Analysis of Pesticides in Oranges: Exploring QuEChERS for Peel, Pulp, and Whole Fruit

When someone is evaluating dissimilar things, you might hear them say "it's like comparing apples and oranges." In the world of pesticide residue analysis, where scientists evaluate real apples and oranges, there are big differences between them, but the variation doesn't stop there. Even within a commodity, there are potentially significant differences that can affect results. In this article, we will discuss the analysis of pesticides in oranges using QuEChERS and look at the effect of extracting whole fruit versus separate peel and pulp samples.

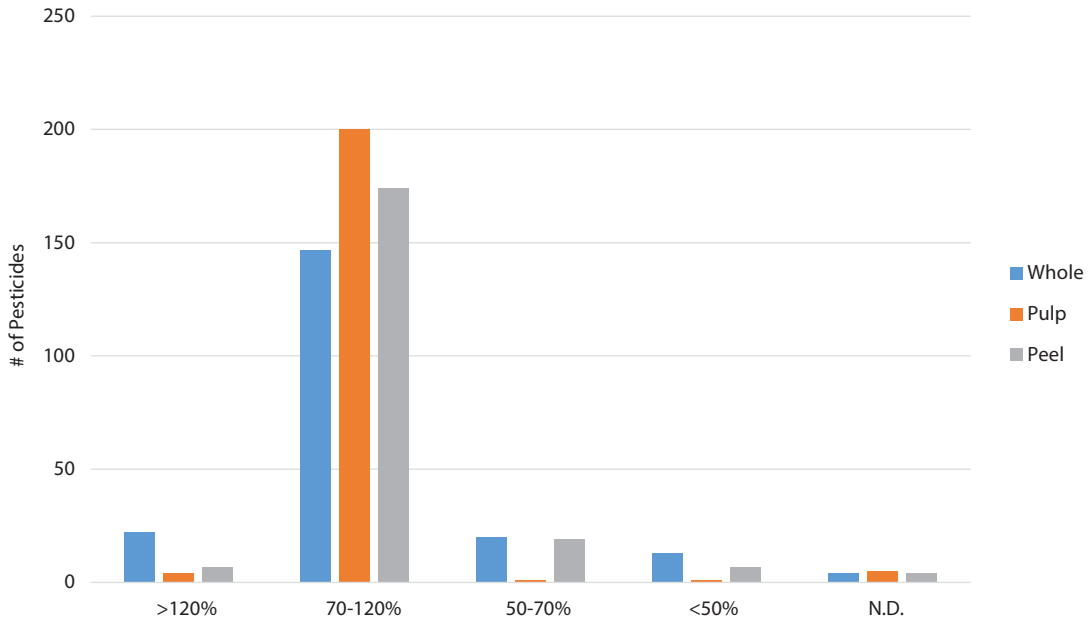
From an analytical perspective, an orange's peel has characteristics that differ from those of the pulp within it. The principal differences between the peel and pulp considered here are the relative water, oil, and sugar content. Pulp contains high amounts of water and sugar compared to peel, whereas peel contains less water and more oil than pulp.

When choosing sample preparation procedures, it is common to tailor the approach to the characteristics of the commodity. But, despite the very different characteristics of the orange's component parts, the whole fruit is often processed for analysis. While preparing the whole orange certainly can work for many pesticides, there may be instances where poor recoveries are observed. Poor recoveries have many potential causes, but in the case of heterogeneous samples, such as oranges, differences in the nature of the sample components could be a contributing factor. Here we present two examples that explore the analysis of pesticides in oranges and the differences that were observed based on sample preparation approaches.

Example 1: A workflow where preparing peel and pulp separately made a significant difference

During a project where we were evaluating various QuEChERS products for the extraction and cleanup of a list of LC-amenable pesticides (cat.# 31971) in a wide variety of spiked commodities using LC-MS/MS, we observed that when the orange was prepared separately as peel and pulp samples, a significantly larger number of pesticides exhibited higher recoveries in the separated peel and pulp samples compared to the whole orange sample (Figure 1).

Figure 1: Comparison of spiked pesticide recoveries (10 ppb) from different parts of oranges using LC-MS/MS.



For all cases in this first example, the whole orange, peel, and pulp samples were extracted using buffered AOAC method extraction salts (cat.# 25852) and cleanup was performed using a dSPE product containing only primary and secondary amine (PSA) and magnesium sulfate (cat.# 26124).

In the whole orange sample, no additional water was added because oranges have adequate water content, about 86%. However, when the peel and pulp were analyzed separately, the peel did get extra hydration because it contains less than 80% water, which is a threshold used for QuEChERS extractions. Table I summarizes the sample preparation processes and the analytical conditions used for this analysis of pesticides in oranges.

When comparing pesticide recoveries between the whole orange sample and the pulp sample, the pulp results showed a marked increase in pesticides recovered in the target 70-120% range compared to the whole orange sample. It should be noted that the sample preparation procedures for these two samples were identical, so the observed difference is likely due to the parts of the orange that were analyzed. The peel sample also showed an increase in the number of pesticides within the desired recovery range, but it underwent additional hydration, which likely helped with analyte recovery. When evaluating sample preparation approaches, one must consider whether or not whole commodity procedures thoroughly homogenize the sample so that the extraction process is as effective as possible. Could it be in our example that the peel's relatively low-moisture characteristic affected the performance of the whole orange sample, ultimately degrading overall performance? A clue to the answer may lie in a second experiment we conducted.

Table I: Sample Preparation and Analytical Methods used in LC-MS/MS Analysis of Pesticides in Oranges.

Sample Preparation:			
Commodity:	Orange Pulp	Orange Peel	Whole Orange
Extraction mass (g)	15	5 g peel, 7.5 g water	15
Extraction solvent	1% acetic acid in acetonitrile		
Extraction salts	AOAC (cat.# 25852)		
Extraction time	1 min shake		
Cleanup dSPE	AOAC 2007.01 (cat. # 26124), 150 mg $MgSO_4$, 50 mg PSA		
Spiking concentration	10 ng/g		
LC Conditions:			
Column	Raptor ARC-18, 2.7 µm, 100 mm x 2.1 mm (cat.# 9314A12)		
EXP Guard	Raptor ARC-18, 2.7 µm, 5 mm x 2.1 mm (cat.# 9314A0252)		
Inline Filter	UltraShield UHPLC precolumn filter (cat.# 25811)		
Instrument	UHPLC MS/MS		
Mobile Phase A	2 mM NH_4 formate + 0.2% formic acid in water		
Mobile Phase B	2 mM NH_4 formate + 0.2% formic acid in methanol		
Gradient	Time (min)	%B	
	0.00	5	
	2.00	60	
	4.00	75	
	6.00	100	
	7.50	100	
	7.51	5	
	9.50	5	
Flow Rate	0.4 mL/min		
Column Temp.	50 °C		
Ion Mode	ESI+/ESI-		
Diluent	90:10 water:matrix matched acetonitrile		
Injection Volume	5 µL		

Example 2: A workflow where the differences were not as pronounced.

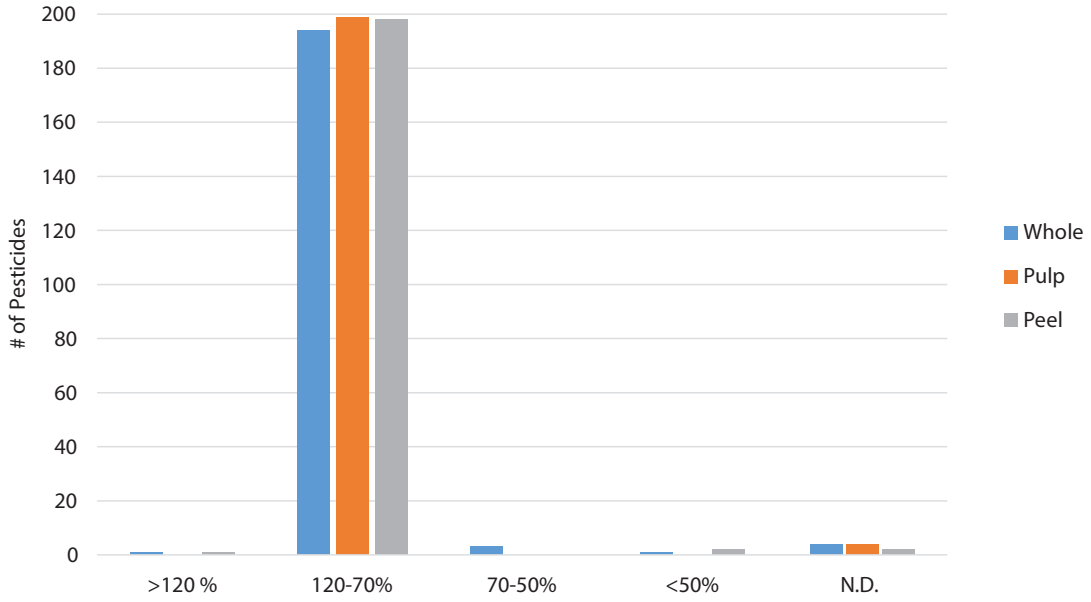
As a complementary project, we also used a GC-MS/MS to evaluate a list of GC-amenable pesticides (cat.# 32562) in the same set of food matrices spiked with the same concentration of pesticides (10 ng/g) that were studied in the LC-MS/MS work. Once again, a QuEChERS approach was used, but in this case we chose to use optimized procedures for each orange part instead of using the same approach for all. This allowed us to take advantage of tailoring the extraction and dSPE to the characteristics of the individual parts (more detail about this is available at https://blog.restek.com/analyzing-orange-peel-and-pulp-separately-or-as-whole/). Table II outlines the sample preparation and analytical conditions used in these different GC workflows.

Table II: Sample Preparation and Analytical Methods used in GC-MS/MS Analysis of Pesticides in Oranges.

Sample Preparation:			
Commodity:	Orange Pulp	Orange Peel	Whole Orange
Extraction mass (g)	15	10 g peel, 4 g water	10
Extraction solvent	1% acetic acid in acetonitrile	acetonitrile	acetonitrile
Extraction salts	AOAC (cat.# 25852)	EN (cat.# 25849)	EN (cat.# 25849)
Extraction time	1 min shake	1 min shake	10 min on lab shaker with stainless-steel ball bearings added to the centrifuge tube
Cleanup dSPE	AOAC 2007.01 (cat. # 26124), 150 mg $MgSO_4$, 50 mg PSA	150 mg $MgSO_4$, 25 mg PSA, 25 mg C18-EC (cat.# 26216)	150 mg $MgSO_4$, 50 mg PSA, 50 mg C18-EC (cat.# 26125)
Spiking concentration	10 ng/g		
GC Conditions:			
Column	Rxi-5ms, 30 m, 0.25 mm ID, 0.25 µm (cat.# 13423)		
Instrument	GC-MS/MS		
Oven Program	Temperature (°C)	Ramp Rate (°C/min)	Hold Time (min)
	90	-	1
	330	@ 8 °C/min	5
Column Flow (constant)	1.4 mL/min		
Injection Volume	1 µL		
Injection Type	splitless, 0.5 min hold time		
Inlet Temperature	250 °C		

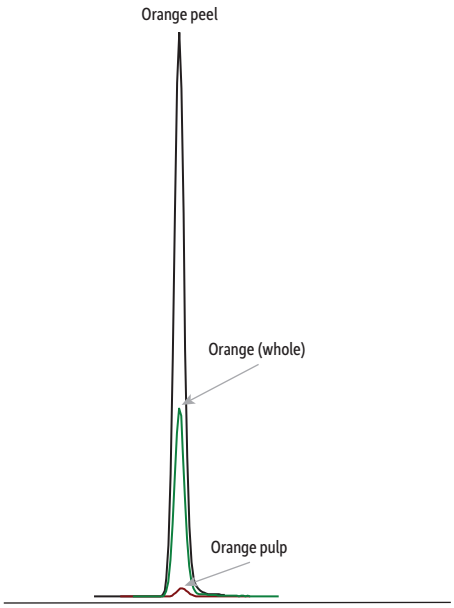
In addition to optimizing the extraction conditions for the individual parts, another homogenization step, accomplished using 1⁄16" steel ball bearings in a centrifuge tube, was used for the whole orange sample. This step was added in an attempt to mitigate the different natures of the peel and the pulp negatively affecting the overall recoveries. This allowed for better mixing between the pulp and peel parts of the orange. Figure 2 shows the recoveries of the GC-amenable compounds that were included in this analysis of pesticides in oranges. We did not observe as much of a difference between analyzing the orange as a whole versus as individual parts. There was only a 3% increase of pesticide residues from whole orange to orange pulp. Also, the peel performed much better (97% in target zone), which suggest that matrix effects from the orange are less severe in GC-MS/MS analysis.

Figure 2: Comparison of spiked recoveries (10 ppb) from different parts of oranges using GC-MS/MS.



While this case does not show significantly different overall recoveries when comparing the whole orange to the separate peel and pulp samples, we do notice, in some cases, that there are significantly different pesticide concentrations recovered from the peel as compared to the pulp. When analyzing an orange for levels of incurred pesticides, we observed much higher levels of some pesticides, like fludioxonil, in the peel than we did in the pulp (Figure 3). We also found cypermethrin and diphenylamine in both peel and whole orange, but not in the pulp (Table III). The different parts of a very heterogeneous sample may exhibit different levels of target pesticides, and if it is important to make that distinction, analyzing the sample parts individually, with optimized sample prep processes for each part, is necessary.

Figure 3: Analysis of pesticides in oranges using separate, optimized procedures for each part can reveal differences in the distribution of pesticide residues.



Peaks	t_R (min)	Precursor Ion	Product Ion	Collision Energy (CE)
1. Fludioxonil	18.16	248	127	30

Column	Rxi-5ms, 30 m, 0.25 mm ID, 0.25 µm (cat.# 13423)
Sample	Whole orange QuEChERS extract (318 ng/g) Orange peel QuEChERS extract (594 ng/g) Orange pulp QuEChERS extract (6.8 ng/g)
Diluent:	Acetonitrile
Injection	
Inj. Vol.:	1 µL splitless (hold 0.5 min)
Liner:	Topaz 4.0 mm ID single taper inlet liner w/wool (cat.# 23447)
Inj. Temp.:	250 °C
Oven	
Oven Temp.:	90 °C (hold 1 min) to 330 °C at 8.5 °C/min (hold 5 min)
Carrier Gas	He, constant flow
Flow Rate:	1.4 mL/min
Detector	TSQ 8000
Transfer Line Temp.:	290 °C
Analyzer Type:	Quadrupole
Source Temp.:	280 °C
Tune Type:	PFTBA
Ionization Mode:	EI
Instrument	Thermo Scientific TSQ 8000 Triple Quadrupole GC-MS

Notes

Sample Preparation (adapted from EN and AOAC QuEChERS methods):

Orange (Whole): 10 g of homogenized orange was fortified with an internal standard and mixed with 10 mL acetonitrile and two steel ball bearings ($^1/_{16}$") and shaken for 10 minutes. Q-sep QuEChERS extraction salts for EN 15662 (cat.# 25849) were added, and the sample was shaken for 1 minute. The sample was centrifuged for 5 minutes, and the supernatant was removed and further cleaned up with prefilled Q-sep QuEChERS dSPE tubes containing 150 mg $MgSO_4$, 50 mg PSA, and 50 mg C18-EC (cat.# 26125).

Orange Peel: 10 g of homogenized orange peel was fortified with an internal standard, hydrated with 4 mL water, and briefly shaken by hand. Acetonitrile (10 mL) was added, and the sample was shaken for an additional 1 minute. Q-sep QuEChERS extraction salts for EN 15662 (cat.# 25849) were added, and the sample was shaken for 1 minute. The sample was centrifuged for 5 minutes, and the supernatant was removed and further cleaned up with prefilled Q-sep QuEChERS dSPE tubes containing 150 mg $MgSO_4$, 25 mg PSA, and 25 mg C18-EC (cat.# 26216).

Orange Pulp: 15 g of homogenized orange pulp was fortified with an internal standard. Acetonitrile with 1% acetic acid (15 mL) was added, and the sample was shaken for 1 minute. Q-sep QuEChERS extraction salts for AOAC 2007.01 (cat.# 25851) were added, and the sample was shaken for an additional 1 minute. The sample was centrifuged for 5 minutes, and the supernatant was removed and further cleaned up with prefilled Q-sep QuEChERS dSPE tubes containing 150 mg $MgSO_4$ and 50 mg PSA (cat.# 26124).

The dSPE supernatant of all samples was analyzed directly (no further dilution) within 24 hours of the initial extraction.

Table III: Incurred pesticides (ng/g) in different parts of oranges. (ND = not detected)

Pesticide	Whole Orange	Peel	Pulp
Fludioxonil	318	594	6.8
Cypermethrin	5.1	8.8	ND
Diphenylamine	1.5	2.3	ND

Conclusion

This article is intended to introduce an idea for your lab to consider: if a given sample has different parts that exhibit very different characteristics, and if you are experiencing poor recoveries when analyzing the commodity as a whole, it may be valuable to evaluate the parts separately. We have noticed in our own studies that complex samples can give poor recoveries. To improve recoveries, testing distinct parts of the sample (e.g., peel and pulp) using optimized sample preparation procedures for each part may help. In summary, when adapting or developing methods for the analysis of pesticides in oranges—or other heterogeneous sample commodities—it might be beneficial to explore whether or not an individual component or whole-sample approach yields the best results.

Q-sep QuEChERS Sample Prep Tubes and Packets

Q-sep QuEChERS dSPE Tubes for Extract Cleanup

Fast, Simple Sample Prep for Multiresidue Pesticide Analysis

- Packaged in foil subpacks of 10 for enhanced protection and storage stability.
- Ready-to-use tubes, no glassware required.
- Pre-weighed, ultra-pure sorbents.
- Support original unbuffered, AOAC (2007.01), European (EN 15662), and mini-multiresidue QuEChERS methods.

26215

Multiple sorbents are used to extract different types of interferences.
$MgSO_4$—removes excess water.
PSA (primary and secondary amine)—removes sugars, fatty acids, organic acids, and anthocyanine pigments.
C18-EC (end-capped)—removes nonpolar interferences.
GCB (graphitized carbon black)—removes pigments, sterols, and nonpolar interferences.

Description	Material	Method	Type	Volume	qty.	Similar to Part #	cat.#
Foodstuffs with fats and waxes (e.g., cereals, avocado, nuts, seeds, and dairy)							
Q-sep QuEChERS dSPE Tubes	150 mg $MgSO_4$, 25 mg PSA, 25 mg C18-EC	Mini-multiresidue	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.	Agilent 5982-5121	26216
	150 mg $MgSO_4$, 50 mg C18-EC	—	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.		26242
	150 mg $MgSO_4$, 50 mg PSA, 50 mg C18-EC	AOAC 2007.01	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.		26125
	1,200 mg $MgSO_4$, 400 mg PSA, 400 mg C18-EC	AOAC 2007.01	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.	Agilent 5982-5158	26221
	1,200 mg $MgSO_4$, 400 mg C18-EC	—	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.		26244
	900 mg $MgSO_4$, 150 mg PSA, 150 mg C18-EC	—	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.		26226
General fruits and vegetables (e.g., celery, head lettuce, cucumber, melon)							
Q-sep QuEChERS dSPE Tubes	150 mg $MgSO_4$, 50 mg PSA	AOAC 2007.01	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.		26124
	150 mg $MgSO_4$, 25 mg PSA	Original unbuffered, EN 15662, mini-multiresidue	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.	Agilent 5982-5021	26215
	1,200 mg $MgSO_4$, 400 mg PSA	AOAC 2007.01	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.		26220
	900 mg $MgSO_4$, 150 mg PSA	Original unbuffered, EN 15662	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.	Agilent 5982-5056	26223
General purpose (wide variety of sample types, including fatty and pigmented fruits and vegetables)							
Q-sep QuEChERS dSPE Tubes	150 mg $MgSO_4$, 50 mg PSA, 50 mg C18-EC, 7.5 mg GCB	—	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.		26243
	900 mg $MgSO_4$, 300 mg PSA, 300 mg C18-EC, 45 mg GCB	—	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.		26245
Highly pigmented fruits and vegetables (e.g., red peppers, spinach, blueberries)							
Q-sep QuEChERS dSPE Tubes	150 mg $MgSO_4$, 25 mg PSA, 7.5 mg GCB	Mini-multiresidue, EN 15662	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.		26218
	150 mg $MgSO_4$, 50 mg PSA, 50 mg C18-EC, 50 mg GCB	AOAC 2007.01	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.		26219
	900 mg $MgSO_4$, 150 mg PSA, 45 mg GCB	EN 15662	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.		26225
	900 mg $MgSO_4$, 300 mg PSA, 150 mg GCB	—	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.		26126
Pigmented fruits and vegetables (e.g., strawberries, sweet potatoes, and tomatoes)							
Q-sep QuEChERS dSPE Tubes	150 mg $MgSO_4$, 25 mg PSA, 2.5 mg GCB	Mini-multiresidue, EN 15662	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.		26217
	150 mg $MgSO_4$, 50 mg PSA, 50 mg GCB	AOAC 2007.01	2 mL Micro-Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (1 mL Extract)	2 mL	100-pk.		26123
	1,200 mg $MgSO_4$, 400 mg PSA, 400 mg C18-EC, 400 mg GCB	AOAC 2007.01	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.		26222
	900 mg $MgSO_4$, 150 mg PSA, 15 mg GCB	EN 15662	15 mL Centrifuge Tubes Prefilled with dSPE Materials for Cleanup (6 mL and 8 mL Extract)	15 mL	50-pk.		26224

Note: No entry in the Method column refers to dSPE formulations not specifically included in one of the cited references. These products can be used to accommodate the various needs of specific matrices not directly met by the cited references.

Q-sep QuEChERS Extraction Salts

- Free-flowing salts transfer easily and completely.
- Easy-open packets eliminate the need for a second empty tube for salt transfer.
- Convenient slim packets fit perfectly into tubes to prevent spills.
- Ready-to-use tubes, no glassware required.
- Pre-weighed, ultra-pure extraction salts.
- Ideal for original unbuffered, AOAC (2007.01), and European (EN 15662) QuEChERS methods.

QuEChERS methods are fast, easy, and cost-effective, and Restek Q-sep products make QuEChERS procedures even easier. No specialized glassware is required when you're using Q-sep extraction packets and tubes. Free-flowing extraction salts and salt packets that fit easily into the extraction tubes make transferring the salts to your sample mess-free and easy.

25847

Description	Material	Method	qty.	cat.#
Q-sep QuEChERS Extraction Kit	4 g $MgSO_4$, 1 g NaCl with 50 mL Centrifuge Tube	Original unbuffered	50 packets & 50 tubes	25848
Q-sep QuEChERS Extraction Salt Packets Only	4 g $MgSO_4$, 1 g NaCl	Original unbuffered	50 packets	25847
Q-sep QuEChERS Extraction Kit	4 g $MgSO_4$, 1 g NaCl, 1 g TSCD, 0.5 g DHS with 50 mL Centrifuge Tube	European EN 15662	50 packets & 50 tubes	25850
Q-sep QuEChERS Extraction Salt Packets Only	4 g $MgSO_4$, 1 g NaCl, 1 g TSCD, 0.5 g DHS	European EN 15662	50 packets	25849
Q-sep QuEChERS Extraction Kit	6 g $MgSO_4$, 1.5 g NaOAc with 50 mL Centrifuge Tube	AOAC 2007.01	50 packets & 50 tubes	25852
Q-sep QuEChERS Extraction Salt Packets Only	6 g $MgSO_4$, 1.5 g NaOAc	AOAC 2007.01	50 packets	25851

DHS – disodium hydrogen citrate sesquihydrate; $MgSO_4$ – magnesium sulfate; NaCl – sodium chloride; NaOAc – sodium acetate; TSCD – trisodium citrate dihydrate

Q-sep Accessories

Q-sep Multispeed Centrifuge for QuEChERS

NEW!

- Program 10 custom cycles for time, braking, and speed or g-force (up to 4500 rpm or 3450 xg).
- QuEChERS-specific presets for AOAC and EN methods make consistent operation quick and simple.
- Convenient lid lighting indicates at a glance if unit is ready, running, or done.
- Control panel can be temporarily locked on one cycle for error-free reproducibility.
- Cool-Flow design prevents samples from overheating by maintaining unit at room temperature.
- Tube holders are carbon fiber for high strength, durability, and years of trouble-free use.
- Clear lid permits safe observation of samples and optical calibration of speed.

Description	Includes	Certification/Compliance	qty.	cat.#
Q-sep Multispeed Centrifuge for QuEChERS	15 mL four-place tube holder (6); 50 mL single-place tube holder (6); 50 mL conical tube insert (6); 2 mL tube adaptors (24); U.S. power cord (1); global/universal power cord (1)	UL61010-1/CSA C22.2 No. 61010-1 and IEC61010-2-020; FDA listed; MET U.S. E112532; CE; RoHS	ea.	28295

Intended Use

General-purpose laboratory centrifuge intended for safe and rapid density-based separation of fluids, including physiologic fluids, in approved specimen receptacles for qualitative or quantitative test procedures. As a general-purpose laboratory centrifuge, it is designed to also run other approved containers filled with chemicals (nonflammable, nonexplosive, nonvolatile, and non-highly reactive only), environmental samples, and other nonhuman body samples. This device is intended to be operated by properly trained personnel who have carefully read the operating manual and are familiar with the function of the device.

Specifications

Tube Capacity	6 x 50 mL tubes 18 x 15 mL tubes 24 x 2 mL tubes
Dimensions (H x W x D)	9 in x 14.5 in x 17 in (23 cm x 37 cm x 43 cm)
Weight	39 lb (17 kg)
Sound Level	64 dB A
Environmental Range	16–32 °C
Voltage	95–253 VAC
Frequency	50/60 Hz
Power Requirement	220 Watts
Centrifuge Motor	1/2 H.P. Brushless DC
Max g-Force	3450 xg
Max Speed	4500 RPM
Cycle Time	30 sec to 99 min, 59 sec (±2%)

Accessories for Q-sep Multispeed and Q-sep 3000 Centrifuges

Description	qty.	cat.#
15 mL four-place tube holder, carbon-fiber material	2-pk.	28293 NEW!
50 mL single-place tube holder, carbon-fiber material	2-pk.	28294 NEW!
50 mL conical tube insert	6-pk.	26249
2 mL tube adaptors	4-pk.	26234

QuEChERS Standards

QuEChERS Standards for AOAC Official Method 2007.01

- Ready to use for generating test mixes, calibration standards, and spiking experiments.
- Reliable standards produced according to specifications defined in AOAC Official Method 2007.01.
- Cost-effective QuEChERS standards can be used without dilutions for greater lab efficiency.

Following QuEChERS methods is even quicker and easier when you use Restek method-specific chemical standards for AOAC Official Method 2007.01 (Pesticide Residues in Foods by Acetonitrile Extraction and Partitioning with Magnesium Sulfate). Our suite of AOAC QuEChERS standards includes internal standards mix, triphenylphosphate (TPP) solution, and QC spike mix. Each standard can be used directly without dilutions because they are formulated to the exact concentrations prescribed by AOAC Method 2007.01.

AOAC QuEChERS IS Solution

(2 components)

α-BHC-d6 (α-HCH-d6) (86194-41-4)
Parathion-d10 (350820-04-1)

Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Max Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
AOAC QuEChERS IS Solution							
40 µg/mL each in acetonitrile, 5 mL/ampul	Yes	6 months	18 months	Ambient	10 °C or colder	ea.	31963

AOAC QuEChERS QC Spike Mix

(27 components)

Atrazine (1912-24-9)
Azoxystrobin (131860-33-8)
Bifenthrin (82657-04-3)
Carbaryl (Sevin) (63-25-2)
Chlorothalonil (1897-45-6)
Chlorpyrifos (2921-88-2)
Chlorpyrifos methyl (5598-13-0)
lambda-Cyhalothrin (91465-08-6)
Cyprodinil (121552-61-2)
2,4'-DDD (53-19-0)
Dichlorvos (DDVP) (62-73-7)
Endosulfan sulfate (1031-07-8)
Ethion (563-12-2)
Imazalil (35554-44-0)
Imidacloprid (138261-41-3)
Kresoxim methyl (143390-89-0)
Linuron (330-55-2)
Methamidophos (10265-92-6)
Methomyl (16752-77-5)
cis-Permethrin (61949-76-6)
trans-Permethrin (61949-77-7)
Procymidone (32809-16-8)
Pymetrozine (123312-89-0)
Tebuconazole (107534-96-3)
Thiabendazole (148-79-8)
Tolylfluanid (731-27-1)
Trifluralin (1582-09-8)

Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Max Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
AOAC QuEChERS QC Spike Mix							
40 µg/mL each in acetonitrile:acetic acid (99.9:0.1), 5 mL/ampul	Yes	3 months	12 months	Ambient	10 °C or colder	ea.	31999

AOAC QuEChERS Triphenylphosphate Solution

Description	CAS #	Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Max Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
Triphenylphosphate	115-86-6	2 µg/mL in acetonitrile:acetic acid (99:1), 5 mL/ampul	Yes	6 months	36 months	Ambient	10 °C or colder	ea.	31964

QuEChERS Reference Standards

Ready to use for QuEChERS extractions—no dilutions necessary.

Pesticide analysis is fast and simple using QuEChERS methods. Use these cost-effective QuEChERS standards for even greater lab efficiency. Standards are compatible with all major methods, including mini-multiresidue, AOAC, and European procedures. Save time with convenient mixes or make your own blend using our full line of single-component solutions.

QuEChERS Internal Standard Mix for GC-MS Analysis

(6 components)

PCB 18 (37680-65-2), 50 µg/mL
PCB 28 (7012-37-5), 50 µg/mL
PCB 52 (35693-99-3), 50 µg/mL
Triphenylmethane (519-73-3), 10 µg/mL
Triphenylphosphate (115-86-6), 20 µg/mL
Tris(1,3-dichloroisopropyl)phosphate (13674-87-8), 50 µg/mL

Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Max Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
QuEChERS Internal Standard Mix for GC/MS Analysis							
In acetonitrile, 5 mL/ampul	Yes	6 months	75 months	Ambient	10 °C or colder	ea.	33267

QuEChERS Internal Standard Mix for GC-NPD and LC-MS/MS Analysis

(2 components)

Triphenylphosphate (115-86-6), 20 µg/mL
Tris(1,3-dichloroisopropyl)phosphate (13674-87-8), 50 µg/mL

Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Max Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
QuEChERS Internal Standard Mix for GC/NPD and LC/MS/MS Analysis							
In acetonitrile, 5 mL/ampul	Yes	6 months	75 months	Ambient	10 °C or colder	ea.	33266

QuEChERS Performance Standards

- Designed for use in all QuEChERS methods for pesticides in fruits and vegetables, including the original unbuffered method, AOAC 2007.01, and EN15662.
- Ideal for initial method evaluations and ongoing method performance validations.
- Optimized blend of chemically compatible analytes for maximum stability and shelf life.
- Precise formulation improves data quality and operational efficiency; spend more time running samples and less time sourcing and preparing standards.
- Quantitatively analyzed to confirm the composition and stability of each mixture.

QuEChERS Performance Standard A

(16 components)

Acephate (30560-19-1)
Azinphos methyl (86-50-0)
Chlorpyrifos (2921-88-2)
Coumaphos (56-72-4)
Diazinon (333-41-5)
Dichlofluanid (1085-98-9)
Dichlorvos (DDVP) (62-73-7)
Dimethoate (60-51-5)
Fenthion (55-38-9)
Malathion (121-75-5)
Methamidophos (10265-92-6)
Mevinphos (7786-34-7)
Omethoate (1113-02-6)
Phosalone (2310-17-0)
Pirimiphos methyl (29232-93-7)
Propargite (2312-35-8)

Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Max Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
QuEChERS Performance Standard A							
300 µg/mL each in acetonitrile:acetic acid (99.9:0.1), 1 mL/ampul	Yes	3 months	12 months	Ambient	10 °C or colder	ea.	31153

QuEChERS Performance Standard B

(7 components)

gamma-BHC (Lindane) (58-89-9)
Chlorothalonil (1897-45-6)
4,4'-DDT (50-29-3)
Dicofol (Kelthane) (115-32-2)
Endosulfan sulfate (1031-07-8)
Endrin (72-20-8)
2-Phenylphenol (90-43-7)

Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Max Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
QuEChERS Performance Standard B							
300 µg/mL each in acetonitrile:acetic acid (99.9:0.1), 1 mL/ampul	Yes	6 months	24 months	Ambient	10 °C or colder	ea.	31154

QuEChERS Performance Standard C

(17 components)

Bifenthrin (82657-04-3)
Captan (133-06-2)
Carbaryl (Sevin) (63-25-2)
Cyprodinil (121552-61-2)
Deltamethrin (52918-63-5)
Fenhexamid (126833-17-8)
Fenpropathrin (39515-41-8)
Folpet (133-07-3)
Imazalil (35554-44-0)
Iprodione (36734-19-7)
Metalaxyl (57837-19-1)
Methiocarb (2032-65-7)
Myclobutanil (88671-89-0)
cis-Permethrin (61949-76-6)
trans-Permethrin (61949-77-7)
Thiabendazole (148-79-8)
Vinclozolin (50471-44-8)

Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Max Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
QuEChERS Performance Standard C							
300 µg/mL each in acetonitrile:acetic acid (99.9:0.1), 1 mL/ampul	Yes	6 months	24 months	Ambient	10 °C or colder	ea.	31155

QuEChERS Performance Standards Kit

- Kit contains organochlorine, organonitrogen, organophosphorus, and carbamate pesticides commonly used on fruits and vegetables.
- Volatile, polar, active, base-sensitive, and nonvolatile compounds are included to allow comprehensive evaluation of QuEChERS extraction and cleanup efficiencies, and optimization of GC and LC instrumental conditions.
- Analytes are divided into three ampuls based on compatibility for maximum stability and shelf life.*

*When combining compounds with different functionalities, chemical stability can be an issue. The analytes in this kit are separated into three mixes to ensure maximum long-term storage stability. For analysis, a fresh working standard should be prepared by combining the three kit mixes in a 1:1:1 ratio to prepare a 100 µg/mL working standard solution. Once blended, Restek does not recommend storing working standards or subsequent dilutions for future use.

Contains 1 mL each of these mixtures. 31153: QuEChERS Performance Standard A 31154: QuEChERS Performance Standard B 31155: QuEChERS Performance Standard C

Cat.# 31153: QuEChERS Performance Standard A (16 components)
Acephate (30560-19-1)
Azinphos methyl (86-50-0)
Chlorpyrifos (2921-88-2)
Coumaphos (56-72-4)
Diazinon (333-41-5)
Dichlofluanid (1085-98-9)
Dichlorvos (DDVP) (62-73-7)
Dimethoate (60-51-5)
Fenthion (55-38-9)
Malathion (121-75-5)
Methamidophos (10265-92-6)
Mevinphos (7786-34-7)
Omethoate (1113-02-6)
Phosalone (2310-17-0)
Pirimiphos methyl (29232-93-7)
Propargite (2312-35-8)

Cat.# 31154: QuEChERS Performance Standard B (7 components)
gamma-BHC (Lindane) (58-89-9)
Chlorothalonil (1897-45-6)
4,4'-DDT (50-29-3)
Dicofol (Kelthane) (115-32-2)
Endosulfan sulfate (1031-07-8)
Endrin (72-20-8)
2-Phenylphenol (90-43-7)

Cat.# 31155: QuEChERS Performance Standard C (17 components)
Bifenthrin (82657-04-3)
Captan (133-06-2)
Carbaryl (Sevin) (63-25-2)
Cyprodinil (121552-61-2)
Deltamethrin (52918-63-5)
Fenhexamid (126833-17-8)
Fenpropathrin (39515-41-8)
Folpet (133-07-3)
Imazalil (35554-44-0)
Iprodione (36734-19-7)
Metalaxyl (57837-19-1)
Methiocarb (2032-65-7)
Myclobutanil (88671-89-0)
cis-Permethrin (61949-76-6)
trans-Permethrin (61949-77-7)
Thiabendazole (148-79-8)
Vinclozolin (50471-44-8)

Description	Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
QuEChERS Performance Standards Kit	300 µg/mL each in acetonitrile/acetic acid (99.9:0.1), 1 mL/ampul. Blend equal volumes of all three ampuls for a 100 µg/mL final solution.	Yes	3 months	Ambient	10 °C or colder	kit	31152

PCB 138 & PCB 153

PCB 138 (35065-28-2)
PCB 153 (35065-27-1)

Conc. in Solvent	CRM?	Min Shelf Life on Ship Date	Max Shelf Life on Ship Date	Shipping Conditions	Storage Temp.	qty.	cat.#
PCB 138 & PCB 153							
50 µg/mL each in acetonitrile, 5 mL/ampul	Yes	6 months	75 months	Ambient	10 °C or colder	ea.	33268

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Questions? Contact us or your local Restek representative (www.restek.com/contact-us).

www.restek.com

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