
ELEMENTAL ANALYSIS AND HEALTH RISK ASSESSMENT OF COW AND BUFFALO MILK CHEESES

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This supplementary material presents studies of various analytes in different types of cheese using flame atomic absorption spectrometry (FAAS), graphite furnace absorption spectrometry (GFAAS), electrothermal atomic absorption spectrometry (ETAAS), inductively coupled plasma optical emission spectrometry (ICP OES) or inductively coupled plasma mass spectrometry (ICP-MS). These studies were obtained from the literature between 2007 to 2025, considering only the elements of interest Cd, Cu, Fe, Mn and Zn. The data obtained in this study were also included in the material.

Table 1S. Concentrations of Cd, Cu, Fe, Mn, and Zn in cheeses by different techniques and values obtained in this study

Analyte	Technique	Concentration	Types of cheese	References
Cd	ICP-MS	5.25-27.20 µg kg ⁻¹	Serro, Araxá, Marajó, Colonial, Caipira, Serrano, Mantiqueira, and Bicas da Serra	Rocha <i>et al.</i> ¹
		0.005 µg kg ^{-1a}	Curd, Mild cream, Kolot, Braided, Strained white, White, Kashar, Triangle, and Other	Altinsoy <i>et al.</i> ²
		0.002 mg kg ^{-1a}	Imeruli cheese	Al Sidawi <i>et al.</i> ³
		0.007 mg kg ^{-1a}	Sulguni cheese	
	GFAAS	0.002-0.01 µg g ⁻¹	Hard cheese	Barone <i>et al.</i> ⁴
		N.D. ^b -0.01 µg g ⁻¹	Fresh cheese	
		0.140-2.95 µg kg ⁻¹	Cow, Blue, Kaseri, Feta, Kefalograviera, Metsovone, Cottage, Mozzarella, Parmesan, Mizithra, and Cream	Christophoridis <i>et al.</i> ⁵
		ETAAS	0.008-0.017 µg g ⁻¹	Cottage cheese
	FAAS	0.0576-0.1172 mg kg ⁻¹	Kariesh and processed	Elafify <i>et al.</i> ⁷
		0.55-0.67 mg kg ⁻¹	Cow's milk cheese	Present work
0.34-0.37 mg kg ⁻¹		Buffalo cheese		
Cu	ICP-MS	91.29-964.25 µg kg ⁻¹	Serro, Araxá, Marajó, Colonial, Caipira, Serrano, Mantiqueira, and Bicas da Serra	Rocha <i>et al.</i> ¹
		247 µg kg ^{-1a}	Curd, Mild cream, Kolot, Braided, Strained white, White, Kashar, Triangle, and Other	Altinsoy <i>et al.</i> ²
		1.261 mg kg ^{-1a}	Imeruli cheese	Al Sidawi <i>et al.</i> ³
		2.463 mg kg ^{-1a}	Sulguni cheese	
	GFAAS	0.97-6.02 µg g ⁻¹	Hard cheese	Barone <i>et al.</i> ⁴
		0.26-2.13 µg g ⁻¹	Fresh cheese	
		134-4421 µg kg ⁻¹	Cow, Blue, Kaseri, Feta, Kefalograviera, Metsovone, Cottage, Mozzarella, Parmesan, Mizithra, and Cream	Christophoridis <i>et al.</i> ⁵

Fe	ICP OES	0.92-63.51 $\mu\text{g g}^{-1}$	Araxá, Caipira, Campo das vertentes, Canastra, Cerrado, Coalho, Colonial, Manteiga, Serrano, and Serro	Andrade <i>et al.</i> ⁸
	FAAS	0.31-0.45 $\text{mg kg}^{-1\text{c}}$	Mussarela, Minas, Prato and Parmesão	Kira and
		0.27-0.52 $\text{mg kg}^{-1\text{d}}$	Mussarela, Minas, Prato and Parmesão	Maihara ⁹
		0.08-0.22 $\mu\text{g g}^{-1}$	Cottage cheese	Capcarova <i>et al.</i> ⁶
		0.1272-0.188 mg kg^{-1}	Kariesh and processed	Elafify <i>et al.</i> ⁷
		6.92-7.53 mg kg^{-1}	Cow's milk cheese	Present work
		N.D. ^b -2.75 mg kg^{-1}	Buffalo cheese	
	ICP-MS	69.09 $\text{mg kg}^{-1\text{a}}$	Imeruli cheese	Al Sidawi <i>et al.</i> ³
	ICP OES	101.1 $\text{mg kg}^{-1\text{a}}$	Sulguni cheese	
		2.29-7.74 $\text{mg kg}^{-1\text{c}}$	Mussarela, Minas, Prato and Parmesão	Kira and
		2.25-7.31 $\text{mg kg}^{-1\text{d}}$	Mussarela, Minas, Prato and Parmesão	Maihara ⁹
	FAAS	1.35-4.38 $\mu\text{g g}^{-1}$	Hard cheese	Barone <i>et al.</i> ⁴
		0.90-3.29 $\mu\text{g g}^{-1}$	Fresh cheese	
		0.390-21.3 mg kg^{-1}	Cow, Blue, Kaseri, Feta, Kefalograviera, Metsovone, Cottage, Mozzarella, Parmesan, Mizithra, and Cream	Christophoridis <i>et al.</i> ⁵
		1.16-2.67 $\mu\text{g g}^{-1}$	Cottage cheese	Capcarova <i>et al.</i> ⁶
		<3.0 ^b	Cow's milk cheese	Present work
		<3.0 ^b	Buffalo cheese	
Mn	ICP-MS	163 $\mu\text{g kg}^{-1\text{a}}$	Curd, Mild cream, Kolot, Braided, Strained white, White, Kashar, Triangle, and Other	Altinsoy <i>et al.</i> ²
		0.886 $\text{mg kg}^{-1\text{a}}$	Imeruli cheese	Al Sidawi <i>et al.</i> ³
		2.348 $\text{mg kg}^{-1\text{a}}$	Sulguni cheese	
	GFAAS	34.5-543 $\mu\text{g kg}^{-1}$	Cow, Blue, Kaseri, Feta, Kefalograviera, Metsovone, Cottage, Mozzarella, Parmesan, Mizithra, and Cream	Christophoridis <i>et al.</i> ⁵
	ICP OES	0.0003-3.29 $\mu\text{g g}^{-1}$	Araxá, Caipira, Campo das vertentes, Canastra, Cerrado, Coalho, Colonial, Manteiga, Serrano, and Serro	Andrade <i>et al.</i> ⁸
	FAAS	0.24-0.30 $\text{mg kg}^{-1\text{c}}$	Mussarela, Minas, Prato and Parmesão	Kira and
		0.24-0.35 $\text{mg kg}^{-1\text{d}}$	Mussarela, Minas, Prato and Parmesão	Maihara ⁹
		0.08-0.68 $\mu\text{g g}^{-1}$	Cottage cheese	Capcarova <i>et al.</i> ⁶
		<0.3 ^b -0.74 mg kg^{-1}	Cow's milk cheese	Present work
		<0.3 ^b	Buffalo cheese	

Zn	ICP-MS	75.86 mg kg ^{-1a}	Imeruli cheese	Al Sidawi <i>et al.</i> ³
		124.8 mg kg ^{-1a}	Sulguni cheese	
	ICP OES	8.15–325.16 µg g ⁻¹	Araxá, Caipira, Campo das vertentes, Canastra, Cerrado, Coalho, Colonial, Manteiga, Serrano, and Serro	Andrade <i>et al.</i> ⁸
		6.90–48.4 mg kg ^{-1c}	Mussarela, Minas, Prato and Parmesão	Kira and
		7.52–49.6 mg kg ^{-1d}	Mussarela, Minas, Prato and Parmesão	Maihara ⁹
	FAAS	3.36–13.94 µg g ⁻¹	Hard cheese	Barone <i>et al.</i> ⁴
		1.08–8.23 µg g ⁻¹	Fresh cheese	
		5.98–51.2 mg kg ⁻¹	Cow, Blue, Kaseri, Feta, Kefalograviera, Metsovone, Cottage, Mozzarella, Parmesan, Mizithra, and Cream	Christophoridis <i>et al.</i> ⁵
		1.80–2.33 µg g ⁻¹	Cottage cheese	Capcarova <i>et al.</i> ⁶
		12.7–66.6 mg kg ⁻¹	Cow's milk cheese	Present work
		8.14–49.3 mg kg ⁻¹	Buffalo cheese	

^aMean concentration; ^bN.D.: not detected, < LOD; ^cdry digestion; ^dhydrolysis with HCl. Analyte: elements of interest; Technique: AAS, MS and OES; Concentration: levels found in each study (min.-max.); Types of cheese: mass-produced or artisanal cheeses. ICP-MS: inductively coupled plasma mass spectrometry; GFAAS: graphite furnace absorption spectrometry; ETAAS: electrothermal atomic absorption spectrometry; FAAS: flame atomic absorption spectrometry; ICP OES: inductively coupled plasma optical emission spectrometry.

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