PALM OIL ANALYSIS. COMPLETE LAB SOLUTIONS FROM UPSTREAM TO DOWNSTREAM

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For the Better

Palm Oil Analysis Reference Book

YOUR PARTNER FOR PALM OIL ANALYSIS

INTRODUCTION

Introduction

Palm oil is an edible vegetable oil derived from the mesocarp (reddish pulp) of the oil palm fruit. Human use of oil palms may date as far back as 5,000 years. Palm oil is naturally reddish in color because of high beta-carotene content and 41% saturated fat content.

Table 1: Fatty Acid Content of Malaysian Palm Oil

Type of fatty acid	Percentage
Myristic saturated C_{14}	0.7 - 1.0%
Palmitic saturated C_{16}	36.7 - 39.4%
Stearic saturated C_{18}	3.6 - 4.4%
Oleic monounsaturated C_{18}	43.6 - 45.3%
Linoleic polyunsaturated C_{18}	10.8 - 12.1%

Source: www.palmoilworld.org

Uses of Palm Oil

Palm oil is a common cooking ingredient in the tropical belt of Africa, Southeast Asia and parts of Brazil. Its use in the commercial food industry in other parts of the world is buoyed by its lower cost and the high oxidative stability (saturation) of the refined product when used for frying. A recent rise in the use of palm oil in the food industry has come from changed labelling requirements that have caused a switch away from other oils containing trans fats.

After milling, various palm oil products are made using refining processes. First is fractionation with crystallization and separation processes to obtain solid (stearin) and liquid (olein) fractions. Then melting and degumming removes impurities. Next the oil is filtered and bleached. Physical refining removes smells and coloration to produce "refined, bleached and deodorized palm oil" **(RBDPO)** and free sheer fatty acids, which are used in the manufacture of soaps, washing powder and other products. Many companies fractionate it further to produce palm olein for cooking oil, or process it into other products.

Table 2: Palm oil and its fractionated products are used in a variety of industry as shown in table below.

Food Applications	Oleochemical	Energy, Biomass & Others
Cheese Analogues	Agrochemical	Animal Feeds
Cooking Oil	Candles	Bio-composite
Confectionary Fats	Cosmetics	Biodiesel
Ice-Cream	Industrial Cleaning	Briquettes
Industrial Frying Fats	Lubricant/Grease	Charcoal
Margarine	Metal Soap/Toilet Soap	Fertilizer
Non-Dairy Creamer	Personal Care	Furniture
Salad Dressings	Polyols	Pulp & Paper
Shortenings	Polyurethane	
Supplements/vitamins	Printing Ink	
Vegetable Ghee	Surfactants	

Source: www.palmoilworld.org

Palm oil is widely used from food applications, personal care, industries to bio-energy. There are many types of raw materials involved in the production process are actually palm oil-derived ingredients.

Table 3: List of Palm Oil-Derived Ingredients

Palm-Oil Derivatives Ingredients		
PKO – Palm Kernel Oil	Sodium Lauryl Sulfoacetate	Cetyl Palmitate and Octyl Palmitate
Palmitate – Vitamin A or Asorbyl Palmitate	Stearic Acid	Glyceryl Stearate
Palmate	Steareth -2	Hydrated Palm Glycerides
Sodium Laureth Sulphate	Steareth -20	Chemicals which Contain Palm Oil
Sodium Lauryl Sulphates	Sodium Isostearoyl Lactylate	
Sodium Dodecyl Sulphate (SDS or NaDs)		

Types of Palm Oil

Palm Kernel Oil is derived from the kernel of the oil palm fruit. Its composition and properties differ significantly from palm oil. It consists mainly of lauric acid C12:0 48%, and myristic acid C14:0 16%.

Palm Kernel Olein is the liquid fraction derived from fractionation of palm kernel oil. It is very useful for margarine fats when interesterified with palm stearin.

Palm Kernel Stearin is the solid fraction derived from fractionation of palm kernel oil. Its solid fat content (SFC) profile indicates whether it is suitable for use in confectionery fats.

Palm Kernel Cake is the by-product of the oil extraction process. It is produced during the milling process of palm fruits contain approximately 50% oil that can be extracted commercially via two methods, i.e. mechanical expression and solvent extraction. The main use of this product is as an ingredient for compounding animal feed. It has high fibre content and thus is usually used in foods for ruminants such as cattle. However palm kernel cake is also a good source of phytin, which is a precursor of phytic acid and inositol.

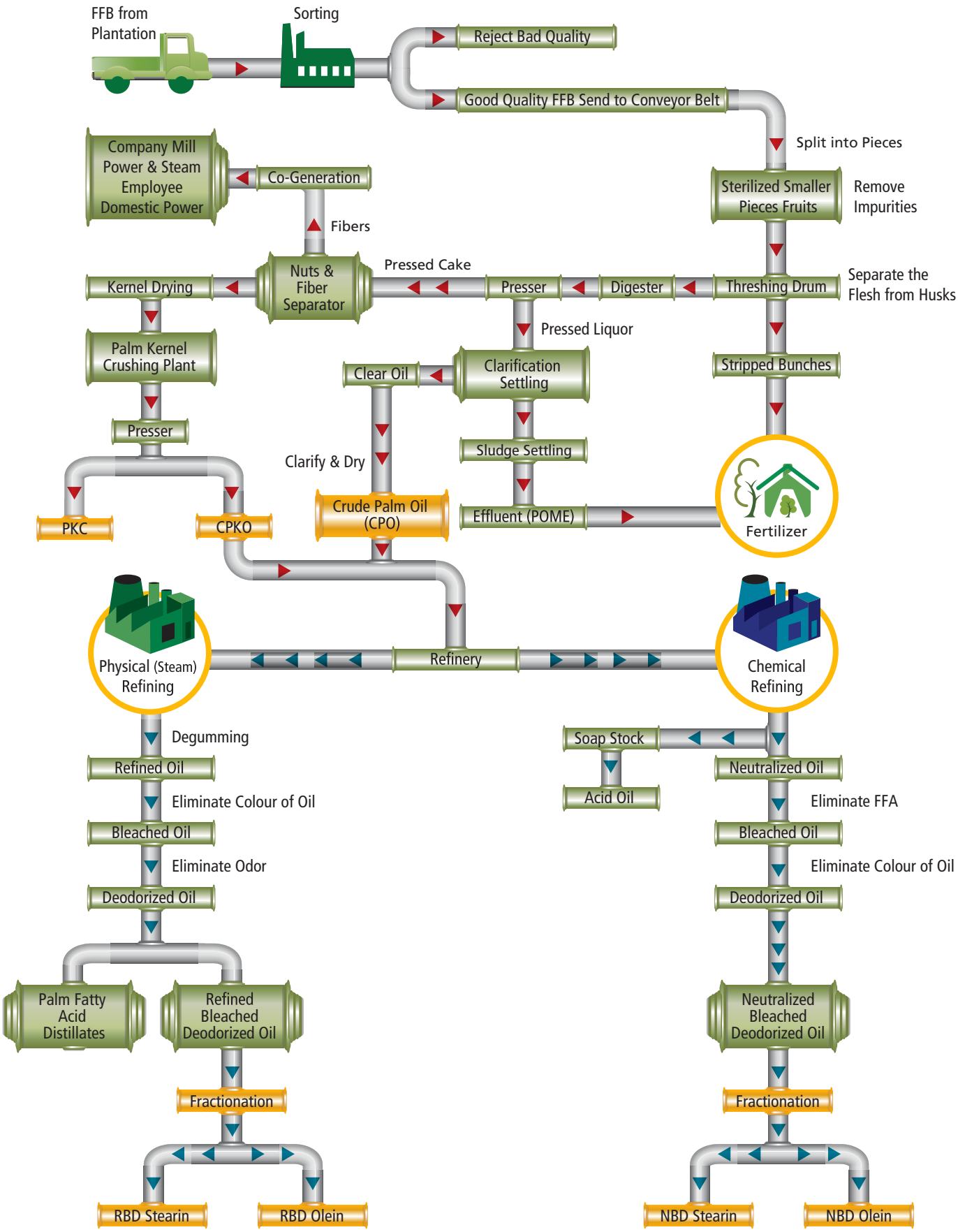
Palm oil is derived from the fleshy mesocarp of the oil palm fruit. It consists mainly of palmitic acid C16:0 43.7%, stearic acid C18:0 4.4%, oleic acid C18:1 39.9%, and linoleic acid 10.3%. Palm oil is unique among vegetables oils because it has a significant amount of saturated acids (10-15%) at the 2nd positions of its triglycerides. It can be fractionated to produce palm olein and palm stearin.

Palm Olein is the liquid fraction derived from the fractionation of palm oil. It has an iodine value of about 56-59 and cloud point of 10°C. Palm Olein is fully liquid at ambient temperature in warm climates. It can be blended with various vegetable oils in different proportions to obtain liquid oils which can withstand lower temperatures.

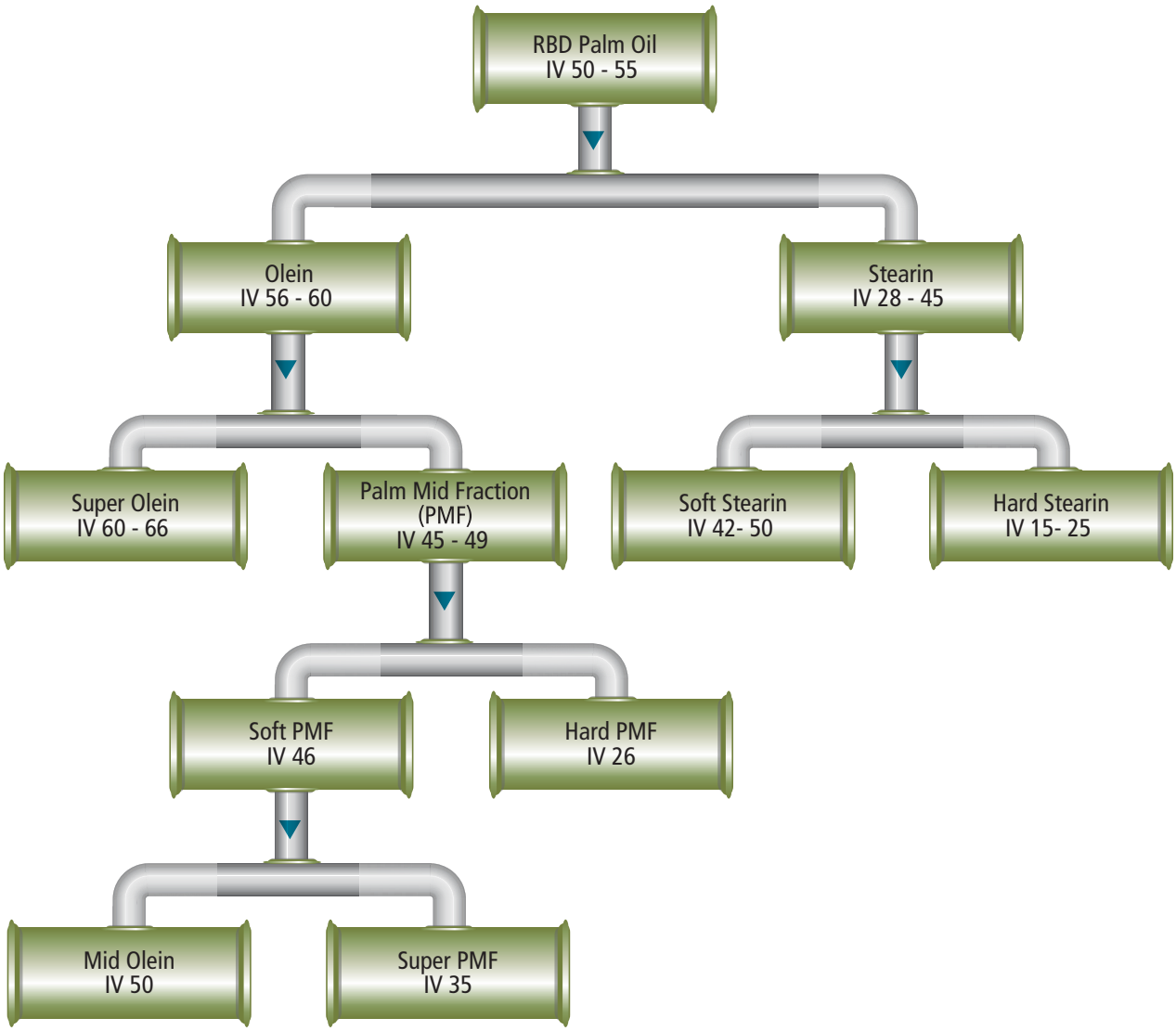
Palm Stearin is the high-melting fraction derived from the fractionation of palm oil. It is a useful natural stock for making trans-free fats. Besides edible usage, palm stearin possesses suitable properties for making soaps and formulating animal feeds. It is also an excellent feedstock for oleochemicals.

Palm Superolein is a double fractionated palm olein (liquid) derived from palm oil produced through a specially controlled crystallization process to achieve an iodine value (IV) of 60 or higher and has a lower cloud point of about 2°C to 5°C.

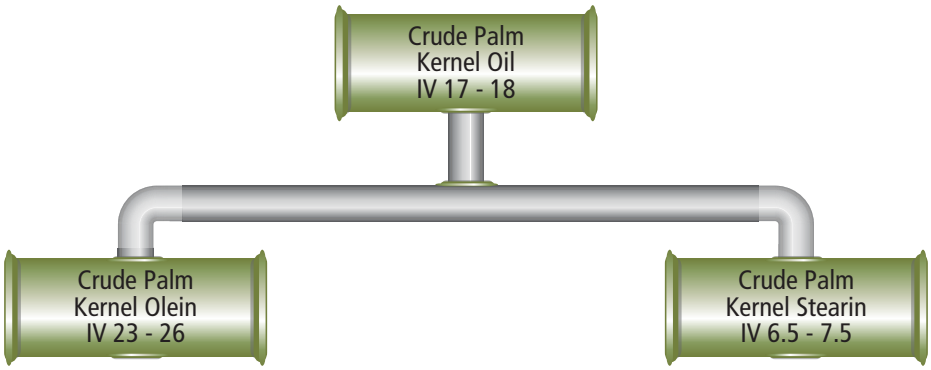
Palm Acid Oil is derived from free fatty acids neutralised by alkali (sodium hydroxide) forming emulsified neutral oil which is then separated and acidified with concentrated sulphuric acid to produce oil which is mainly fatty acid. Acid oil requires further refining or purification before it is used in laundry soap and washing powder.


FFB from Plantation
Sorting
Reject Bad Quality
Good Quality FFB Send to Conveyor Belt
Split into Pieces
Company Mill Power & Steam Employee Domestic Power
Co-Generation
Fibers
Sterilized Smaller Pieces Fruits
Remove Impurities
Pressed Cake
Kernel Drying
Nuts & Fiber Separator
Presser
Digester
Threshing Drum
Separate the Flesh from Husks
Pressed Liquor
Palm Kernel Crushing Plant
Clear Oil
Clarification Settling
Stripped Bunches
Presser
Clarify & Dry
Sludge Settling
PKC
CPKO
Crude Palm Oil (CPO)
Effluent (POME)
Fertilizer
Physical (Steam) Refining
Refinery
Chemical Refining
Degumming
Soap Stock
Refined Oil
Neutralized Oil
Eliminate Colour of Oil
Acid Oil
Eliminate FFA
Bleached Oil
Bleached Oil
Eliminate Odor
Eliminate Colour of Oil
Deodorized Oil
Deodorized Oil
Palm Fatty Acid Distillates
Refined Bleached Deodorized Oil
Neutralized Bleached Deodorized Oil
Fractionation
Fractionation
RBD Stearin
RBD Olein
NBD Stearin
NBD Olein

Fractionation of Palm Oil



Fractionation of Palm Kernel Oil



Source: MPOB (1992)

Why is it so important to test quality of palm oil?

Quality control-monitoring and testing are important in ensuring the quality of palm oil. The quality control parameters are used to judge the quality of palm oil products and it can be monitored and tested to ensure that the palm oil is not deliberately or accidentally adulterated.

Some important parameters in palm oil analysis are described below.

Bleachability (DOBI) :

Acronym for "Deterioration of Bleaching Index". The bleachability of CPO in the refining process is largely determined by the extent of oxidation, which leads to the formation of persistent coloured products. A pale near-white colour is regarded as an important characteristic of well-refined oil. The DOBI test can be easily obtained by simple spectrophotometric measurement and is used to predict the ease of bleaching of crude palm oil during refining. It involves the measurement of the absorption of ultraviolet light by a solution of the oil at two different wavelengths and defined as the numerical ratio of the uncorrected absorbance at 446nm to that at 269nm.

DOBI = (Absorbance at 446nm) / (Absorbance at 269nm)
Absorbance 446 is related to the unchanged carotene content (carotene is easily destroyed by oxygen).
Absorbance 269 is related to the concentration of secondary oxidation of crude palm oil
Crude palm oil quality: DOBI - Good (3-4); Average (2-3); Poor (<1)

Carotenoids (Vitamin A) :

Responsible for the strong colour of the unrefined oil and capable of being transformed into Vitamin A in the body. Crude palm oil contains 500-700 ppm carotenoids, mainly as alpha- and beta-carotenes, the precursors of Vitamin A. Carotenoids are usually thermally destroyed during the deodorization stage of the refining process. Their presence however, offers some oxidative protection to the oil by themselves being oxidised first prior to the triglycerides.

Fatty Acid Composition (Fatty Acids Methyl Esters, FAME

The fatty acid composition (FAC) measures the weight percentage of the individual fatty acids (as methyl esters), whether present as free fatty acids or in the esterified form in the triacylglycerol molecules.
By various transesterification / esterification methods, fatty acids are converted to methyl esters. Separation of the mixture of methyl esters is obtained by different degrees of interactions between the individual methyl esters with the chromatographic columns.

Free Fatty Acid (FFA) :

A fatty acid is a carboxylic acid consisting of a long aliphatic chain (e.g. palmitic, stearic or oleic acid) which is either saturated or unsaturated that bond to glycerol to form a fat. Most naturally occurring fatty acids have a chain of an even number of carbon atoms, from 4 to 28. Fatty acids are usually derived from triglycerides or phospholipids. When they are not attached to other molecules, they are known as free fatty acids.

The 5% FFA limit for standard CPO is higher than would be acceptable for other vegetable oils. This is because the palm fruit contains a very active lipase (fat splitting) enzyme, which rapidly breaks down the triglycerides to a mixture of FFA, monoglycerides and diglycerides. The enzyme is released from the fruit cells when the fruit is over-ripe or when it is bruised. Oil with a maximum FFA of 2.5% and minimal oxidation is produced and is easier to refine. Moreover, lower FFA means also a lower content of mono- and di-glycerides which can cause difficulty in fractionation.

Iodine Value (IV) :

The Iodine Value of an oil/fat is the number of grams of iodine absorbed by oil/fat and it is measure of the amount of unsaturation (number of double bonds) in fat. All oils contain a mixture of fatty acids, both saturated and unsaturated. The proportion of unsaturated acids is a useful identity characteristic. The total number of unsaturated bonds is readily measured by the Iodine Value – literally the number of grams of iodine needed to react with the double bonds in 100gm of oil. Being natural products, oils show some variation due to variety and growing conditions. For example, the iodine value for palm oil is 50-55, palm olein is 56 or higher, palm super olein is 60 or higher and palm stearin is 48 or less.

Melting Point (MP) :

It measures the physical properties of oil. Fats are mixtures of different glycerides, so they melt over a range of temperatures. A conventional method of obtaining a clear-cut result is used. The 'slip melting point' is obtained by filling a capillary tube with the sample in liquid form, crystallizing it under precise cooling conditions, and then determining the point at which the sample rises in the tube when heated in a waterbath. The sample is not completely molten but a precise reproducible figure is obtained. For palm oil, MPOB (Malaysian Palm Oil Board) have established a range of 33-39°C. PORAM and Codex have adopted a slip melting point of 24°C or less for palm olein, and 44°C or more for palm stearin. Codex also gives a point of 19.5°C or less for palm super olein.

Methyl and Ethyl Esters of Fatty Acids (FAMEs/FAEEs) :

The presence of FAMEs and FAEEs in oil is indicative of an occurred reaction of free fatty acids with methanol (formed by degradation of cell walls) or ethanol (formed during fermentation processes). Their presence indicates an incorrect manipulation of palm oil or a slight oil deodorization (to eliminate off-odors produced by microorganisms). Their content can be measured without carrying out any oil saponification and using appropriate preparative chromatography, performed prior to the analysis by GC. Some important parameters in palm oil analysis are described below.

Moisture & Impurities (M&I) :

There is an optimum moisture level to maintain freshness and to prevent further damage of the palm oil quality. Impurities are undesirable and are a source of microbes together with moisture. The impurities come from debris, the bulk of which is picked up during loose fresh fruit bunch collection. It is recommended that the two parameters should have their own limits-i.e. moisture 0.17% and Impurities 0.08%.

Oxidation Test (PV & AV) :

The peroxide value is a direct measure of the amount of oxygen that has combined at the double bonds of the fatty acids. In time these oxidised bonds are broken, resulting in short chain volatile compounds and residues of oxidised glycerides. These residues are measured by the Anisidine Value. A high figure is an indication that oxidation has taken place in the past, and there has been a loss of quality. The two are sometimes combined – 2 x Peroxide + 1 x Anisidine is defined as the Totox Value. While convenient, it entails some loss of information.

Saponifiable Matter :

Composed of substances able to form soaps with an ester functional group that can be hydrolyzed under basic conditions. These include triglycerides, phospholipids, glycolipids, sphingolipids, cholesteryl ester, or waxes. Since saponifiable components of the original oil mixture do form soaps, the result of a soap making procedure is a mixture of soaps and other, frequently oily, materials.

Tocopherol / Tocotrienols Content (Vitamin E) :

The major forms of tocopherols and tocotrienols present in palm oil are alpha-tocopherol and gamma-tocotrienols. Tocopherols and tocotrienols are antioxidants and provide some natural oxidative protection to the oil. They are especially important in RED palm olein because of the uniquely long shipment and storage times for the cooking oil. It is amphipathic and lipid-soluble compounds that are easily oxidized when subjected to heat, light and alkaline conditions.

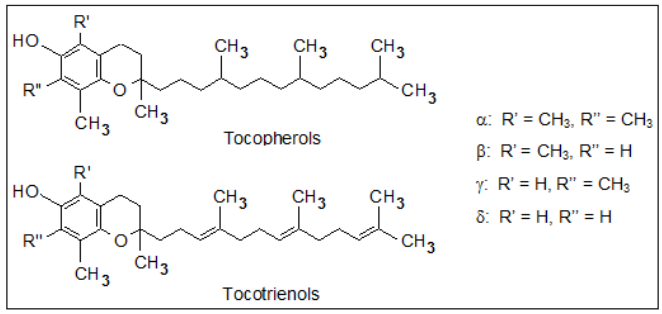


Fig 1: Schematic representation of Tocopherols and Tocotrienols.

Triglycerides (TG) :

Also called triacylglycerol (TAG), is a chemical compound formed from one molecule of glycerol (a trihydric alcohol containing three -OH hydroxyl groups) and three fatty acids that release water (H2O) as a by-product. Triglycerides are the main constituents of vegetable oils and animal fats. It has lower densities than water (they float on water), and at normal room temperatures may be solid or liquid. When solid, they are called "fats" or "butters" and when liquid they are called "oils".

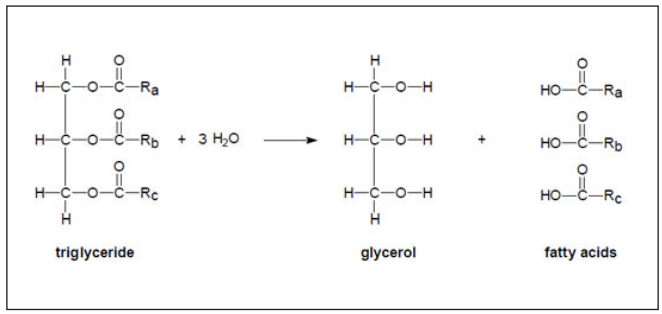


Fig 2: Schematic representation of formation of triglyceride with water as a by-product.

Unsaponifiable Matter :

Unsaponifiables are fraction of substances in oil & fat that fail to form soaps when blended with sodium hydroxide, but it is soluble in ordinary fat solvent.

Unsaponifiable constituents are an important from a nutritional and analytical point of view to check the authenticity of the oil and its stability. Unsaponifiables can be beneficial to a soap formula because they may have properties such as moisturization, conditioning, vitamins, texture, etc. On the other hand, if the proportion of unsaponifiables is too high, or the specific unsaponifiables present do not provide significant benefits, a defective or inferior soap product can result. It is defined as the substances soluble in oil which after saponification are insoluble in water but soluble in the solvent used for the determination. It includes lipids of natural origin such as sterols, higher aliphatic alcohols, antioxidants, waxes, pigments, fat-soluble vitamins and hydrocarbons as well as any foreign organic matter non-volatile at 100°C e.g. mineral oil which may be present.

PARAMETER	DEFINITION / PRINCIPLE	ANALYTICAL METHOD	TRADITIONAL TECHNIQUE	PERKINELMER PALM OIL SOLUTION TECHNIQUES	ADVANTAGES
Fatty Acid Composition (FAC)	Determination of FAME (C_6-C_{20}) by Normalize %	AOCS Ce 1e-91	GC-FID (Capillary Column)	Clarus GC-FID (Capillary Column)	Provides fatty acid profile, including normalized percentage of individual FAME, of different types edible oil & fat products.
Triglyceride (TG) Content	Separation of glyceride group, identification by reference to a standard TG solution, content determination by peak areas ratio	AOCS Ce 5-86	GC-FID (On Column Injection)	Clarus GC-FID (On Column Injection)	Provides detailed TG profile of different types edible oil & fat products, by reporting the TG Carbon Number in the sample.
Trans Unsaturated Fatty Acid Content	Determination of FAME (C_{18}:1, C_{18}:2, C_{18}:3) relative to total FAC	AOCS Ch 2a-94	GC-FID (Capillary Column)	Clarus GC-FID (Capillary Column)	Provides trans-fatty acid profile of different types edible oil & fat products.
Total Isolate (non-conjugated) Trans-fat	Rapid (5 min) determination of trans fat (trans conjugated linoleic acid, C_{18}:2 isomer), absorption bands near 990, 984 & 950cm^{-1}	AOCS Cd 14e-09	FTIR	Trans Fat FTIR Analyzer	- Ensures regulatory compliance at reduced cost - Easy to implement – out of the box solution - Fast results (<1 minute) - No sample preparation - No solvents - Can measure liquid and solids fats - AOCS recommends for >1%
Antioxidant: BHA, BHT, TBHQ	Extraction of antioxidant follow by separation and determination with a calibrated standard	AOCS 938.15	HPLC	Flexar HPLC	
DOBI (For CPO Only)	Ratio Abs 446nm: 269nm for 0.5-1% oil sample in iso-octane or n-hexane	MPOB p2.9	UV-Vis Spectrophotometer	Lambda 365 UV-Vis Spectrophotometer	Pre-programmed DOBI method for easy operation, simply click to measure and display DOBI values
Carotene Content	Absorbance at 446nm calculated as beta carotene (PPM)	MPOB p2.6	UV-Vis Spectrophotometer	Lambda 365 UV-Vis Spectrophotometer	Pre-programmed Carotene method for easy operation, simply click to measure and display Carotene values
Anisidine Value	100 times of optical density at 350nm resulting from the reaction of 1g of oil with 100ml of solvent & anisidine reagent. (to determine the amount of aldehydes, 2-alkenals)	AOCS Cd 18-90	UV-Vis Spectrophotometer	Lambda 365 UV-Vis Spectrophotometer	Pre-programmed Anisidine method for easy operation, simply click to measure and display Anisidine values

PARAMETER	DEFINITION / PRINCIPLE	ANALYTICAL METHOD	TRADITIONAL TECHNIQUE	PERKINELMER PALM OIL SOLUTION TECHNIQUES	ADVANTAGES
Phosphorous Content	Ashing the oil sample together with Mg) followed by colorimetric as Phospovanadomolybdic complex (ppm)	AOCS Cd 18-90	UV-Vis Spectrophotometer	Lambda 365 UV-Vis Spectrophotometer	Pre-programmed Phosphorus method for easy operation, simply click to measure and display Phosphorus values
Fe, Cu, Ni, Pb, Cd	Ashing the oil sample followed dissolvation with diluted HCl and analysed by direct aspiration, determination with their respective calibrated standard solution.	AOAC 999.11	AAS, ICPOES	PinAAcle 500 AAS Avio 200 ICPOES	Single element technique by AAS or rapid and high throughput multi-elements analysis by ICPOES in single run for macro and micro nutrients.
P, K, Mg, Ca, B, Cu, S, Zn	Fertilizer Samples are prepared as according to MS 417	MS 417	AAS, ICPOES	PinAAcle 500 AAS Avio 200 ICPOES	Single element technique by AAS or rapid and high throughput multi-elements analysis by ICPOES in single run for macro and micro nutrients.
Na, K, Mg, Ca	Soil Nutrient Status – Effective cation exchange capacity	Extraction EPA 9080 or 9081	AAS, ICPOES	PinAAcle 500 AAS Avio 200 ICPOES	Single element technique by AAS or rapid and high throughput multi-elements analysis by ICPOES in single run for macro and micro nutrients.
P, K, Mg, Ca, B, Cu, S, Zn	Leaf nutrient	Closed Microwave EPA 3052 Or Dry ashing and followed by acid digestion	AAS, ICPOES	PinAAcle 500 AAS Avio 200 ICPOES	Single element technique by AAS or rapid and high throughput multi-elements analysis by ICPOES in single run for macro and micro nutrients.
Cu, Fe, Zn, Cd, Pb	Dry ashing the oil sample followed dissolvation with diluted HNO_3 and analysed by direct aspiration, determination with their respective calibrated standard solution.	AOAC 999.11	AAS	PinAAcle 900Z AAS	Single element technique by AAS. Fiber optic system, Transverse Heated Graphite Atomizer (THGA), Longitudinal Zeeman effect (LZE) GFAAS technique provide accurate determination
As, Cd, Hg, Pb, (Edible Oil)	Oil samples are digested by HNO_3, H_2O_2 in closed vessels microwave digestor or direct organic oil sample aspiration , determination with their respective calibrated standard solution.	AOAC 2015.01	ICP-MS	NexION 1000 ICPMS	Rapid and high throughput multi-elements ICP-MS analysis in single run for trace elemental analysis.

PARAMETER	DEFINITION / PRINCIPLE	ANALYTICAL METHOD	TRADITIONAL TECHNIQUE	PERKINELMER PALM OIL SOLUTION TECHNIQUES	ADVANTAGES
Cr, Cu, Fe, Ni, Mn	Oil sample dissolved in MIBK or MIBK+HNO3, direct injection into GFAAS using calibration solution of organometallic reference compounds.	MPOB p2.11:2004 AOCS Ca 18-79	GFAAS	PinAAcle 900Z AAS	Fiber optical system, Transverse Heated Graphite Atomizer (THGA), Longitudinal Zeeman effect (LZE) GFAAS technique provide accurate determination
Cr, Cu, Fe, Ni	Sample dissolved in MIBK, direct aspiration AAS using calibration solution of organometallic reference compounds.	MPOB p2.10:2004 AOCS Ca 15-75	AAS	PinAAcle 900Z AAS	Fiber optical system, Transverse Heated Graphite Atomizer (THGA), Longitudinal Zeeman effect (LZE) GFAAS technique provide accurate determination
Phosphorous	Direct oil analysis with simple dilution in GFAAS (LGE Zeeman correction)	MPOB p2.8 Part 2:2004	GFAAS	PinAAcle 900Z AAS	Single element technique by AAS
Chloride	Dry ashing the oil sample followed dissolvation with diluted HNO3 and analysed by direct aspiration, determination with their respective calibrated standard solution.	Dry ashing and followed by acid digestion	ICPOES, ICPMS	Avio 200 ICPOES Nexion 1000 ICPMS	Rapid Chloride (Precursor of 3MCPD) analysis by ICPOES & ICPMS in oil.
Phosphorous	Direct oil analysis depending on the dilution solvent, from crude oil to degummed, refined, bleached, deodorized	AOCS Ca 20-99	ICPOES	Avio 200 ICPOES	Rapid and high throughput phosphorous analysis by ICPOES in oil.
As, Pb, Sn, Hg, Cd, Sb	Edible oil in Food Act and Regulations, Schedule 14	Food Act and Regulations Schedule 14	AAS ICPOES ICPMS	PinAAcle 900Z AAS Avio 200 ICPOES NexION 1000 ICPMS	Single element technique by AAS or rapid and high throughput multi-elements analysis by ICPOES / ICPMS in single run for heavy metal in edible oil analysis.
P, Ca, Mg, K, Na	Biodiesel, FAME determination. Sample shall be diluted with xylene or other suitable solvent	EN 14214:2003 EN 14107:2003 EN 14538:2006	ICPOES	Avio 200 ICPOES	Rapid and high throughput multi-elements analysis by ICPOES in biodiesel.
Na	Biodiesel, FAME determination of sodium content	BS EN 14108:2003	AAS	PinAAcle 500 AAS	Single element technique by AAS. Fiber optic system provide accurate determination

PARAMETER	DEFINITION / PRINCIPLE	ANALYTICAL METHOD	TRADITIONAL TECHNIQUE	PERKINELMER PALM OIL SOLUTION TECHNIQUES	ADVANTAGES
K	Biodiesel, FAME determination of potassium content	BS EN 14109:2003	AAS	PinAAcle 500 AAS	Single element technique by AAS. Fiber optic system provide accurate determination
Ca, Na, P, Ng, K, Fe, Zn, Cu, Mn, Co, Mo, As, Pb, Cd	Animal feeding stuffs	BS EN 15510:2017	ICPOES	Avio 500 ICPOES	Rapid and high throughput multi-elements analysis by ICPOES In animal feeds
Cd, Pb	Animal feeding stuffs	BS EN 15550:2017	GFAAS	PinAAcle 900Z AAS	Fiber optical system, Transverse Heated Graphite Atomizer (THGA), Longitudinal Zeeman effect (LZE) GFAAS technique provide accurate determination
Free Fatty Acid Value	Mg KOH/g sample	AOCS Ca 3a-46	Acid-base Titration	Palm Oil Analyzer	Pre-calibrated FFA method using similar palm oil samples for easy operation, simply scan to measure and display values
Volatile Matter (Moisture)	Loss in weight when heated to 103°C (at least 15 min)	AOCS Ca 2a-25	Oven and Balance	Palm Oil Analyzer	Pre-calibrated Volatile matter method using similar palm oil samples for easy operation, simply scan to measure and display values
Moisture			Karl Fischer Titration	Palm Oil Analyzer	Pre-calibrated moisture method using similar palm oil samples for easy operation, simply scan to measure and display values
Impurities	Insoluble in n-hexane	AOCS Ca 3a-46	Gravimetric	Palm Oil Analyzer	Pre-calibrated Impurities method using similar palm oil samples for easy operation, simply scan to measure and display values
Peroxide Value (PV)	Meq active O_2/Kg sample which O KI	AOCS Cd 8-53	Iodometric Titration	Palm Oil Analyzer	Pre-calibrated Peroxide Value method using similar palm oil samples for easy operation, simply scan to measure and display values
Iodine Value (IV)	Degree of unsaturation express in number of gram I_2 absorbed by 100g of fat	AOCS Cd 1d-92	Iodometric (back titration) Wijs method	Palm Oil Analyzer	Pre-calibrated Iodine value method using similar palm oil samples for easy operation, simply scan to measure and display values

PARAMETER	DEFINITION / PRINCIPLE	ANALYTICAL METHOD	TRADITIONAL TECHNIQUE	PERKINELMER PALM OIL SOLUTION TECHNIQUES	ADVANTAGES
Saponification Value (SV)	Mg KOH to saponify 1g of fat Splitting of oils and fats by hydrolysis, or under basic conditions saponification, yields fatty acids, with glycerin (glycerol) as a byproduct. The split-off fatty acids are a mixture ranging in carbon chain length from C_4 to C_{18}, depending on the type of oil or fat	AOCS Cd 3-25	Acid-base Titration	Palm Oil Analyzer	Pre-calibrated Saponification Value method using similar palm oil samples for easy operation, simply scan to measure and display values
2-MCPD, 3-MCPD Fatty Acid Ester and Glycidol fatty Acid Ester	Indirect determination of 2-MCPD, 3-MCPD fatty acid ester and Glycidol fatty acid ester by acid transesterification as PBA derivative prior to GCMS analysis	AOCS Cd 29a-13 AOCS Cd 29b-13 AOCS Cd 29c-13	GCMS	Clarus GCMS SQ8 (SIM mode) with autosampler, PSS injector and an Elite-5MS (non-polar) capillary column	Single preparation method to determine 3 parameters by GCMS analysis. SMART source for fast and easy access maintenance.
Determination of Tocopherols and Tocotrienols in vegetable oils and fats	Dissolution of oil or fat in organic solvent and direct HPLC separation of the individual Tocopherols and Tocotrienols		HPLC	Flexar HPLC	

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Choose the LAMBDA™ 265 for routine UV / Vis applications including liquids analysis.
Range: 190 nm - 1100 nm
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Range: 190 nm - 1100 nm
Bandwidth: 0.5 nm - 4 nm (variable)
Integrating sphere option

LAMBDA™ 465

Choose the LAMBDA™ 465 for measurements on turbid and light-scattering liquid samples and suspensions.
Range: 190 nm - 1100 nm
Bandwidth: 0.5 nm - 4 nm (variable)
Pre-monochromator for reduced stray light

Features & Benefits

- Double-beam design for highest stability.
- High throughput, low stray-light optics for high accuracy
- Pre-aligned lamps for easy replacement and minimal downtime

PerkinElmer Palm Oil Analyzer

Rapid quality control of palm oil parameters is easily achieved with the PerkinElmer FT-IR Palm Oil Analyzer. The analysis is to provide an effective solution in time and cost savings for the palm oil industry. Each run including results display takes less than 1 minute

The instrument can be configured for liquids only to perform key quality parameters analysis of palm oil. It can also be configured with the Near Infrared Reflectance Accessory NIRA to analyze both liquid and solid samples.

PerkinElmer Palm Oil Analyzer with NIRA Accessory

Key Benefits of PerkinElmer FT-IR Palm Oil Analyzer

- Fast
- Cost effective
- Requiring minimal sample preparation
- No use of chemicals (no wet chemistry)
- Simultaneous multiple parameters analysis

PerkinElmer FTIR Palm Oil Analyzer able to analyze both solid and liquid samples easily.

Liquid Sample Parameters

- Free Fatty Acids (FFA)
- Iodine Value (IV)
- Moisture Value
- Impurities
- Adulterants
- Fatty Acid Composition (FAC)

Solid Sample Parameters

- Oil Content, Volatile Matter (VM) and Moisture in Palm Kernel Expeller (PKE)
- Oil Content in Spent Earth (SE)

Advantages of PerkinElmer FTIR Palm Oil Analyzer in Palm Oil Analysis

The instrument comes with:

- Preset calibrations or only requiring calibration fine-tuning on site with ready method settings for quick start
- Calibrations of most parameters are from similar palm oil standards and not from other edible oils such as olive oil, sunflower oil, etc. which are not exactly the same as the samples being run.
- Vial drop-in heatable cell for correct liquid transmission measurement of the oil samples
- Disposable glass vials to eliminate cleaning (Standard 10 mm cuvettes can also be used and provided if required).
- Preheater to warm up samples to required temperature to reduce waiting time
- Absolute virtual instrument (AVI) technology for
  - ~ Improve calibration transfer between instruments
  - ~ Accurate wavelength calibrations with all accessories

Calibration Transfer with Absolute Virtual Instrument (AVI)

- Although FT-IR spectrometers use a reference laser, the wavenumber calibration and lineshape are affected by differences in beam divergence and uniformity
- True for all FT-IR spectrometers
- These differences can occur:
  - ~ Between instruments
  - ~ When using different sampling accessories
  - ~ When components are changed
  - ~ AVI allows calibration and lineshape to be maintained
- AVI measures the current instrument performance relative to an absolute standard (methane) and an ideal lineshape function
- Applies correction
- Uses an on-board methane gas cell to provide correction for any sampling configuration

Using AVI provides you with the critical assurance that your instrument is optimized with respect to these important calibration parameters at all times, not just immediately follow a service engineer's call. With AVI, the calibration curves that have been built painstakingly for different parameters on one instrument can be shared with other PerkinElmer FTIRs.

Key Features

Improved, more consistent FT-IR performance

- Actively standardizes instrument response function
- Traceable to know standards
- Maintains calibration despite resolution and sampling system changes
- Easy user recalibration when components are changed
- Improved calibration transfer between systems

Simple Implementation

- Avoides Master Instrument/ Slave Instrument transfer issues
- No hardware adjustment
- On-demand recalibration provides assurance throughout instrument life

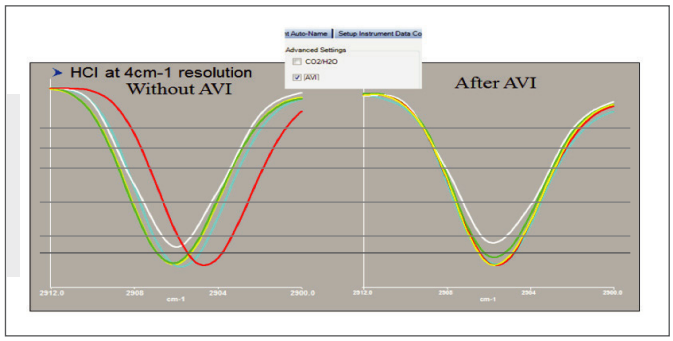


Fig 3: AVI correcting differences between instruments.

Quant Results

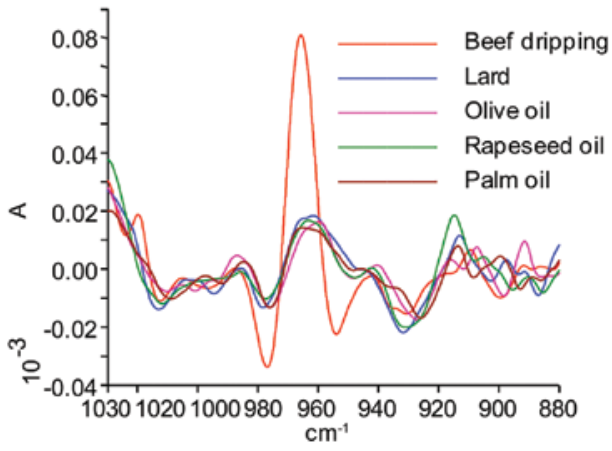
Sample Name	FFA (%)	Moisture (%)	IV
CPO009	2.9776	0.1296	54.3756

Fig 4: Multiple parameters analysis (FFA, IV and Moisture) results for Crude Palm Oil.

The Palm Oil Analyzer can be upgraded from a Near infrared System to a Dual Range Mid/Near Infrared System. This allows additional analytical capabilities such as

1) Biodiesel Analysis Add-on package for FAME biodiesel content analysis according to ASTM D7371 and EN 14078
2) Trans Fat Analysis Pack for implementation of AOCS Cd 14e-09 for trans-fat in edible oils and fats for reliable measurement at levels of 1% or better
3) Accessories such as ATR which to provide additional Mid-IR liquid or solid sampling which requires spectral interpretation

Which are not standard on the basic PerkinElmer Palm Oil Analyzer system to be expanded.



Commercial sample	TFA(%m)
Beef dripping	5.51
Lard	0.50
Olive oil	0.03
Rapeseed oil	0.32
Palm oil	0.25

Fig 5: Second-derivative spectra of commercial fat and oil samples, and the calculated trans-fat values with the Trans Fat FTIR Analyzer

Adulterant Screen: a new approach targets the knowns, screens for everything else, in crude and refined palm oil

For palm oil producers, nothing is as important as your brand. And to protect it, you need to know that the ingredients in your products are nutritious, safe, and authentic. But with the cost of raw ingredients steadily increasing, the temptations of economic adulteration can be strong.

Some adulterants such as glycerine, diesel, Hexane and recycled oil simply make for an inferior product. But others recycled oil – can be downright dangerous. And these substances and more can find their way into the end products and nutraceuticals customers rely on every day.

That's what Adulterant Screen™ based solutions are designed to prevent. With Adulterant Screen software on our FT-IR and NIR systems, everyone in your lab can easily add extra safeguards and perform pass/fail screening for adulterants and authenticity, with no sample preparation and no scientific background required, in a minute or less. Setup is simple, too, with customizable workflows and powerful results visualization features that you can add to your existing materials verification processes. And it works alongside the nutritional parameters you may be already testing for. Adulterant Screen solutions: Helping you guard against the next major food threat. And the next.

Adulterant Screen takes a novel approach to adulterant detection, with sophisticated algorithms that combine chemometric modelling and residuals analysis to detect both targeted and nontargeted economic adulterants. And it does it with high sensitivity – and without costly quantitative calibration development. What's more, it's an approach that prepares you for tomorrow's threats through simple system updates that sensitize the Adulterant Screen system to suspected adulterants – so you're always prepared for the next big adulteration threat.

Most food producers are concerned about particular adulterant in their ID verification testing. In addition to detecting abnormalities in routine identity confirmation, Adulterant Screen software can detect both targeted and nontargeted threats with statistical probabilities and semiquantitative amount estimates. It allows you to identify targeted adulterants with utmost sensitivity. Using a principal components model to handle spectral variability of acceptable samples, Adulterant Screen software gives fewer false negatives – and a high degree of confidence in your results. Plus, proprietary statistical residuals analysis detects relevant abnormal spectral components that could be due to adulterants.

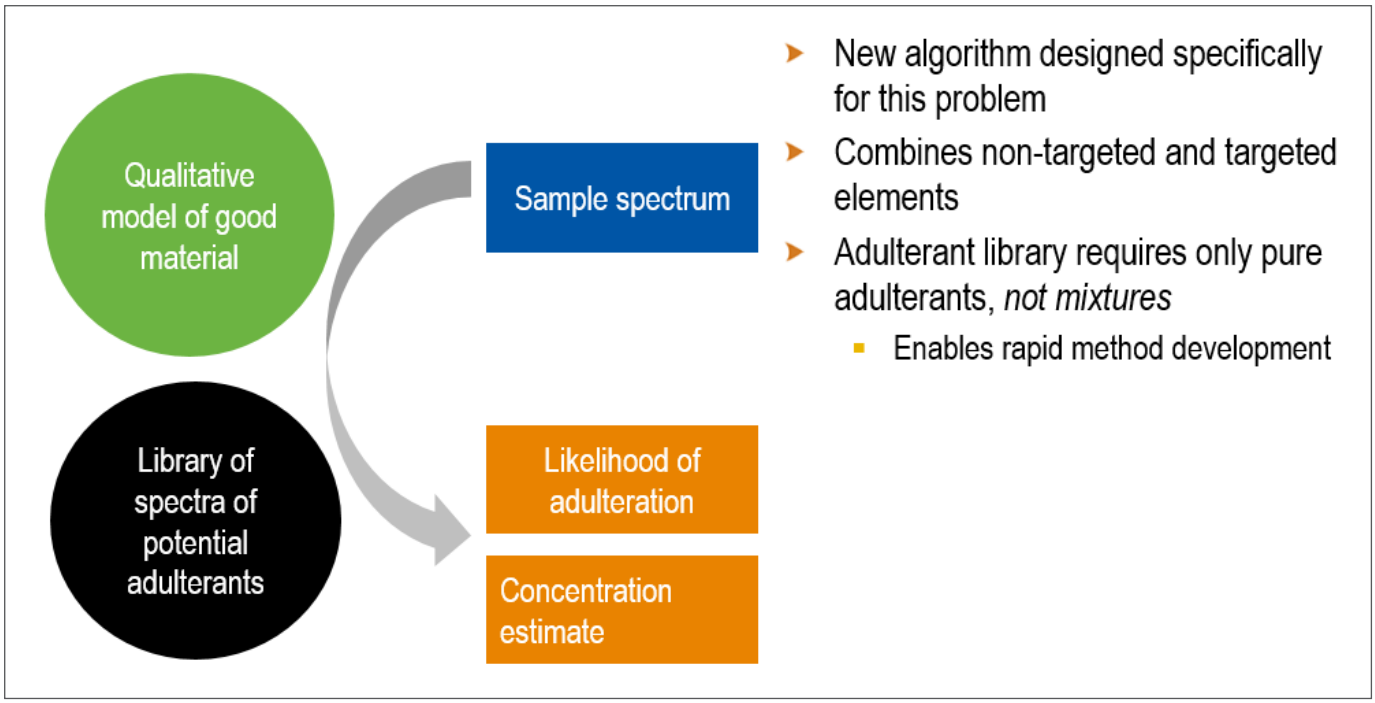


Fig 6: Adulterant Screen Novel Approach

The simple way to setup and test for all your parameters

With Adulterant Screen, you can detect for known and unknown adulterants right alongside your normal materials verification and quantitative measurements – and that goes a long way toward increasing confidence in your ingredients' purity and authenticity. All you need are spectra of pure materials and any pure threat you want to target – the software builds the model that includes acceptable batch-to-batch variability and is sensitive to the targeted threat.

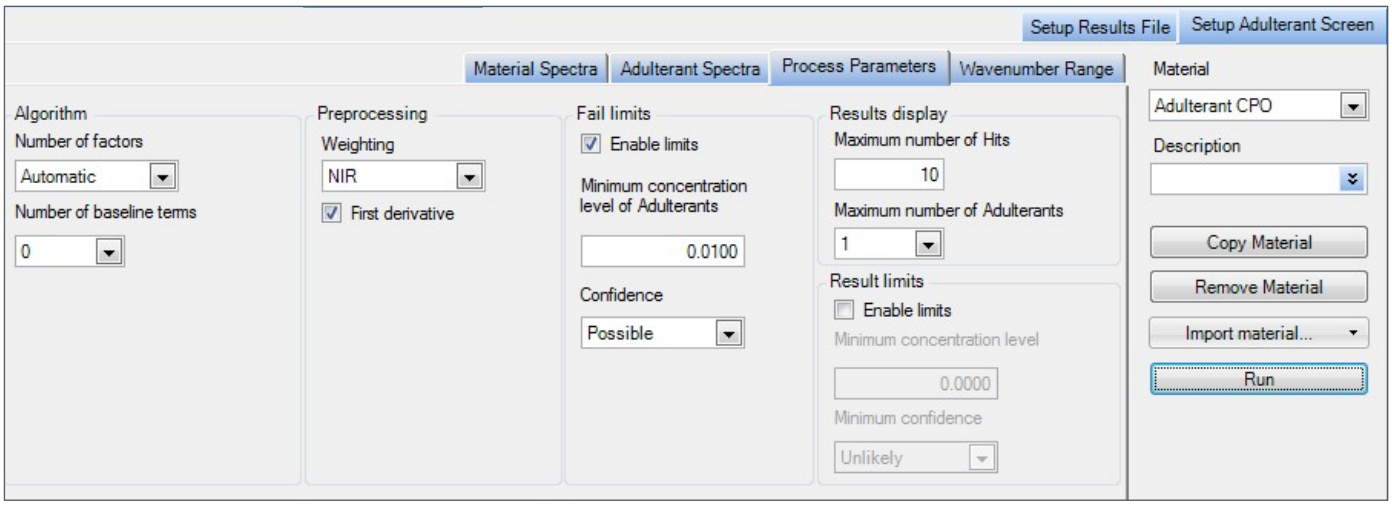


Fig 7: Adulterant Parameters Setting Up

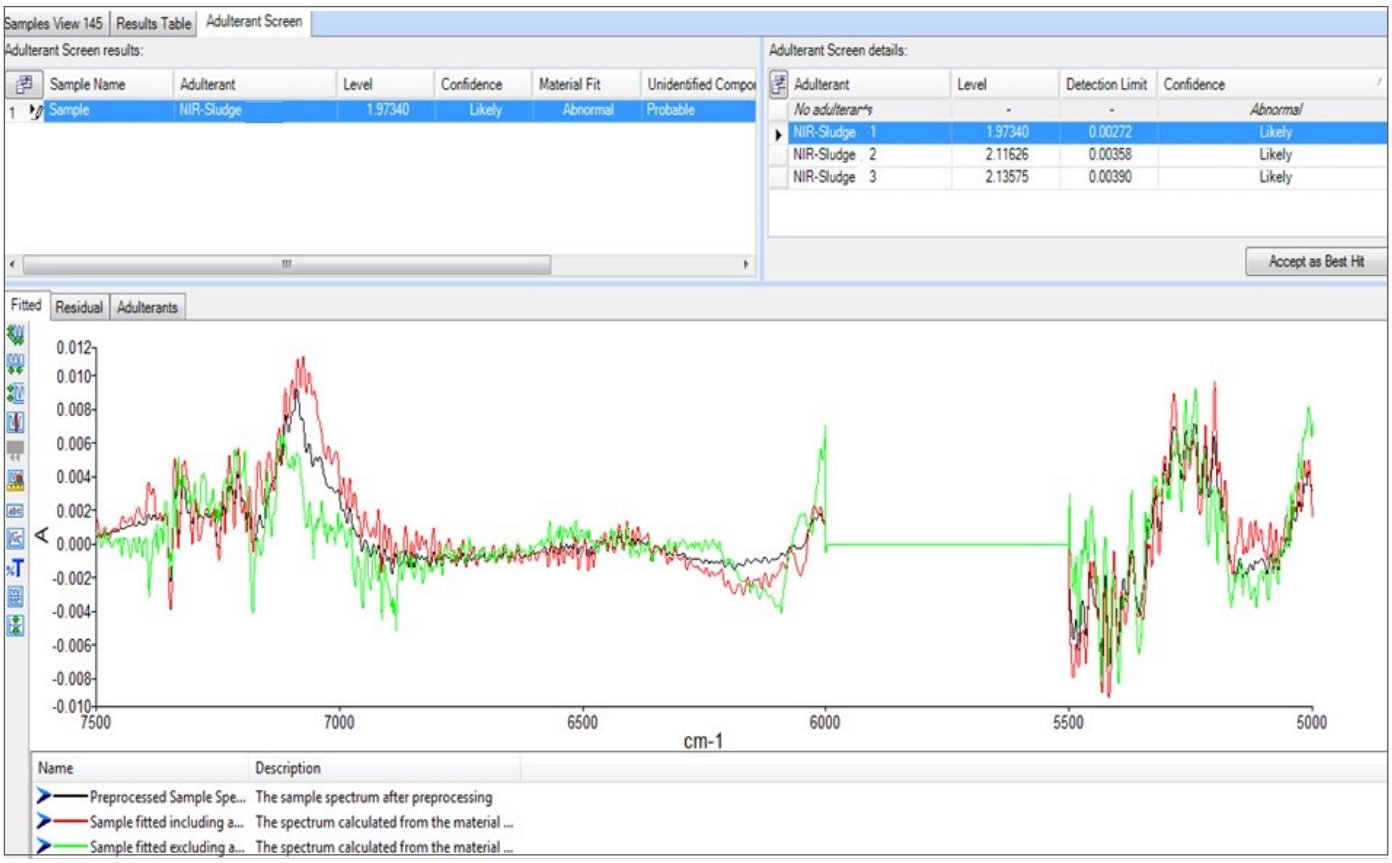


Fig 8: Adulterant Screen – Sample results

Soaps are sodium or potassium salts of long chain fatty acids. When triglycerides in fat/oil react with aqueous NaOH or KOH, they are converted into soap and glycerol. This is called alkaline hydrolysis of esters. Since this reaction leads to the formation of soap, it is called the **Saponification process** (Figure 9). The saponification reaction is exothermic in nature, because heat is liberated during the process. The soap formed remains in suspension form in the mixture. Soap is precipitated as a solid from the suspension by adding common salt to the suspension. This process is called **Salting out of Soap**.

If the saponification reaction is ineffective, free fatty acid (FFA) is presented. This would modify the alkalinity of the soap condition and affects its downstream applications.

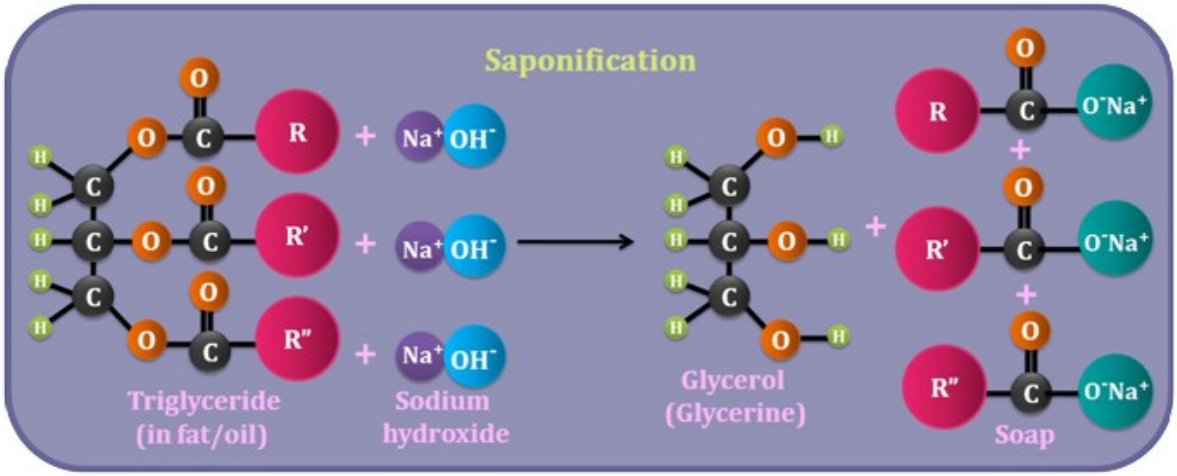


Fig 9: Saponification Process

The chemicals used in these wet chemistry methods in laboratories in the soap making industry runs into millions of dollars every year. PerkinElmer has developed a rapid FTIR-ATRand NIRA methods, that do not require sample preparation, using the PerkinElmer FT-IR Palm Oil Analyser. Both methods provide an effective environmental friendly solution and savings in both time and cost for the palm oil soap industry.

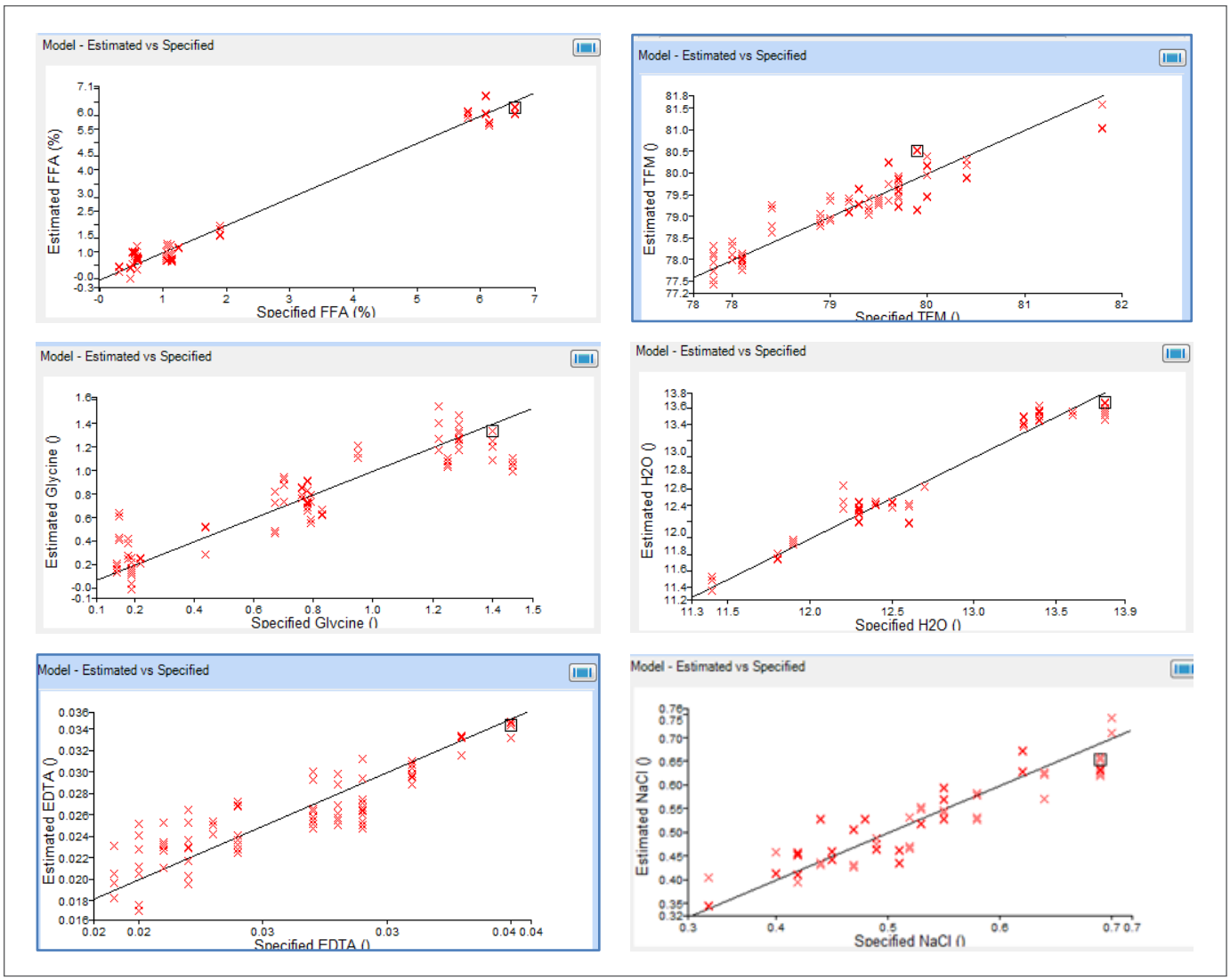


Fig 10: Calibration Models for Soap Noodle Parameters- FFA, TFM, Gly, H2O, EDTA & NaCl

Regression Summaries of Calibration Models for Soap Noodle Parameters- FFA, TFM, Gly, H2O, EDTA & NaCl using ATR and NIRA methods.

	Regression Summary	
Property	**FTNIR-NIRA Method % Variance (R squared)**	**FTIR-UATR Method % Variance (R squared)**
FFA	98.08%	97.98%
EDTA	66.60%	75.57%
Moisture	82.18%	79.45%
Glycine	86.64%	83.06%
TFM	79.33%	87.04%
NaCl	83.76%	82.59%

PerkinElmer FTIR Palm Oil Analyser with an UATR and NIRA accessories provide an alternative rapid analytical tool to the wet chemistry reference methods for quality control soap noodles parameters. The calibration models for parameters of FFA, TFM, Gly, H2O & EDTA are good and can be improved with more samples to cover the gaps and a wider composition range.

Spectrum Two N™ FT-NIR Spectrometer

PerkinElmer Palm Oil Analyzer – Spectrum Two N

The Spectrum Two N™ provides optimal spectral performance, highly robust and transportable and based on FT-NIR technique ensures ease-of-use, reliable with unparalleled accuracy and precision Near-IR analyses. It's the perfect instrument with versatilities that combine high-end performance with features such as portability and plug-and-play function featuring various accessories catering to different applications, allowing users with different levels of expertise, from novice to trained experts, to be able to operate proficiently and confidently with no time.

Key Features:

- Standard Atmospheric Vapor Compensation (AVC), Absolute Virtual Instrument (AVI), and Automatic Performance Verification (APV) features for accurate, precise and reproducible results, ensures data transferability between instruments.
- Widest range of sampling options with a plug-and-play NIR reflectance module (NIRM) for solid samples analysis, a heatable transmission module (HTM) for liquid samples analysis, and a triggered probe for through-container remote sampling module (RSM), easily switch between accessories for onboard solids reflectance, liquids transmission, or remote sample analysis.
- Specialized software modules, including Spectrum Touch™ for simplified workflows, prebuilt methods, and starter calibration models built-in. Spectrum Adulterant Screen for simple, yet sensitive detection of economic adulterants. Spectrum Quant™ Advanced Algorithms Pack for development of multivariate quantitative methods/calibration models for targeted parameters. Spectrum AssureID for development of SIMCA product verification methods for Spectrum 10, macros, or AssureID workflows.
- High-performance, room-temperature LiTaO3 (lithium tantalate) NIR detector.
- High-sensitivity and temperature stabilized InGaAs detector for quantitative analyses, low light applications.
- Optional Spectrum Two N Portability Pack enabling wireless connectivity, battery powered operation, and portability with the specific Spectrum Two N carry case.

Palm Oil Applications:

From upstream to downstream production, Frontier FTNIR and Spectrum Two N™ caters to your every palm oil application needs, whether for qualitative or quantitative analyses.

Sectors	Parameters
Palm Oil Plantation	• Straight, mixed, compound fertilizers analyses (N, P2O5, K2O, MgO, CaO, B2O3 etc.) • Ganoderma detection
Palm Oil Mill	• Crude Palm Oil, CPO • Free Fatty Acid, FFA • Moisture • Debris • Palm Kernel, PK • Oil Content • Free Fatty Acid, FFA • Moisture • Fresh Fruit Bunch, FFB • Oil Content • Moisture • Empty Fruit Bunch, EFB • Oil Content • Moisture • Press Cake Fibre, PCF • Oil Content • Moisture • Sludge • Oil Content • Moisture • Decanter Cake, DC • Oil Content • Moisture • Spent Earth • Oil Content • Mesocarp • Oil Content • Moisture

Sectors	Parameters
Palm Oil Refinery	• Refined, Bleached, Deodorized (RBD) Oil (Palmitic, Olein, Stearin-based) • Free Fatty Acid, FFA • Moisture • Iodine Value, IV • Peroxide Value, PV • Anisidine Value, AV • Solid Fat Content, SFC • Slip Melting Point, SMP
Downstream	• Fatty Acid Composition, FAC • Monoglycerides, Di- & Tri-glycerides • Adulterants Screening • Fatty Acid Methyl Ester, FAME • Iodine Value, IV • Anisidine Value, AV • Moisture • Shortening & Margarine • Free Fatty Acid, FFA • Iodine Value, IV • Peroxide Value, PV • Slip Melting Point, SMP • Moisture • Soap Noodle • Free Fatty Acid, FFA • Moisture • Total Fatty Matter, TFM • Glycine • Ethylenediaminetetraacetic acid, EDTA • Fatty Acid Composition, FAC • Sodium Chloride, NaCl

PerkinElmer Palm Oil Online NIR Analyzer – DA7440 and DA7300

From upstream to downstream production, Frontier FTNIR and Spectrum Two N™ caters to your every palm oil application needs, whether for qualitative or quantitative analyses.

DA7440

DA7300

Introduction

The process of palm oil production involves a number of stages from the sterilization of the oil palm fresh fruit bunch to the digestion, threshing and clarification of the oil. At each processing phase a different form of waste is produced. The milling process and plantation activities generate a large amount of solid waste consisting of trunks, fronds, leaves from the plantation and empty fruit bunch (EFB), palm oil mill sludge (POMS), palm kernel cake (PKC), decanter cake, fibre and shells from processing.

Traditional Soxhlet extraction which required 2 days to obtain oil loss data resulted more oil loss during the milling operation and less crude palm oil productivity. However, with the advancement in latest spectroscopy technologies of online NIR technology, this rapid NIR technique is able to monitor oil loss in minute so that the mill operation can have an effective control to reduce oil lost and improve oil productivity.

Complete solutions

When you buy an analysis system from us, we deliver a complete solution including instrument, installation and train¬ing, calibrations, software and after sales services. A Perten Instrument representative will install and train your staff locally. We offer calibration packages that range from basic needs to cutting edge applications. Our SimPLUS software allows you to control, monitor and maintain the DA 7300 NIR and DA7440 NIR as you see fit – locally or control a network of multiple instruments from a central location.

Save Money and Improve Quality

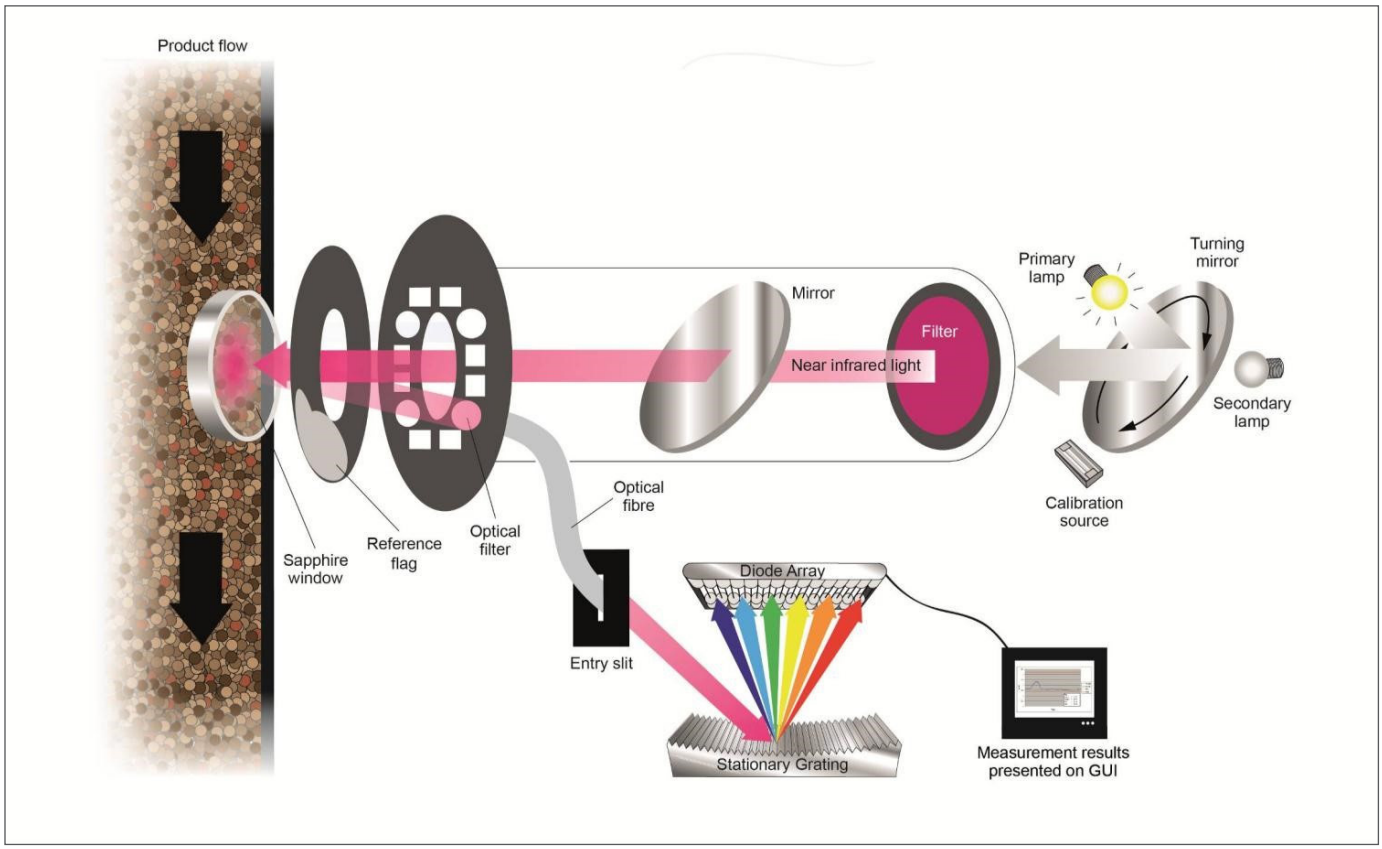
Our analytical instruments help you save money. They are all rapid, accurate, robust and easy to use - in other words they were designed for industrial use and will work equally well on the factory floor as in the lab. As they help you improve efficiency and save money, they typically pay back their cost in less than 6 months. These are some of the ways they can bring you benefits:

- determine oil lost, moisture and more in oil palm fruit bunch
- optimize pressing, extraction of oil from oil palm fruit bunch

What you can analyze

The following are the most commonly measured parameters. They can be determined on-line, at-line or in the lab.

- Moisture
- Oil content



DA On-Line Principles of Operation

Online DA 7300 & DA7440 User Interface

Thermal Analysis

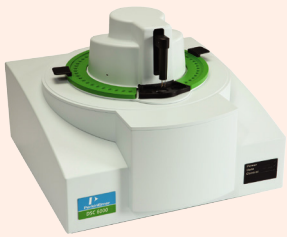
At PerkinElmer, we're committed to the future of thermal analysis. We've manufactured thermal analysis instrumentation since 1960, and no one understands the applications of DSC and TGA like we do. Whether you're performing QA/QC applications, or developing the cures of tomorrow, our advanced thermal analysis systems and hyphenated techniques will open your eyes to a world of exciting new opportunities

Differential Scanning Calorimeter (DSC)

The differential scanning calorimeter (DSC) is a fundamental tool in thermal analysis. It can be used in many industries – from pharmaceuticals to polymers and from nanomaterials to food products. The information these instruments generate is used to understand amorphous and crystalline behavior, polymorph and eutectic transitions, curing and degree of cure, and many other material properties used to design, manufacture and test products. DSCs are manufactured in several variations, but PerkinElmer is the only company to make both single and double-furnace styles.

DSC 4000

- Single furnace DSC
- Upgradable to 45-position autosampler
- Upgradeable to DSC 6000
- Low-mass furnace and easy-to-fit lids allows for fast measurements
- Integrated mass flow controller provides convenient gas control and switching
- Hardened nickel chromium plate with no exposed thermocouples makes cleaning easy
- Portable cooling device (PCD) enables cost-effective operation
- Temperature range and robustness prevents furnace oxidation



DSC 6000

- Single-furnace DSC
- Modulated Temperature DSC
- Upgradable to photocalorimeter accessory or 45-position autosampler
- Included enhanced software package
- MT-DSC enables the separation of kinetic and thermal events
- Liquid nitrogen cooling enables the faster cooling rates needed for challenging applications
- Advanced photocalorimeter accessory allows for the study of photocured materials
- Continuously increase your laboratory's capabilities with a variety of cooling system options and autosampler

DSC 8000

- All new double-furnace design delivers the most accurate heat-flow measurements
- Upgradable to 96-position autosampler
- Included enhanced software package
- Non-oxidating, chemically resistant platinum alloy furnaces
- Controlled heating and cooling for the most accurate results
- Upgradeable to DSC 8500
- Heating rates from 0.01 °C to 300 °C/min
- High-pressure cell option enabling measurement of samples to 600 psi
- Remote sampling head enabling measurements of hazardous samples
- Includes MT-DSC for understanding kinetic events
- Switch easily between cooling accessories in the lab – future proofing your investment

DSC 8500

- Double-furnace Hyper DSC
- Included enhanced software package
- Upgradeable to 96-position autosampler
- Extremely fast controlled scanning rates to 750 °C/min
- In-situ ballistic cooling to 2100 °C/min, enabling experiments that mimic real-world processes
- Extremely fast readout rates (100 points/second) providing high data Integrity
- Proven Hyper DSC superior in typical applications such as isothermal crystallization, polymorph/amorphous-material studies, high sensitivity measurements and process simulation

Thermogravimetric Analyzer (TGA)

The Thermogravimetric Analyzer (TGA) is an essential laboratory tool used for material characterization. It is a technique in which, upon heating a material, its weight increases or decreases. TGA is used as a technique to characterize materials used in various environmental, food, pharmaceutical, and petrochemical applications.

TGA 4000

- Compact footprint of top loading TGA
- High performance balance and furnace for maximum accuracy and precision
- Top loading balance for easy sample loading and unloading
- Furnace and balance isolated from operators to minimize maintenance, ensuring uptime
- Fast cooling reduces cycle times improving productivity
- Integrated mass flow controller extends applications flexibility
- Optional 45 position autosampler allows unattended operation, improving productivity
- Pyris software suite is easy to use and feature rich for maximum application flexibility

TGA 8000™

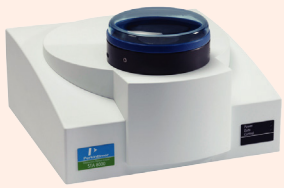
TGA 8000™ gives you complete control over your sample environment while delivering enhanced performance, maximum application flexibility, high throughput and reliability - even unattended. Plus our advanced hyphenation technology works beautifully with FT-IR, MS, GC/MS, and more for greater understanding of evolved gases.

Key Features

- High sensitivity ultra-microbalance
- Balance thermally isolated from furnace
- Fast cool-down increases throughput
- Most responsive temperature control gives accurate results
- Efficient gas switching gives reproducible results
- Ion stream eliminates static drift
- Autosampler runs 48 samples unattended
- AccuPik improves automated measurement of volatile samples
- Atmosphere control due to wide temperature range -20 °C to 1,200 °C
- High scan rates: 0.1 °C to 500 °C/min
- Mass-flow controlled gas environment
- iOS Application, iPhone® or iPad®, for local control and monitoring of auto load, furnace movement, and much more
- Colored illumination systems for unique identification of instrument run status
- Mixing of up to three gases with optional Gas Mixing Device
- Track sample position with patent pending positioning system in the autosampler
- Fully automated sample loading/ unloading
- Fast, simple, efficient coupling to FT-IR, GC/MS, MS when your work requires hyphenation

STA 6000

- Simultaneous analysis of TG with DTA mode (ΔT) and DSC (mW) mode for fast enhanced result interpretation
- Innovative patent pending SaTurnA sensor to measure both sample and reference temperature directly for superb performance
- Vertical displacement balance sensor (not rotational) provides weight insensitivity to sample position, e.g., no spurious weight change from melting



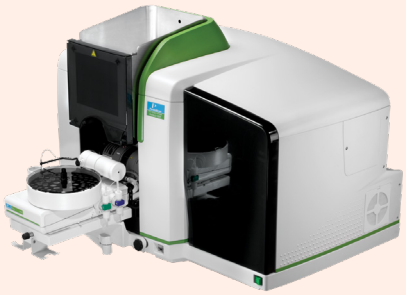
STA 8000

- Simultaneous analysis of TG with DTA mode (ΔT) and DSC (mW) mode for fast enhanced result interpretation
- Wide temperature range allows measurements from below room temperature to 1600 °C. Superior accuracy and sensitivity in a small package with an attractive price
- Superior weight, heat flow and temperature accuracy in a small package with an attractive price
- Top loading balance for ease of sample loading
- Balance below furnace for optimum isolation from contamination
- Vertical displacement balance sensor (not rotational) provides weight insensitivity to sample position, e.g., no spurious weight change from melting

Atomic Spectroscopy

Whether it's AA, ICP-OES, or ICP-MS - or all three - rely on us to help you with instrument choices, options, and, of course, great results. Plus, we are at your side with a wealth of documentation and with experienced user support. How can we help you?

Introducing new solutions from the world leader in Atomic Spectroscopy:



PinAAcle™ 900 or 500 AA Spectrometers

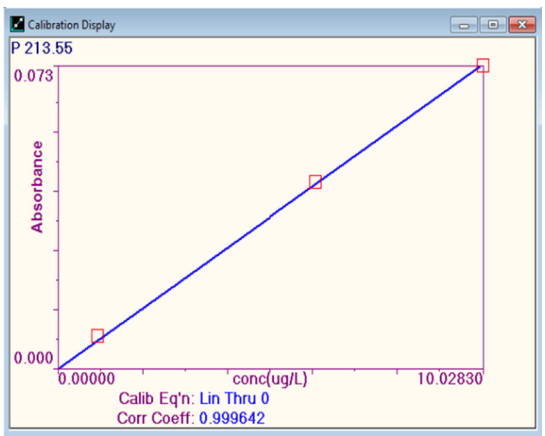
The PinAAcle™ series of atomic absorption (AA) spectrometers brings AA performance to new heights. Engineered with an array of exciting technological advances, it offers a variety of configurations and capabilities to deliver exactly the level of performance you need:

- Flame only, furnace only, or space-saving stacked designs featuring both
- Flame, furnace, flow injection, FIAS-furnace and mercury / hydride capabilities on a single instrument
- Choice of Deuterium or longitudinal Zeeman background correction
- TubeView™ color furnace camera simplifies autosampler tip alignment and sample dispensing
- Proven Syngistix™ software offering both ease-of-use and exceptional flexibility

And no matter which PinAAcle model you select (900F, 900Z, 900H, 900T or 500), you'll discover an intuitive, highly efficient system capable of simplifying your journey from sample to results—even with the most difficult matrices.

Direct oil analysis with simple dilution in PinAAcle 900Z GFAAS (LZE Zeeman correction) with improved sensitivity of Phosphorus, Copper, Iron & Nickel

Calibration curve and Peak Overlays for determination of Phosphorus in Palm Oil



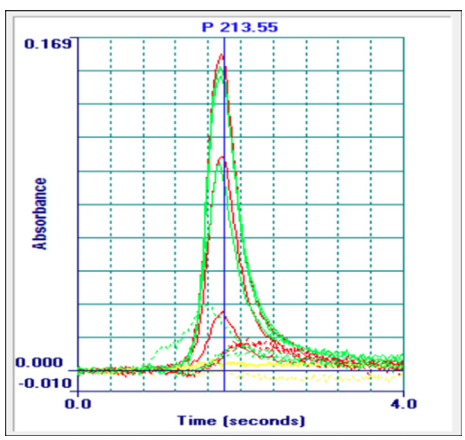


Fig 11: Calibration curve and Peak Overlays for determination of Phosphorus in Palm Oil

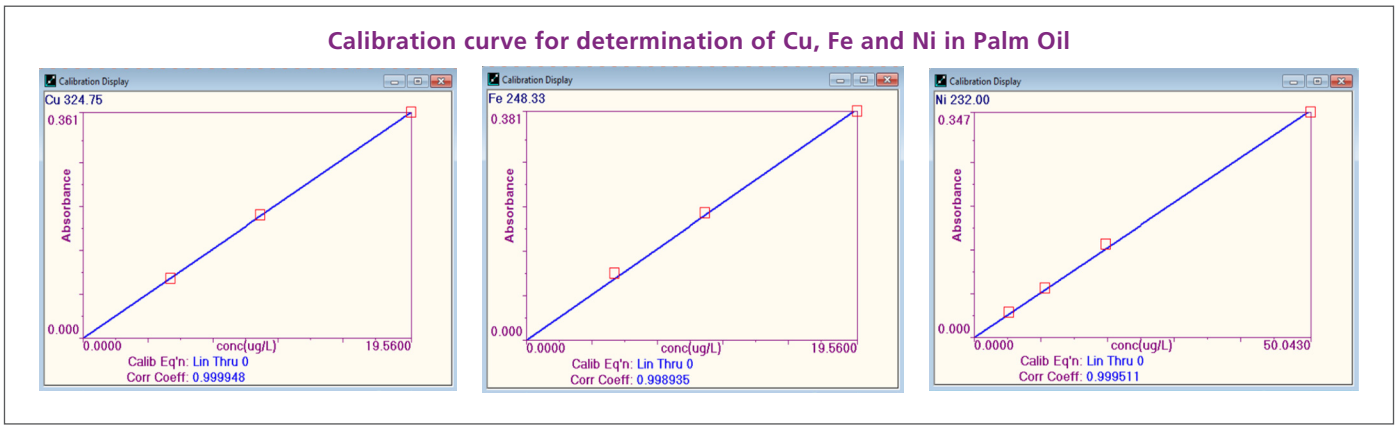


Fig 12: Calibration curve for determination of Cu, Fe and Ni in Palm Oil

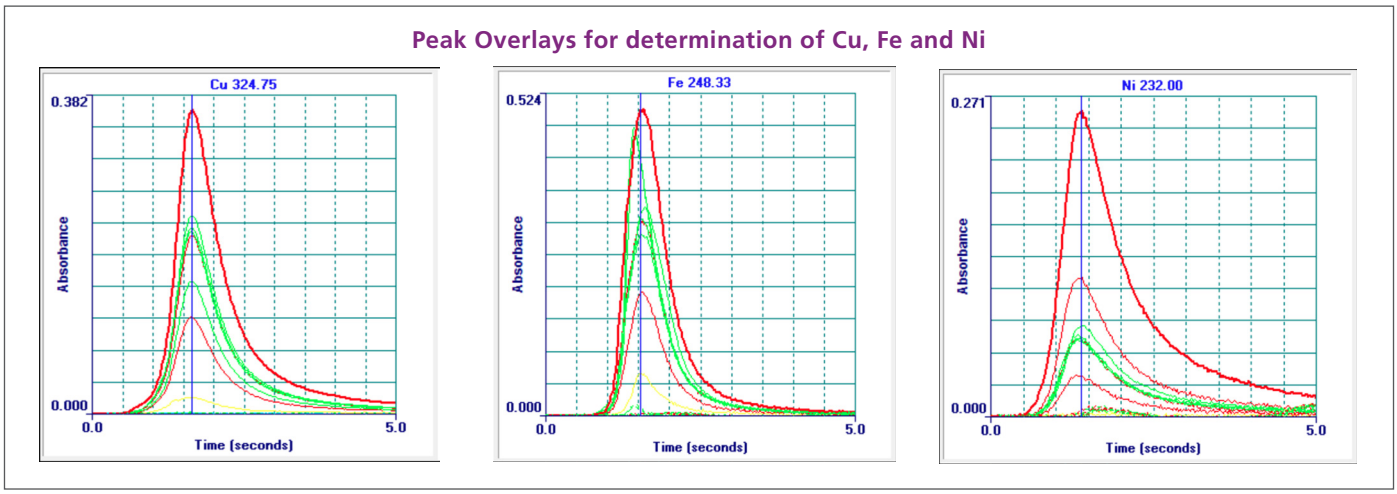


Fig 13: Peak Overlays for determination of Cu, Fe and Ni

Peak overlays for standards (red) and QC checks (green) run on the PinAAcle 900z for the analysis of Cu, Fe, and Ni in edible oils. Solid lines are the analytical signal after background correction (AA-BG); dotted lines are the background signal (BG).

Avio™ 500 or 200 ICP-OES Spectrometers

With its groundbreaking features and expanded capabilities, the Avio series is more than just an evolution of the world's most popular ICP-OES… it's a revolution. Built around the proven design of the Avio platform, delivers breakthrough performance through a series of cutting-edge technologies that enhance plasma stability, simplify method development and dramatically reduce operating costs:

- Flat PlateTM Plasma Technology — with a patented, maintenance-free RF generator uses half the argon of traditional systems dramatically reducing operating costs.
- Patented Dual View — offers radial and axial viewing of the plasma for effective measurement of elements with high and low concentrations in the same method.
- Simultaneous detection of all wavelengths at all times with no storage or sample time penalty with Universal Data Acquisition
- Greater uptime and sample throughput with PlasmaShear's maintenance-free design
- Unsurpassed matrix tolerance with vertical torch design
- PlasmaCamTM Viewing Camera — delivers continuous viewing of the plasma, simplifying method development and enabling remote diagnostic capabilities for maximum uptime.
- NEW SyngistixTM for ICP software – adds a whole new level of simplicity and productivity to ICP analysis through a workflow-based architecture, improving efficiencies in the laboratory.

The Avio is available in two models:

- Avio 200 – a bench-top, dual-view ICP-OES with full-wavelength-range CCD array detector, delivering flexibility and excellent analytical performance.
- Avio 500 – a bench-top, dual-view ICP-OES with two solid-state SCD detectors, delivering superior detection limits and true simultaneous measurements.

Rapid Chloride (Precursor of 3MCPD) analysis by ICPOES in oil. Calibration curve for determination of Cl in Palm Oil

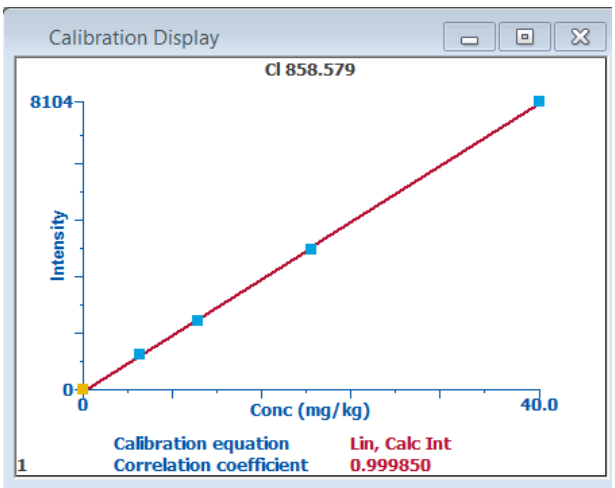


Fig 14: Rapid Chloride (Precursor of 3MCPD) analysis by ICPOES in oil. Calibration curve for determination of Cl in Palm Oil

NexION® 2000 or 1000 ICP-MS Spectrometers

With a data acquisition speed 10 times faster than any other ICP-MS on the market, the new NexION series ICP-MS open up a whole new world of efficiency and opportunity, allowing you to measure more in less time, and accurately characterize nanoparticles.

In addition to the exceptional application flexibility afforded by its speed, the instrument also delivers superior uptime and productivity through a variety of unique features engineered to enhance signal stability:

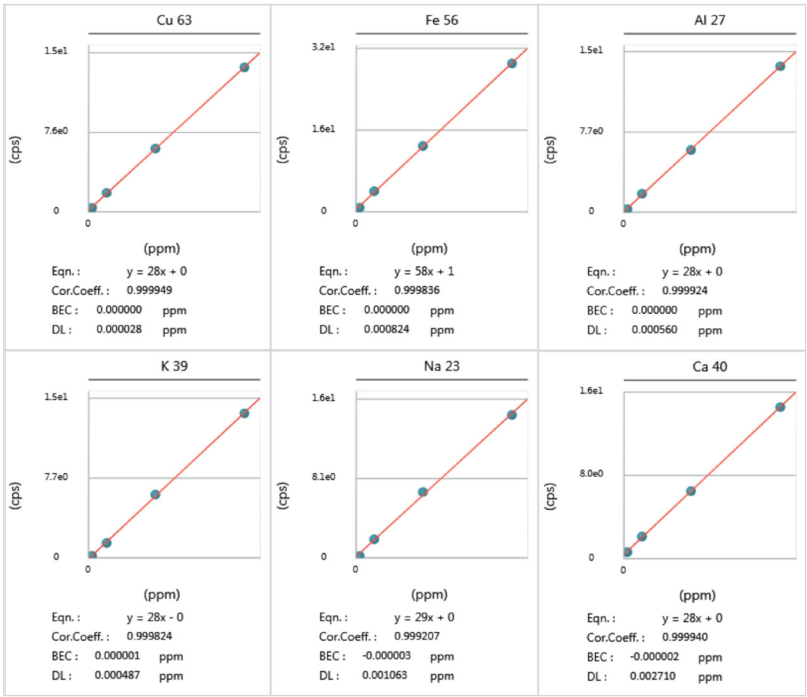
- Triple Cone Interface produces the industry's most tightly focused ion beam and prevents sample deposition on internal components.
- 1st Quadrupole - Quadrupole Ion Deflector turns positively charged ions 90° into the Universal Cell and filters off neutrals.
- 2nd Quadrupole – Quadrupole Cell (Universal Cell Technologies with super interference removal using DRC (Dynamic Reaction Cell) or KED (Kinetic Energy Discrimination) present in both models.
- Analyzing Quadrupole made of a unique steel alloy for negligible thermal expansion for unparalleled stability.
- No extraction lenses to clean for minimized maintenance.

Plus, the NexION series offers simple operation through PerkinElmer's Syngistix™ for ICP-MS, a new workflow-based software also designed to improve efficiencies in the laboratory. Syngistix features an easy-to-use, intuitive interface, along with new automated method setup tools for faster implementation. The software's optional dedicated Nano Application Module can be coupled with the NexION series ICP-MS for an unprecedented level of nanomaterial detection and characterization.

PerkinElmer's new NexION series ICP-MS includes an array of technical innovations that reduce background and interferences, optimize signal stability, minimize maintenance requirements and downtime, and generate better results. Find out for yourself.

Direct Analysis of palm oil samples via Nexion 2000

Calibration Curve for Aluminium, Arsenic, Copper, Iron, Calsium, Cadmium, Potassium, Sodium in palm oil



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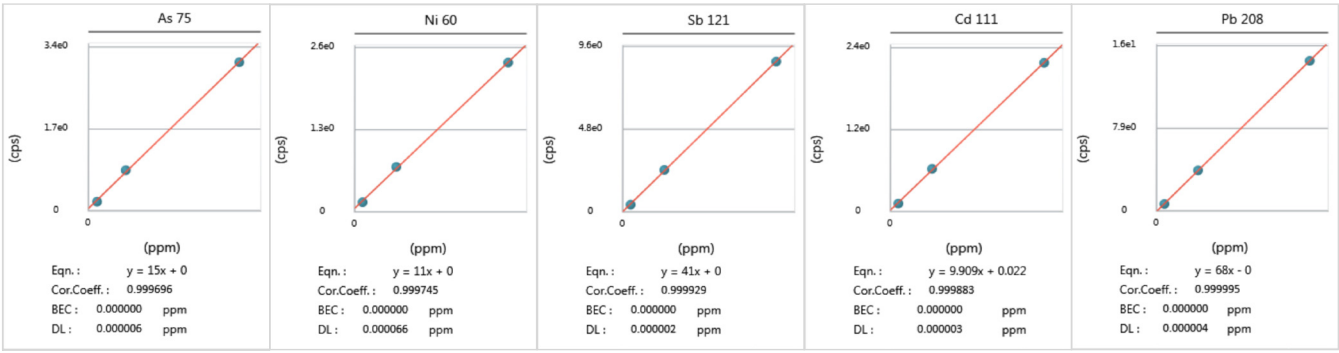

Fig 15: Calibration Curve for Aluminium, Arsenic, Copper, Iron, Calsium, Cadmium, Potassium, Sodium in palm oil

Chromatography System

As your instrument partner in chromatography, we deliver unrivalled flexibility. Whatever your application, requirements, or budget, we have a solution for you. GC, GC custom, GC/MS, LC/MS, HPLC/UHPLC — you can pick from extensive product lines in all of these technologies. Select the instruments that are best for you, and upgrade when you are ready.

We are the only chromatography vendor with a sample-handling and preparation solution. That's a simple way to save big. Fast. And we provide the software you need to analyze your results. From start to end. We have it all.

Clarus® 590

- Robust, proven design provides reliable performance year after year.
- Intuitive touch screen is easy to use
- Dual-channel, real-time signal display on the touch screen
- Flexible configurations with integrated headspace or thermal desorption, mass spectrometer or Swafer
- Multiple language support simplifies interaction and raises staff comfort level
- The Clarus 590 GC is the platform of several turn-key solutions for the Petrochemical industry (Refinery and Natural Gas analyzers), alternative energies (Biodiesel), environmental and forensic applications
- Scalable TotalChrom Chromatography Data Systems (CDS) make data management and reporting easier than ever.
- Complete instrument control through TotalChrom, TurboMass as well as Waters® Empower™ 2 and Agilent® EZChrom Elite™ drivers

Clarus® 690

Patented high-performance oven - the unique oven design of the Clarus 690 GC provides the fastest available heat-up and cool-down rate, enabling shorter injection-to-injection and analytical cycle times, maximizing your sample throughput and achieve maximum return on your investment

- Its twin-walled oven design with concentric air exhaust* allows the user to achieve greater separation at near-ambient temperatures without the use of special coolants, especially important for the analysis of Volatile Organic Compounds (VOCs).
- Fast oven heat-up allows faster chromatography, particularly useful when speeding up the elution of late eluting compounds.
- Fastest available cool-down rate is delivered using forced convection air. This greatly reduces non-productive time between runs.
- Universal Programmable Split-Splitless (PSS) and Programmable On-Column (POC) injectors design enables Large Volume Injection of volatile solvents and cold on-column injections without the use of expensive cooling agents
- Novel Swafer™ micro-flow technology dramatically simplifies complex tasks helping to make the Clarus 690 GC easily used by operators at all skill levels
- Complete instrument control is available through TotalChrom™, TurboMas™ as well as Waters® Empower™ 3 and Agilent® EZChrom Elite™ drivers.

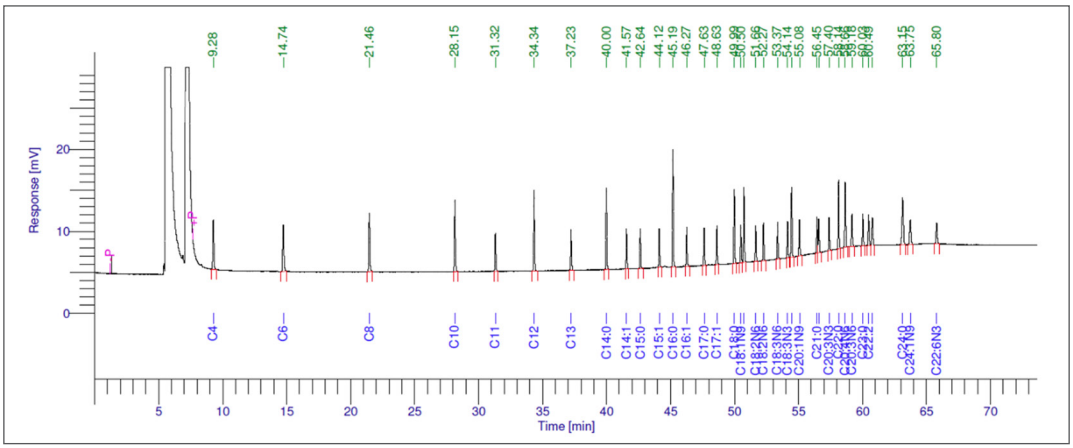

Fig 16: FAME chromatogram of palm oil samples using Perkin Elmer Clarus 690 –FID

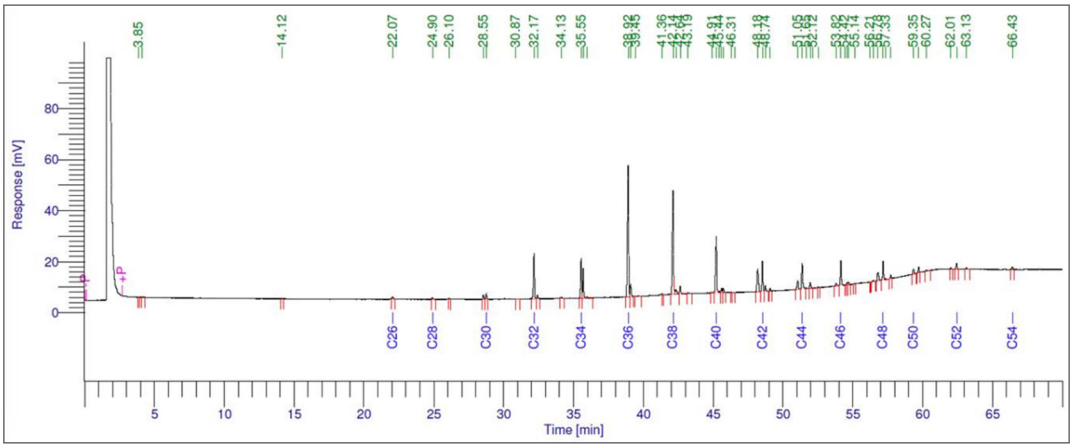

Fig 17: Triglycerides chromatogram of palm oil samples using Perkin Elmer Clarus 690 -FID

Clarus® SQ 8 GC Mass Spectrometers

Clarus® SQ8 GC/MS

- Most sensitive detector delivers exceptional sensitivity
- Easiest SMART source to access and maintain (EI and CI)
- Universal Programmable Split/Splitless (PSS) Injector
- Headspace and Thermal Desorption Sample Introduction Systems
- Marathon™ Filament delivers long life even under the most difficult chromatography conditions
- TurboMass GC/MS software delivers easy environmental compliance
- Fastest heat-up and cool-down oven in conventional GC

Choose from: Clarus SQ 8 S, Clarus SQ 8 T, Clarus SQ 8 C

Change ion source components less than 5 minutes without any tools!

Typical selected ion chromatogram of PBA derivative of 3MCPD, 2MCPD and 3MCPD-d5 and 3MBPD-d5 working Standard.

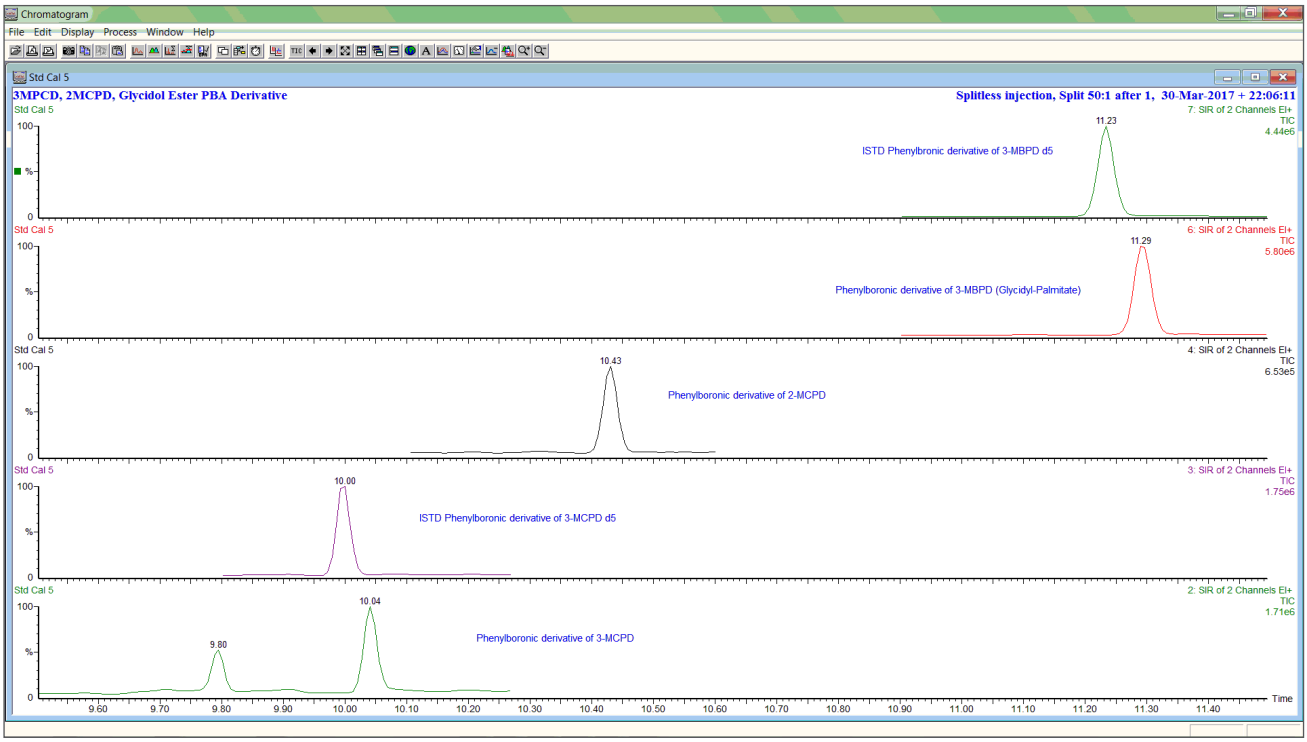

Fig 18: Typical selected ion chromatogram of PBA derivative of 3MCPD, 2MCPD and 3MCPD-d5 and 3MBPD-d5 working Standard.

Flexar™ HPLC/UHPLC

Flexar™ HPLC

Let's start with the basics – ergonomics, safety, reliability, ease, performance. You get it all with the Flexar LC. The elegant user interface is streamlined to improve throughput and optimize operator safety. And Flexar simplifies your process so you can focus on your application. It's the HPLC system you'll count on day after day.

- Integrated LC tube management for streamlined chromatography
- Hidden plug-and-play drainage automatically interconnects with components added to system
- Convenient solvent manager with integrated degasser and software communication link
- Built on rugged and reliable PerkinElmer LC technology for maximum uptime and low cost of ownership
- High-speed PDA Plus™ (200 hz) detector with optimal 50 mm flowcell

Flexar™ FX-20 UHPLC

Ultra high performance means the highest resolution, highest sensitivity and fastest analysis – in other words, a superlative LC system. Flexar FX-20 is the ultimate in UHPLC with maximum throughput and minimum stress for you. Getting more sample information in less time lets you be more productive. Just what you want.

- Dual-reciprocating piston 18,000 psi pump provides as much as 10x or more improvement in productivity
- Integrated piston wash function keeps pump pistons clean, even with buffers
- Synchronized injection with piston position for ultimate retention time precision.
- View pump pressure profiles real-time with Chromera CDS
- Pulse dampener-less design allows for increased productivity with less recovery time between runs
- Dual Binary solvent selection adds more solvent choices to support your applications

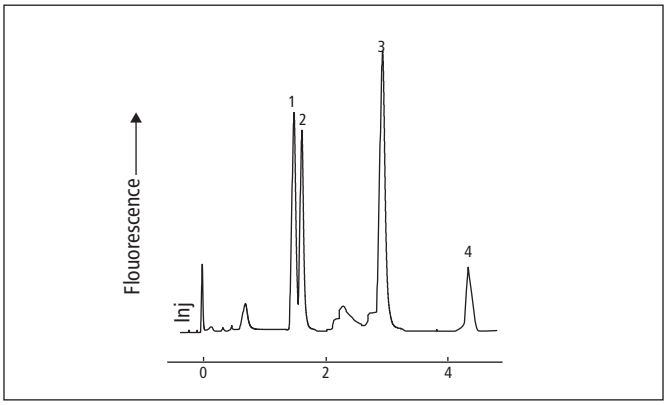

Fig 19: Tocopherols in Palm Oil on Brownlee Analytical Silica.
Peak 1: α-tocopherol Peak 2. α-tocotrienol
Peak 3. β-tocotrienol Peak 4. γ-tocotrienel

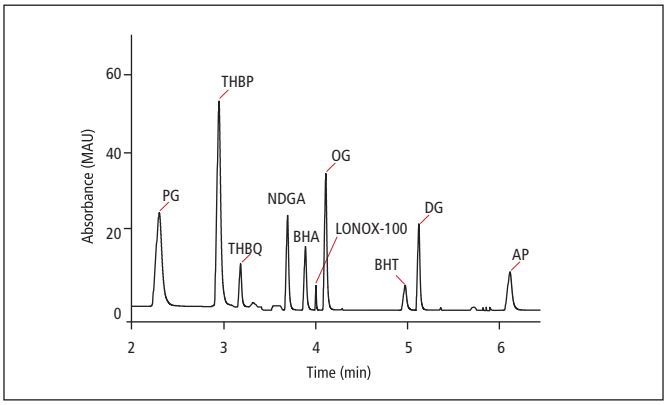

Fig 20: Chromatogram from the analysis standard solution with 10 antioxidants using a C18 HPLC column.

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