



## **S2 PUMA**

# **Analysis of Food and Feed**

- Simple, Accurate, and Precise Elemental Analysis of Food and Feed Products

# Know What Is Inside – Food Analysis with the S2 PUMA



With an increasing global population, the food industry is challenged to provide safe and nutritious groceries for all of us. Because edibles are such an important part in our lives, strict legal regulations and recommendations require safe standards are met.

## Elemental Analysis for Safe Food

To ensure compliance with these directives, continuous product quality monitoring in all steps of food production is necessary.

This includes quality checks:

- At customs
- When receiving feedstock
- During processing
- Before packaging
- And spot tests of the final product.



Analysis of food guarantees that contaminants are monitored and that foreign particles within the food matrix are detected. Other quality control applications include the inspection of mineral supplements and other vital mineral elements. The ever increasing demand for healthier and yet cost-efficiently produced foods is a challenge for research and development groups. Food safety thereby remains a critical issue. Longer food chains of processed groceries require safety concepts such as HACCP (Hazard analysis and critical control points), which ensure safe edibles at any point in the production chain. Scientists and inspectors could not deliver without reliable analytics.



S2 PUMA Single - Robust elemental analyzer with easy and convenient operation.

For those and other food & feed industry-related applications, X-ray fluorescence (XRF) is the ideal analytical technique to determine quickly, easily, and reliably elemental data of high quality. The S2 PUMA is a benchtop energy-dispersive X-ray fluorescence (EDXRF) spectrometer which is a high-performance, easy-to-operate instrument for your food and food-related analysis.

# S2 PUMA – Performance for a Wide Range of Food Industry Applications

Food safety applications are manifold. Examples include the analysis of:

- Mg, Ca, and Fe in milk powder
- The ash content (through Na, Mg, K, and Ca oxides) in pet food
- Heavy metal contamination
- Metallic foreign matter residues from processing plants

The areas where XRF is used in the food & feed industry are diverse, too. They do not only relate to the processing chain and quality control, but also include:

- Counterfeit screening
- Regulatory compliance, e.g. Cl compliance for salt labeling requirements for snack foods (NaCl, KCl, and CaCl<sub>2</sub>)
- Fortification processes, often through Fe and Ca in rice and dairy products
- Product control, e.g. of brighteners (TiO<sub>2</sub>)

Many of these applications are regulated both by official and compendial method standards. These norms emphasize analytical instrument stability and reliability. To demonstrate the precision and accuracy of the S2 PUMA, the following pages show analyses examples relevant to the food and feed industry with focus on repetition tests.

## Reliable Food Analysis

To demonstrate the precision and accuracy of food products analysis with the S2 PUMA, a repetition test was conducted with a certified mussel tissue sample (see Table 1). The samples have been dried, ground, and pressed. Measuring times were 200 s with 10 kV and 120 s with 40 kV. A 500 µm Al filter was in place for all measurements. The excellent calibration curve for the critical light element Na is shown in Figure 1.

The measured elements show results with low standard deviations, indicating precise and reliable measurement data. Particularly nutritionally critical elements such as Na and Cl (as a proxy for salt) show excellent repeatability.

Measurement	Na [wt.-%]	Mg [mg/100 g]	Si [wt.-%]	P [wt.-%]	S [wt.-%]	Cl [wt.-%]	K [wt.-%]	Ca [wt.-%]	Fe [mg/100 g]	Zn [mg/100 g]
Rep-01	3.01	0.43	0.12	0.71	1.63	5.52	0.86	0.24	85	73
Rep-02	3.03	0.42	0.12	0.71	1.64	5.54	0.86	0.23	83	73
Rep-03	3.03	0.43	0.13	0.71	1.64	5.56	0.87	0.24	83	73
Rep-04	3.03	0.43	0.12	0.71	1.65	5.57	0.87	0.24	85	74
Rep-05	3.03	0.43	0.12	0.71	1.64	5.57	0.86	0.24	86	74
Rep-06	3.05	0.42	0.12	0.71	1.65	5.60	0.87	0.25	86	75
Rep-07	3.06	0.44	0.12	0.72	1.66	5.60	0.87	0.24	83	75
Rep-08	3.06	0.43	0.13	0.72	1.65	5.60	0.87	0.24	82	75
Rep-09	3.06	0.43	0.13	0.72	1.65	5.60	0.87	0.24	83	75
Rep-10	3.04	0.42	0.13	0.71	1.66	5.61	0.87	0.24	85	75
<b>Mean value</b>	<b>3.04</b>	<b>0.43</b>	<b>0.12</b>	<b>0.71</b>	<b>1.65</b>	<b>5.58</b>	<b>0.87</b>	<b>0.24</b>	<b>84</b>	<b>74</b>
<b>Standard Deviation</b>	<b>0.02</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.01</b>	<b>0.03</b>	<b>0.01</b>	<b>0.00</b>	<b>1.5</b>	<b>0.9</b>
<b>Relative Standard Deviation [%]</b>	<b>0.51</b>	<b>0.95</b>	<b>1.52</b>	<b>0.44</b>	<b>0.52</b>	<b>0.53</b>	<b>0.58</b>	<b>1.78</b>	<b>1.72</b>	<b>1.24</b>
<b>Reference value</b>	<b>3.06</b>	<b>0.44</b>	<b>T</b>	<b>0.69</b>	<b>1.63</b>	<b>5.60</b>	<b>0.85</b>	<b>0.22</b>	<b>89</b>	<b>71</b>

Table 1: Repetition test results for certified mussel tissue sample.

# Milk Powder Analysis – Making Sure our Infants are Safe

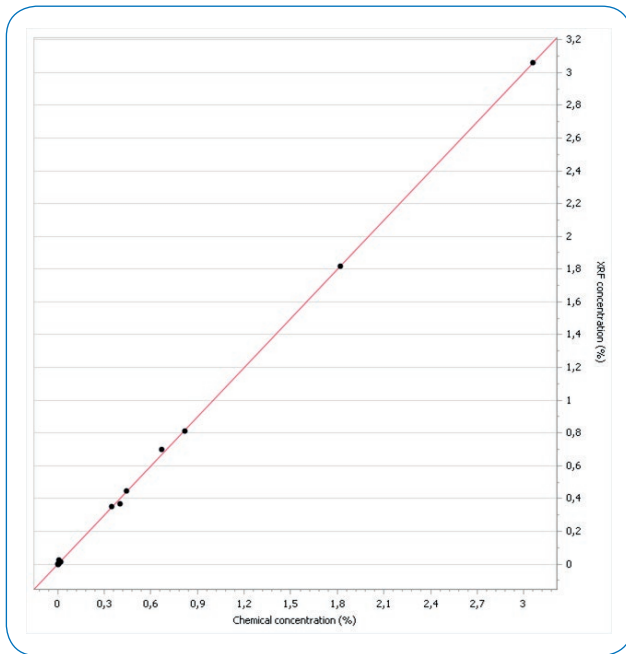


Figure 1: Na calibration curve for food calibration with very good squared correlation coefficient of 0.99977.

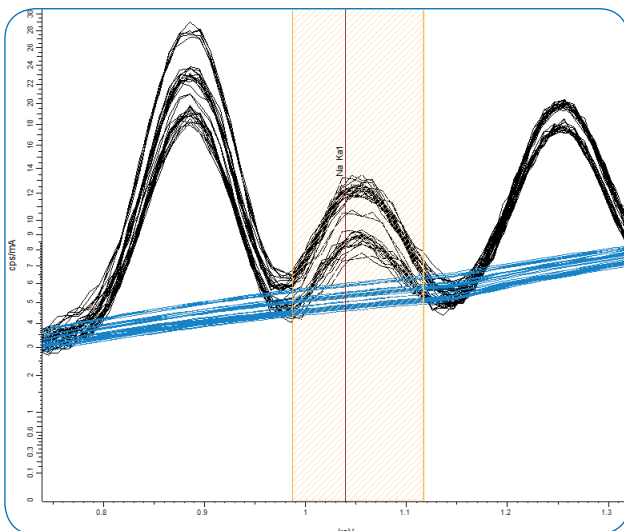


Figure 2: Milk powder spectra with integration range of Na peak and lower envelope modelling of background.

Milk powder is one of the most critically monitored foods, since it is fed to babies. Elements of interest include Na, Ca, and Fe. These elements get monitored throughout the whole production process (HACCP). The measurements can also be applicable to flour or cacao powder and other powdered dry foods.

With a measurement time of 120 s on pressed pellets the samples were analyzed under helium atmosphere with reduced pressure (see Table 2). Measurements under reduced helium pressure reduce gas consumption by 80% compared to conventional gas flushing, which has a significant positive effect on instrument running cost. The S2 PUMA delivers reliable results for the light elements such as Na (see Table 3 and Figure 2), but also the results of the heavier Fe show excellent precision, despite its low mean concentration.

Table 2: Measurement conditions for Na in milk powder.

Line	Voltage [kV]	Current [μA]	Filter	Concentration Range [mg/100 g]	Calibration Standard Deviation [mg/100 g]
Na Kα1	10	automatic*	none	114 - 261	5.83

\*optimized for maximal count rate

Table 3: Analytical precision of milk powder measurements.

Element	Mean [mg/100 g]	Standard Deviation [mg/100 g]	Relative Standard Deviation [%]
Na	240	2.5	1.04
Mg	61	1.4	2.34
P	257	0.8	0.33
Cl	418	0.8	0.20
K	597	4.5	0.75
Ca	381	2.1	0.55
Fe	4.86	0.05	1.06

# Monitoring Feed for Animals and Pets

Ensuring food safety throughout the whole production chain starts by controlling feed for dairy and meat producing animals. Content to be analyzed includes nutritional elements on the one side, but also heavy metals on the other. The chicken starter sample from AAFCO (Association of American Food Control Officials) was prepared as pressed pellet and was measured with 10 and 40 kV (see Table 4). The results from a precision test are shown in Table 5 below. Low standard deviations for the heavy elements in question demonstrate the high repeatability of the S2 PUMA's measurement results.

Table 4: Applied analysis conditions for feed sample calibration.

Element Range	Voltage [kV]	Current [μA]	Filter	Measurement Time [s]	Atmosphere
Na, Mg, P, S, Cl	10	automatic*	none	60	He reduced
K, Ca, Fe, Cu, Zn	40	automatic*	500 μm Al	120	He reduced

\*optimized for maximal count rate



Table 5: Precision test on AAFCO sample.

Sample ID	Na [wt.-%]	Mg [wt.-%]	P [wt.-%]	S [wt.-%]	Cl [wt.-%]	K [wt.-%]	Ca [wt.-%]	Fe [—]	Cu [mg/100 g]	Zn [—]
Rep-01	0.28	0.27	0.67	0.25	0.98	1.28	1.41	25.3	1.3	16.8
Rep-02	0.29	0.27	0.67	0.25	0.98	1.27	1.41	25.2	1.3	16.7
Rep-03	0.28	0.26	0.67	0.25	0.98	1.29	1.41	25.5	1.3	16.9
Rep-04	0.28	0.26	0.66	0.25	0.98	1.28	1.42	25.2	1.2	16.8
Rep-05	0.27	0.25	0.66	0.25	0.98	1.27	1.40	25.3	1.3	16.6
Rep-06	0.26	0.25	0.66	0.25	0.98	1.29	1.42	25.2	1.2	16.8
Rep-07	0.29	0.26	0.66	0.25	0.98	1.28	1.41	25.1	1.4	16.7
Rep-08	0.28	0.25	0.66	0.25	0.98	1.29	1.41	25.3	1.4	16.6
Rep-09	0.28	0.26	0.66	0.25	0.98	1.27	1.39	25.2	1.3	16.6
Rep-10	0.25	0.24	0.66	0.25	0.97	1.28	1.38	25.2	1.2	16.6
Mean value	0.28	0.26	0.66	0.25	0.98	1.28	1.40	25.3	1.3	16.7
Standard Deviation	0.012	0.008	0.005	0.001	0.004	0.007	0.013	0.108	0.074	0.110
Relative Standard Deviation [%]	4.40	3.00	0.73	0.32	0.39	0.57	0.92	0.43	5.72	0.66



# Versatile EDXRF-Performance – S2 PUMA



S2 PUMA XY Autochanger – Autonomously analyses up to 20 samples while allowing changes to the order, amount, and type of samples at any time.



S2 PUMA without TouchControl for external control by PC or for remote management via TCP/IP.

The S2 PUMA comes in three basic configurations: Single, Carousel, and XY Autochanger. This provides the customer with a wide range of sample handling options for best application fit. For larger sample batches the XY Autochanger is the configuration of choice! A 20 position sample tray is served by a fully automatic sample grabber with liquid cup detection. This ensures autonomous sample analysis of larger sample volumes with added peace of mind. As S2 PUMA Automation, the XY Autochanger can be implemented in fully automated labs by either conveyor belt or robot interface link-up.

For light element analysis and short measurement times, the HighSense™ LE detector is the perfect choice. High count rates, fast signal processing, and designed particularly for the analysis of light elements, the HighSense LE detector together with the S2 PUMA's high power 50 W X-ray tube is ideal for food and feed applications in industrial production environments due to short measurement times and high sample throughput.

SampleCare™ is a multi-layer system to protect the instrument's vital components from contamination. This ensures high system uptime, low maintenance cost, and short repair times in case of sample spillage.

A wide range of measurement atmospheres guarantees best analysis conditions for every application. Air, helium, nitrogen, and vacuum are all available to optimize analytical performance to save on operating cost.

For routine analysis the optional TouchControl™ touchscreen enables line workers to use the instrument with confidence with only very minimal amount of training. The glove-compatible TouchControl makes an external PC obsolete for production control analysis and restricts access to critical instrument control functions for data safety and integrity. In work environments where the instrument is controlled remotely via TCP/IP, it can also be configured without TouchControl.

The integrated HD camera and small-spot collimator masks make it possible to localize the area on the sample to be analyzed, e.g. for small particle inclusions within food packaging.

# Powerful Features for Your Applications

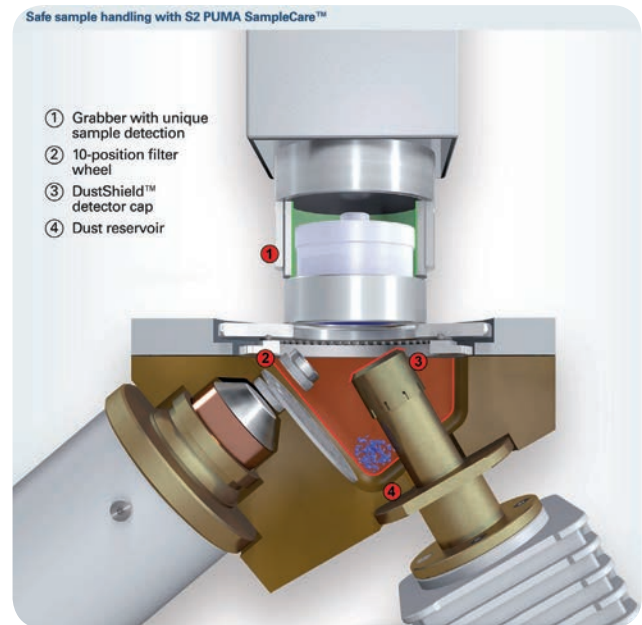
The powerful instrument software SPECTRA.ELEMENTS allows the full control of the system from an external PC for lab managers and advanced users. The connection to the instrument is via TCP/IP, so that the instrument can be fully controlled from a remote work station.

SPECTRA.ELEMENTS comes with an ergonomic tab-based user interface, which makes all important functionalities easily accessible, including the Loader to start measurements, the Wizard calibration tool, and the Results Manager. SPECTRA.ELEMENTS is also available as 21 CFR Part 11-compliant version which is a critical feature for many environments regulated by the FDA (US Food and Drug Administration) and ensures safe data handling through electronic record keeping, electronic signatures, audit trailing, and other measures.

SMART-QUANT FP is the powerful Fundamental Parameter solution for samples where no standards are available or when quick overview analyses are required.

## S2 PUMA – Benefits for Food & Feed Applications

- High analytical accuracy and precision through direct excitation with a powerful 50 W tube
- Fast measurements with the high-count rate HighSense™ LE silicon drift detector
- Light elements performance with LE-configuration
- For quality control at the production line with high sample volumes, the XY Autochanger runs your samples automatically while maintaining full sample flexibility
- SampleCare™ spillage protection ensures high instrument uptime and low running cost
- TouchControl™ enables line workers the routine operation of the instrument without external PC and with only very minimal training
- SMART-QUANT FP is the powerful standardless Fundamental Parameter solution which allows for quick analyses of completely unknown samples



SampleCare™ provides peace of mind particularly when measuring delicate or liquid samples.




TouchControl™ for instrument control without external PC.

Technical Data		
	S2 PUMA Single	S2 PUMA XY Autochanger
<b>Element range</b>	Sodium to americium (Na – Am) Carbon to americium (C – Am) with light element (LE) detector	
<b>Concentration range</b>	From ppm to 100 %	
<b>X-ray tube</b>	Pd or Ag anode; max. power 50 W; max. voltage 50 kV (low kV version: 30 kV max.)	
<b>Primary beam filters</b>	10-position automatic filter changer for wide range elemental analysis	
<b>Detector</b>	Silicon Drift Detector: Peltier cooled (no need for liquid nitrogen) with DustShield™; Also available as fast HighSense™ LE version with super-high count rates	
<b>Collimator masks *</b>	For small spot analysis: 1, 3, 8, 12, 18, 23 and 28 mm	
<b>Sample observation *</b>	Integrated HD video camera, for exact sample positioning and documenting the measurement position of a sample	
<b>Atmosphere Mode</b>	Air mode: For heavier elements in all sample types Helium mode*: Best performance for light elements in liquids and loose powders Nitrogen mode*: Cost-saving analysis of liquid samples Vacuum mode*: Enhanced light elements performance for stable samples and lowest cost of operation	
<b>TouchControl™</b>	Integrated 12.1" TFT touchscreen, adjustable, multilingual user interface, optional	
<b>Connectivity</b>	Built-in Ethernet port RJ45, 3x USB ports for mouse, keyboard, printer	
<b>Power requirements</b>	100-240 V, 50/60 Hz, max. power consumption 600 VA	
<b>Sample types</b>	Loose powders, granules, solids, pressed pellets, fused beads, and liquids	
<b>Sample rotation *</b>	Spins all sample types and sizes for better measurement statistics with inhomogenous samples	
<b>Sample sizes</b>	Up to 51.5 mm (2.03") Ø; Liquids, loose powders, and smaller samples in liquid cups up to 50 ml	Up to 40 mm (1.56") Ø and 38 mm (1.49") height in sample holders with max. 200 g sample weight, or 51.5 mm Ø as sample ring; Liquids, loose powders, and smaller samples in liquid cups up to 20 ml
<b>Sample loader</b>	Single position, manual loading	EasyLoad™ XY sample tray with 20-positions, removable; Grabber with automatic liquid sample detection
<b>Dimensions</b> (width x depth x height; weight)	67 x 71 x 37 cm; 87 kg (26.2 x 27.8 x 14.6"; 192 lbs)	67 x 71 x 61 cm; 108 kg (26.2 x 27.8 x 23.8"; 238 lbs)
<b>Quality &amp; safety</b>	DIN EN ISO 9001:2008 2006/42/EC (CE-certified Machinery directive) 2014/35/EC (Electrical equipment) 2014/30/EC (Electromagnetic Compatibility) German Type Approval and Vollschutz according to BfS RöV Fully radiation-protected system; radiation <1 µSv/h (H*) Compliant to ICRP, IAEA, EURATOM	

\* optional packages

TouchControl™, SampleCare™, EasyLoad™, HighSense™, and DustShield™ are trademarks of Bruker AXS Inc.

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