spiromesifen	Q	0.01
Spiroxamine	Q	0.01
Sulfotep	Q	0.01
Sulphur*		0.5
Sulprofos		0.01
Tebuconazole	Q	0.01
Tebufenpyrad	Q	0.01
Tebupirimfos		0.01
Tebuthiuron		0.01
Tecnazene	Q	0.01
Teflubenzuron	Q	0.01
Tefluthrin	Q	0.01
Tepraloxydim		0.01
Terbacil		0.01
Terbufos	Q	0.01
Terbufos-sulfon	Q	0.01
Terbumeton		0.01
Terbuthylazine	Q	0.01
Terbutryn		0.01
Tetrachlorvinphos	Q	0.01
Tetraconazole	Q	0.01
Tetradifon	Q	0.01
Tetrahydrophthalimide (degr. captan)		0.01
Tetramethrin		0.01
Tetrasul		0.01
Thiabendazole		0.1
Thiobencarb		0.01
Thiocyclam		0.01
Thiometon		0.01
Thiometon-sulfone		0.01
Tolclofos-methyl	Q	0.01
Tolfenpyrad		0.01
Tolylfluanid	Q	0.01
Transfluthrin		0.01
Triadimefon	Q	0.01
Triadimenol	Q	0.01
Triallat		0.01
Triamiphos		0.01
Triazamate		0.01
Triazophos	Q	0.01
Trichloronate		0.01
Tricyclazole		0.01
Trietazine		0.01
Trifenmorph		0.01
Trifloxystrobin	Q	0.01
Triflumizole	Q	0.01
Trifluralin	Q	0.01
Trinexapac-ethyl		0.01
Vernolate		0.01
Vinclozolin	Q	0.01
Zoxamide	Q	0.01

Q: Accredited components (Dutch Accreditation Council (RvA), registration number L335)
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ANALYSIS LIST PESTICIDES
Normec Groen Agro Control

Normec Groen Agro Control

Analysis list Fruit and vegetables, SPV A090, A104 & A178, LC-MSMS

Version 27, valid since 19-09-2022

List of components and their reporting limit in mg/kg

1-Naphthalene Acetamide		0.01	Carbofuran	Q	0.005	Dimethomorph	Q	0.01
1-naphthylacetic acid		0.01	Carbofuran-3-OH	Q	0.005	Dimoxystrobin	Q	0.01
2,4,5-T		0.01	Carbosulfan	Q	0.01	Diniconazole	Q	0.01
2,4-D		0.01	Carboxin	Q	0.01	Dinocap		0.01
2,4-DB		0.05	Carfentrazone-ethyl	Q	0.01	Dinotefuran	Q	0.01
4-Chlorophenoxyacetic acid		0.01	Carpropamid	Q	0.01	Dipropetryn		0.01
Abamectin/avermectin (B1a+B1b)	Q	0.01	Chlorantraniliprole	Q	0.01	Disulfoton	Q	0.05
Acephate	Q	0.01	Chlorbromuron	Q	0.01	Disulfoton-sulfone	Q	0.01
Acequinocyl	Q	0.01	Chlordimeform	Q	0.01	Disulfoton-sulfoxide	Q	0.01
Acetamiprid	Q	0.01	Chlorfenvinphos (α+β)	Q	0.01	Dithianon		0.01
Acibenzolar acid		0.1	Chlorfluazuron		0.01	Diuron	Q	0.01
Acibenzolar-S-methyl		0.01	Chloridazon	Q	0.01	DMSA	Q	0.01
Alachlor	Q	0.01	Chlorobenzuron		0.01	DMST	Q	0.01
Alanycarb		0.01	Chlorotoluron	Q	0.01	Dodemorph	Q	0.01
Aldicarb	Q	0.01	Chlorpyrifos-ethyl	Q	0.01	Dodine	Q	0.01
Aldicarb-sulfone	Q	0.01	Chlorpyrifos-methyl	Q	0.01	Emamectin	Q	0.01
Aldicarb-sulfoxide	Q	0.01	Chlorthiamid	Q	0.01	EPN	Q	0.02
Ametoctradin	Q	0.01	Chlorthiophos	Q	0.01	Epoxiconazole	Q	0.01
Amisulbrom		0.01	Chromafenozide		0.01	Etaconazole	Q	0.01
Amitraz		0.01	Cinosulfuron		0.01	Ethiofencarb	Q	0.01
Amitraz DMF (2,4-Dimethyl-formamide)		0.01	Clethodim	Q	0.01	Ethiofencarb-sulfone		0.01
Amitraz DMPF (2,4-Dimethylphenyl-1-methyl-formamide)	Q	0.01	Clethodim-sulfone		0.01	Ethiofencarb-sulfoxide	Q	0.01
Amitraz-DMA (2,4-Dimethylaniline)	Q	0.01	Clethodim-sulfoxide		0.01	Ethion	Q	0.01
Anilazine		0.03	Climbazole		0.01	Ethiprole	Q	0.01
Anilofos		0.01	Clodinafop		0.01	Ethirimol	Q	0.01
Asulam	Q	0.01	Clofentezin	Q	0.01	Ethofumesate	Q	0.01
Atrazine	Q	0.01	Clomazone	Q	0.01	Ethoprophos	Q	0.01
Atrazine-desethyl	Q	0.01	Clopyralid		0.01	Ethoxysulfuron	Q	0.01
Azaconazole	Q	0.01	Clothianidin	Q	0.01	Etofenprox	Q	0.01
Azadirachtin	Q	0.01	Cyantraniliprole	Q	0.01	Etoxazole	Q	0.01
Azamethiphos	Q	0.01	Cyazofamid	Q	0.01	Famoxadone	Q	0.01
Azimsulfuron		0.01	Cyclanilide		0.01	Fenamidone	Q	0.01
Azinphos-methyl	Q	0.01	Cycloxydim	Q	0.01	Fenamiphos	Q	0.01
Azoxystrobin	Q	0.01	Cyenopyrafen		0.01	Fenamiphos-sulfone	Q	0.01
Benfuracarb (as carbofuran)		0.01	Cyflufenamid	Q	0.01	Fenamiphos-sulfoxide	Q	0.01
Benomyl (as carbendazim)		0.01	Cyflumetofen	Q	0.01	Fenarimol	Q	0.01
Benoxacor		0.01	Cyhexatin/Azocyclotin		0.01	Fenazaquin	Q	0.01
Bensulfuron-methyl	Q	0.01	Cymoxanil	Q	0.01	Fenbuconazole	Q	0.01
Bentazon		0.01	Cyproconazole	Q	0.01	Fenbutatinoxide	Q	0.01
Bentazon-8-OH		0.01	Cyprodinil	Q	0.01	Fenchlorphos oxon	Q	0.01
Benthiavalicarb-isopropyl		0.01	Cyromazine	Q	0.01	Fenhexamid	Q	0.01
Bifenazate		0.01	Cythioate	Q	0.01	Fenitrothion	Q	0.03
Bifenazate diazene		0.01	Demeton-S-methyl	Q	0.05	Fenoxycarb	Q	0.01
Bispyribac		0.01	Demeton-S-methylsulfone	Q	0.01	Fenpicoxamide		0.01
Bitertanol	Q	0.01	Desmedipham	Q	0.01	Fenpropidin	Q	0.01
Bixafen	Q	0.01	Diafenthiuron	Q	0.01	Fenpropimorph	Q	0.01
Boscalid	Q	0.01	Diazinon	Q	0.01	Fenpyrazamine	Q	0.01
Bromacil	Q	0.01	Dicamba		0.02	Fenpyroximate	Q	0.01
Bromoxynil		0.01	Dichlofluanid	Q	0.01	Fensulfothion	Q	0.01
Bromuconazole	Q	0.01	Dichlorophen		0.01	Fensulfothion-oxon	Q	0.01
Bupirimate	Q	0.01	Dichlorprop		0.01	Fensulfothion-oxon-sulfone	Q	0.01
Buprofezin	Q	0.01	Dichlorvos	Q	0.01	Fensulfothion-sulfone	Q	0.01
Butafenacil	Q	0.01	Diclobutrazol	Q	0.01	Fenthion	Q	0.01
Butocarboxim	Q	0.01	Diclofop		0.01	Fenthion-oxon		0.01
Butocarboxim-sulfone	Q	0.01	Dicrotophos	Q	0.01	Fenthion-oxon sulfoxide		0.01
Butocarboxim-sulfoxide	Q	0.01	Diethofencarb	Q	0.01	Fenthion-oxon-sulfone	Q	0.01
Buturon	Q	0.01	Difenoconazole	Q	0.01	Fenthion-sulfone	Q	0.01
Cadusafos	Q	0.01	Difethialone		0.01	Fenthion-sulfoxide	Q	0.01
Captafol	Q	0.1	Diflubenzuron	Q	0.01	Fentin		0.01
Carbaryl	Q	0.01	Dimethenamid-P		0.01	Flamprop-M-methyl		0.01
Carbendazim	Q	0.01	Dimethirimol	Q	0.01	Flazasulfuron		0.01
Carbetamide	Q	0.01	Dimethoate	Q	0.01	Flonicamid	Q	0.01

Q: Accredited components (Dutch Accreditation Council (RvA), registration number L335)

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List of components and their reporting limit in mg/kg

Flonicamid-TFNA	Q	0.01	Isoxaben	Q	0.01	Oxydemeton-methyl		0.01
Flonicamid-TFNG	Q	0.01	Isoxaflutole	Q	0.01	Paclobutrazol	Q	0.01
Florasulam	Q	0.01	Isoxaflutole-diketonitrile		0.01	Paraoxon	Q	0.01
Fluazifop		0.01	Isoxathion	Q	0.01	Paraoxon-methyl	Q	0.01
Fluazifop-p-butyl	Q	0.01	Kresoxim-methyl	Q	0.01	Penconazole	Q	0.01
Fluazinam		0.01	Landrin (2,3,5- and 3,4,5)	Q	0.01	Pencycuron	Q	0.01
Flubendiamide	Q	0.01	Lenacil	Q	0.01	Penflufen		0.01
Flubenzimine	Q	0.01	Linuron	Q	0.01	Penoxsulam		0.01
Flufenacet	Q	0.01	Lufenuron		0.01	Phenisopham		0.01
Flufenacet alcohol	Q	0.01	Malaoxon	Q	0.01	Phenkapton		0.01
Flufenacet oxalate		0.01	Malathion	Q	0.01	Phenmedipham	Q	0.01
Flufenacet sulfonic acid		0.01	Mandipropamid	Q	0.01	Phenothrin	Q	0.01
Flufenacet thioglycolate sulfoxid		0.01	Matrin		0.05	Phorate	Q	0.01
Flufenoxuron	Q	0.01	MCPA		0.01	Phorate-sulfone	Q	0.01
Flumethrin		0.1	MCPB		0.01	Phorate-sulfoxide		0.01
Flumioxazine	Q	0.01	Mecoprop		0.01	Phosalone	Q	0.01
Fluometuron	Q	0.01	Mefenacet	Q	0.01	Phosmet	Q	0.01
Fluopyram	Q	0.01	Mefentrifluconazole		0.01	Phosmet oxon		0.01
Fluoxastrobin	Q	0.01	Mepanipyrim	Q	0.01	Phosphamidon	Q	0.01
Flupyradifurone	Q	0.01	Mepanipyrim 2-OH-propyl*	Q	0.01	Picoxystrobin	Q	0.01
Fluquinconazole	Q	0.01	Mephosfolan	Q	0.01	Pinoxaden		0.01
Flurprimidol	Q	0.01	Mepronil	Q	0.01	Piperalin	Q	0.01
Flusilazole	Q	0.01	Mesosulfuron methyl		0.01	Piperonyl butoxide	Q	0.01
Fluthiacet-methyl	Q	0.01	Mesotrione		0.01	Pirimicarb	Q	0.01
Flutianil		0.01	Metaflumizone	Q	0.01	Pirimicarb-desmethyl*	Q	0.01
Flutolanil	Q	0.01	Metalaxyl/metalaxyl-M	Q	0.01	Pirimiphos-methyl	Q	0.01
Flutriafol	Q	0.01	Metamifop		0.01	Prochloraz	Q	0.01
Fluxapyroxad		0.01	Metazachlor	Q	0.01	Prochloraz BTS44595		0.01
Forchlorfenuron	Q	0.01	Metconazole	Q	0.01	Prochloraz BTS44596		0.01
Formetanate	Q	0.1	Methamidophos	Q	0.01	Profenofos	Q	0.01
Formothion		0.01	Methidathion	Q	0.01	Propachlor ESA		0.03
Fosthiazate	Q	0.01	Methiocarb	Q	0.01	Propamocarb	Q	0.01
Foxim		0.01	Methiocarb-sulfone	Q	0.01	Propaquizafop	Q	0.01
Furathiocarb	Q	0.01	Methiocarb-sulfoxide	Q	0.01	Propargite	Q	0.01
Halofenozide	Q	0.01	Methomyl	Q	0.01	Propiconazole	Q	0.01
Halosulfuron-methyl		0.01	Methoxyfenozide	Q	0.01	Propoxur	Q	0.01
Haloxyfop	Q	0.01	Metobromuron	Q	0.01	Propoxycarbazone	Q	0.01
Heptenophos	Q	0.01	Metoxuron	Q	0.01	Propyzamide	Q	0.01
Hexaconazole	Q	0.01	Metsulfuron-methyl	Q	0.01	Proquinazid	Q	0.01
Hexythiazox	Q	0.01	Milbemectin (A3+A4)		0.01	Prosulfocarb	Q	0.01
Hymexazol	Q	0.05	Molinate	Q	0.01	Prosulfuron	Q	0.01
Icaridine		0.01	Monocrotophos	Q	0.01	Prothiocarb	Q	0.1
Imazalil	Q	0.01	Monolinuron	Q	0.01	Prothioconazole-desthio	Q	0.01
Imazamox		0.01	Monuron	Q	0.01	Pydiflumetofen		0.01
Imazapic		0.01	Myclobutanil	Q	0.01	Pymetrozine	Q	0.01
Imazapyr		0.01	Naled		0.01	Pyraclostrobin	Q	0.01
Imazaquin	Q	0.01	Napropamide	Q	0.01	Pyridaben	Q	0.01
Imazethapyr	Q	0.01	Naptalam		0.01	Pyridaphenthion	Q	0.01
Imibenconazole	Q	0.01	Neburon	Q	0.01	Pyridate	Q	0.01
Imidacloprid	Q	0.01	Nicosulfuron	Q	0.01	Pyridate CL 9673		0.01
Indaziflam		0.01	Nitenpyram	Q	0.01	Pyrifenox	Q	0.01
Indoxacarb (R+S)	Q	0.01	Novaluron	Q	0.01	Pyrimethanil	Q	0.01
Iodosulfuron-methyl		0.01	Nuarimol	Q	0.01	Pyrimidifen		0.01
Ioxynil		0.01	Omethoate	Q	0.01	Pyriofenone		0.01
Iprobenfos	Q	0.01	Orthosulfamuron		0.01	Pyriproxyfen	Q	0.01
Iprovalicarb	Q	0.01	Oryzalin		0.1	Pyroxsulam	Q	0.01
Isocarbophos	Q	0.01	Oxadixyl	Q	0.01	Quinalphos	Q	0.01
Isofetamid		0.01	Oxamyl	Q	0.01	Quinclorac	Q	0.01
Isoprothiolane	Q	0.01	Oxamyl-oxime*	Q	0.01	Quinmerac	Q	0.01
Isoproturon	Q	0.01	Oxasulfuron	Q	0.01	Quinoclamine	Q	0.01
Isopyrazam	Q	0.01	Oxathiapiprolin		0.01	Quizalofop		0.01
Isouron	Q	0.01	Oxycarboxin	Q	0.01	Quizalofop-p-tefuryl		0.01

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Normec Groen Agro Control

Analysis list Fruit and vegetables, SPV A090, A104 & A178, LC-MSMS

Version 27, valid since 19-09-2022

List of components and their reporting limit in mg/kg

Rimsulfuron	Q	0.01
Rotenone	Q	0.01
Saflufenacil		0.01
Sedaxane		0.01
Spinetoram	Q	0.01
Spinosad	Q	0.01
Spirodiclofen	Q	0.01
Spiromesifen	Q	0.01
Spirotetramat	Q	0.01
Spirotetramat-enol	Q	0.01
Spirotetramat-enol-glucoside*	Q	0.01
Spirotetramat-ketohydroxy*	Q	0.01
Spirotetramat-monohydroxy*	Q	0.01
Spiroxamine	Q	0.01
Sulcotrione	Q	0.01
Sulfamethoxazole	Q	0.01
Sulfentrazone		0.01
Sulfosulfuron	Q	0.01
Sulfoxaflor (RR+SR)	Q	0.01
Tebuconazole	Q	0.01
Tebufenozide	Q	0.01
Tebufenpyrad	Q	0.01
Teflubenzuron	Q	0.01
Tembotrione	Q	0.01
TEPP		0.01
Terbufos	Q	0.05
Terbufos-sulfon	Q	0.01
Terbufos-sulfoxide	Q	0.01
Terbuthylazine	Q	0.01
Tetraconazole	Q	0.01
Thiabendazole	Q	0.01
Thiabendazole-5-OH*		0.01
Thiacloprid	Q	0.01
Thiamethoxam	Q	0.01
Thidiazuron		0.01
Thiencarbazone-methyl		0.01
Thiodicarb	Q	0.01
Thiofanox		0.01
Thiofanox-sulfone	Q	0.01
Thiofanox-sulfoxide	Q	0.01
Thiometon-sulfone		0.01
Thiophanate-methyl	Q	0.01
Tolclofos-methyl	Q	0.01
Tolfenpyrad	Q	0.01
Tolylfluanid	Q	0.01
Topramezone	Q	0.01
Tralkoxydim		0.01
Tralomethrin	Q	0.01
Triadimefon	Q	0.01
Triapenthenol	Q	0.01
Triasulfuron		0.01
Triazamate		0.01
Triazophos	Q	0.01
Triazoxide		0.01
Tribenuron-methyl	Q	0.01
Trichlorfon	Q	0.01
Triclopyr		0.02
Tricyclazole	Q	0.01
Tridemorph	Q	0.01
Trifloxystrobin	Q	0.01
Triflumizole	Q	0.01
Triflumizole FM-6-1		0.01
Triflumuron	Q	0.01
Triflusulfuron-methyl	Q	0.01
Triforine	Q	0.01
Triticonazole	Q	0.01
Tritosulfuron		0.01
Uniconazole	Q	0.01
Valifenalate		0.01
Vamidothion	Q	0.01
Zoxamide	Q	0.01

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Normec Groen Agro Control
Analysis list AGF, specific analysis

Normec Groen Agro Control

Version 27, valid since 19-09-2022

List of components and their reporting limit in mg/kg

Component	Q	Analysis method	Reporting limit
Amines and morpholin Morpholin, Triethanolamin, N,N-Diethylethanolamin, N,N-Dimethylethanolamin, 1-methoxy-2-propylamin, 3-Methoxypropylamin, 2-Amino-2-methyl-1propanol Diethanolamin		LC-MS/MS, A134	0.1 0.3
Amitrole		LC-MS/MS, A135	0.05
6-Benzyladenine		LC-MS/MS, A138	0.01
Total inorganic bromide	Q	IC, A039	5
Chloormequat, Mepiquat	Q	LC-MS/MS, A100	0.005
Diquat, Paraquat		LC-MS/MS, A133	0.03
Dithiocarbamates Sum of: Ferbam, Mancozeb, Maneb, Metiram, Nabam, Propineb, Thiram, Zineb, Ziram	Q	GC-MS, as CS2, A066	0.01 CS2
Ethephon	Q	GC-FID, as ethylene, A080	0.05
Ethephon	Q	LC-MS/MS, A131	0.01
Ethylene oxide, 2-chloro-ethanol	Q	GC-MSMS, A088 + A178	0.01
Fosethyl-aluminium **Phosphonic acid**	Q	LC-MS/MS, A131	0.01 0.05
Gibrilic acid		LC-MS/MS	0.01
Glyfosate, Glufosinate, AMPA	Q	LC-MS/MS, A131	0.01
Guazatine		LC-MS/MS	0.01
Maleic Hydrazide		LC-MS/MS, A136	0.05
Matrine, Oxymatrine		LC-MS/MS, A090 + A178	0.01
Nitrate	Q	Analyser, A081/A089	70
Nitrate (low), Nitrite		HPEA-IC, A081/A089 + A039	5
Perchlorate, Chlorate	Q	LC-MS/MS, A131	0.01
Prohexadione-calcium		LC-MS/MS	0.01
Quarternair ammonium compounds Didecyldimethylammonium chloride (DDAC; C10) Didecyldimethylammonium chloride (DDAC; C8, C12) Benzalkonium chloride (BAC; C10, C12, C14, C16, C18) Benzalkonium chloride (BAC; C8) Cetrimonium	 Q Q	LC-MS/MS, A103	0.01
Sulfite		Williams methode, A163	5.0
Thiourea (metabolites of dithiocarbamates) Ethylene thioureum (ETU), Propylene thioureum (PTU)		LC-MS/MS, A137	0.01

Q: Accredited components (Dutch Accreditation Council (RvA), registration number L335)

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Version 27, valid since 19-09-2022

List of components and their reporting limit in mg/kg

Component	Q	Analysis method	Reporting limit
Trimethyl-sulfonium		LC-MS/MS	0.01
Acidic pesticides after hydrolysis 2.4-D, 2.4.5-T, 2.4-DB, Dichlorprop, Fluazifop, Haloxyfop, MCPA, MCPB, Quizalofop		LC-MS/MS, A090 + A178	0.01
Heavy Metals		ICP-MS, A068 + A095	
Aluminium	Q		0.5
Arsenic	Q		0.02
Barium	Q		0.05
Cadmium	Q		0.01
Chromium	Q		0.02
Cobalt	Q		0.05
Copper	Q		0.02
Mercury	Q		0.01
Lead	Q		0.01
Nickel	Q		0.05
Tin	Q		0.01
Silver	Q		0.01
Zinc	Q		0.1

Q: Accredited components (Dutch Accreditation Council (RvA), registration number L335)

Annex 2 Unregistered / banned components

Table A1 *Components found in the samples that are unregistered or banned in either Uganda or the EU. All components listed are insecticides, with their specification indicated in column 2, as well as the known commercial tradename(s) (max 2 examples) as found on the Agricultural Chemicals Register for Uganda under the Ministry of Agriculture, Animal Industry and Fisheries2, dated to 4 February 2022.*

Component	Specification	Commercial names (2 examples)	Status in Uganda	Status in EU
Acephate	Organophosphate		unregistered	banned
Chlorpyrifos-ethyl	Organophosphate	ASCORIS 48EC, TRICEL 48EC	registered	banned
Clothianidin	Neonicotinoid		unregistered	banned
Cypermethrin	Pyrethroide	FASTAC 100EC, FURY 10EC	registered	partly approved
Cyromazine	Triazine growth regulator		unregistered	banned
Imidacloprid	Neonicotinoid	MAC-IMIDA, DIMIPRID 200SL	registered	banned
Methamidophos	Organophosphate		banned	banned
Omethoate	Organophosphate		banned	banned
Profenofos	Organophosphate,	ROCKET 44EC, HITCEL 44EC	registered	banned
Thiamethoxam	Neonicotinoid	STRIKER 247SC, ACTARA 25WG	registered	banned

Annex 3 List of samples with residues detected

Table A2 *List of positive samples indicating MRL EU, MRL codex and ARfD PRIMO NL values. Formatted in red font those values above or equal to 100%. Indicated also in red the components unregistered or banned in Uganda in column 3.*

Sample	Sample ID	Component	Concentration (mg/kg)	MRL codex (mg/kg)	MRL codex %	MRL EU (mg/kg)	MRL EU%	ARfD PRIMo NL %
Tomato	JIN-TOM-01	Cypermethrin	0.079	0.2	40	0.5	16	92
Tomato	JIN-TOM-01	Profenofos	0.2	10	2	10	2	1
Tomato	JIN-TOM-02	Acetamiprid	0.023	0.2	12	0.5	5	5
Tomato	JIN-TOM-02	Metalaxyl	0.022	0.5	4	0.3	7	0
Tomato	JIN-TOM-03	Omethoate	0.014	0.01	140	0.01	140	41
Tomato	KAB-TOM-01	Acetamiprid	0.012	0.2	6	0.5	2	3
Tomato	KAB-TOM-01	Cypermethrin	0.13	0.2	65	0.5	26	151
Tomato	KAB-TOM-01	Profenofos	0.27	10	3	10	3	2
Tomato	KAB-TOM-02	Acetamiprid	0.057	0.2	29	0.5	11	13
Tomato	KAB-TOM-02	Lambda-cyhalothrin (incl. gamma-)	0.01	0.3	3	0.07	14	12
Tomato	KAB-TOM-02	Profenofos	0.015	10	0	10	0	0
Tomato	KAB-TOM-02	Propamocarb	2.4	2	120	4	60	14
Tomato	KAB-TOM-03	Acetamiprid	0.038	0.2	19	0.5	8	9
Tomato	KAB-TOM-03	Clothianidin	0.014	0.05	28	0.04	35	1
Tomato	KAB-TOM-03	Cypermethrin	0.017	0.2	9	0.5	3	20
Tomato	KAB-TOM-03	Flubendiamide	0.02	2	1	2	1	1
Tomato	KAB-TOM-03	Lambda-cyhalothrin (incl. gamma-)	0.022	0.3	7	0.07	31	26
Tomato	KAB-TOM-03	Profenofos	0.077	10	1	10	1	0
Tomato	KAB-TOM-03	Propamocarb	1	2	50	4	25	6
Tomato	KAM-TOM-01	Propamocarb	0.42	2	21	4	11	2
Tomato	KAM-TOM-01	Tebuconazole	0.025	0.7	4	0.9	3	5
Tomato	KAM-TOM-02	Cypermethrin	0.028	0.2	14	0.5	6	33
Tomato	KAM-TOM-02	Pirimiphos-methyl	0.058	0.5	12	0.01	580	2
Tomato	KAM-TOM-02	Profenofos	0.092	10	1	10	1	1
Tomato	KAM-TOM-02	Propamocarb	0.9	2	45	4	23	5
Tomato	KAM-TOM-03	Cypermethrin	0.19	0.2	95	0.5	38	221

Sample	Sample ID	Component	Concentration (mg/kg)	MRL codex (mg/kg)	MRL codex %	MRL EU (mg/kg)	MRL EU%	ARfD PRIMo NL %
Tomato	KAM-TOM-03	Pirimiphos-methyl	0.081	0.5	16	0.01	810	3
Tomato	KAM-TOM-03	Profenofos	0.14	10	1	10	1	1
Tomato	KAM-TOM-04	Cyromazine	0.01	1	1	0.6	2	1
Tomato	KAM-TOM-04	Pirimiphos-methyl	0.011	0.5	2	0.01	110	0
Tomato	KIS-TOM-02	Chlorpyrifos-ethyl	0.05	1	5	0.01	500	
Tomato	KIS-TOM-03	Cypermethrin	0.17	0.2	85	0.5	34	198
Tomato	KIS-TOM-03	Profenofos	0.071	10	1	10	1	0
Tomato	MBA-TOM-01	Acetamiprid	0.024	0.2	12	0.5	5	6
Tomato	MBA-TOM-01	Chlorpyrifos-ethyl	0.021	1	2	0.01	210	
Tomato	MBA-TOM-01	Flubendiamide	0.018	2	1	2	1	1
Tomato	MBA-TOM-02	Acetamiprid	0.014	0.2	7	0.5	3	3
Tomato	TOR-TOM-01	Acephate	0.078	1	8	0.01	780	5
Tomato	TOR-TOM-01	Cypermethrin	0.021	0.2	11	0.5	4	24
Tomato	TOR-TOM-01	Lambda-cyhalothrin (incl. gamma-)	0.014	0.3	5	0.07	20	16
Tomato	TOR-TOM-01	Methamidophos	0.013	0.01	130	0.01	130	25
Tomato	TOR-TOM-02	Abamectin	0.03	0.05	60	0.09	33	35
Tomato	TOR-TOM-02	Acetamiprid	0.074	0.2	37	0.5	15	17
Tomato	TOR-TOM-02	Profenofos	0.018	10	0	10	0	0
Tomato	TOR-TOM-03	Acetamiprid	0.016	0.2	8	0.5	3	4
Tomato	TOR-TOM-03	Cypermethrin	0.048	0.2	24	0.5	10	56
Tomato	TOR-TOM-03	Profenofos	0.041	10	0	10	0	0
Tomato	TOR-TOM-04	Acetamiprid	0.021	0.2	11	0.5	4	5
Green pepper	JIN-GPP-01	Acetamiprid	0.053	0.2	27	0.3	18	13
Green pepper	JIN-GPP-01	Profenofos	0.057	3	2	0.01	570	0
Green pepper	JIN-GPP-02	Acetamiprid	0.042	0.2	21	0.3	14	10
Green pepper	JIN-GPP-02	Metalaxyl	0.04	1	4	0.5	8	0
Green pepper	JIN-GPP-03	Acetamiprid	0.016	0.2	8	0.3	5	4
Green pepper	JIN-GPP-03	Cypermethrin	0.03	2	2	0.5	6	36
Green pepper	JIN-GPP-03	Metalaxyl	0.031	1	3	0.5	6	0
Green pepper	KAB-GPP-01	Cypermethrin	0.13	2	7	0.5	26	155
Green pepper	KAB-GPP-01	Profenofos	1.5	3	50	0.01	15000	9
Green pepper	KAB-GPP-02	Profenofos	0.059	3	2	0.01	590	0
Green pepper	KAM-GPP-01	Acetamiprid	0.019	0.2	10	0.3	6	5
Green pepper	KAM-GPP-02	Cypermethrin	0.013	2	1	0.5	3	16

Sample	Sample ID	Component	Concentration (mg/kg)	MRL codex (mg/kg)	MRL codex %	MRL EU (mg/kg)	MRL EU%	ARfD PRIMo NL %
Green pepper	KAM-GPP-02	Profenofos	0.16	3	5	0.01	1600	1
Green pepper	KAM-GPP-02	Propamocarb	0.015	3	1	3	1	0
Green pepper	KAM-GPP-02	Thiamethoxam	0.01	0.7	1	0.7	1	0
Green pepper	KAM-GPP-03	Pirimiphos-methyl	0.066	0.5	13	0.01	660	3
Green pepper	KAM-GPP-03	Propamocarb	0.096	3	3	3	3	1
Green pepper	KIS-GPP-01	Cypermethrin	0.044	2	2	0.5	9	52
Green pepper	KIS-GPP-01	Profenofos	0.31	3	10	0.01	3100	2
Green pepper	KIS-GPP-02	Acetamiprid	0.012	0.2	6	0.3	4	3
Green pepper	KIS-GPP-03	Acetamiprid	0.03	0.2	15	0.3	10	7
Green pepper	KIS-GPP-04	Cypermethrin	0.026	2	1	0.5	5	31
Green pepper	KIS-GPP-04	Profenofos	0.23	3	8	0.01	2300	1
Green pepper	MBA-GPP-03	Cypermethrin	0.24	2	12	0.5	48	286
Green pepper	MBA-GPP-04	Lambda-cyhalothrin (incl. gamma-)	0.019	0.3	6	0.1	19	23
Green pepper	TOR-GPP-01	Abamectin	0.062	0.005	1240	0.07	89	74
Green pepper	TOR-GPP-01	Acetamiprid	0.14	0.2	70	0.3	47	33
Green pepper	TOR-GPP-01	Azoxystrobin	0.42	3	14	3	14	
Green pepper	TOR-GPP-01	Imidacloprid	0.13	1	13	0.9	14	10
Green pepper	TOR-GPP-01	Omethoate	0.018	0.01	180	0.01	180	54
Green pepper	TOR-GPP-02	Abamectin	0.028	0.005	560	0.07	40	33
Green pepper	TOR-GPP-02	Acetamiprid	0.17	0.2	85	0.3	57	41
Green pepper	TOR-GPP-02	Azoxystrobin	0.26	3	9	3	9	
Green pepper	TOR-GPP-02	Imidacloprid	0.068	1	7	0.9	8	5
Green pepper	TOR-GPP-02	Metalaxyl	0.032	1	3	0.5	6	0
Green pepper	TOR-GPP-03	Abamectin	0.024	0.005	480	0.07	34	29
Green pepper	TOR-GPP-03	Acetamiprid	0.19	0.2	95	0.3	63	45
Green pepper	TOR-GPP-03	Azoxystrobin	0.38	3	13	3	13	
Green pepper	TOR-GPP-03	Imidacloprid	0.11	1	11	0.9	12	8
Green pepper	TOR-GPP-03	Omethoate	0.014	0.01	140	0.01	140	42
Cabbage	JIN-CAB-03	Cypermethrin	0.025	1	3	1	3	0
Cabbage	JIN-CAB-03	Omethoate	0.018	0.01	180	0.01	180	0
Cabbage	JIN-CAB-03	Profenofos	0.01	0.05	20	0.01	100	0

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Report 3303
ISSN 1566-7197

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