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Correction: Chemical analysis in saliva and the search for salivary biomarkers – a tutorial review

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Correction for 'Chemical analysis in saliva and the search for salivary biomarkers – a tutorial review' by Kamonwad Ngamchuea, *et al.*, *Analyst*, 2018, **143**, 81–99.

In the published article some errors were present in Tables 1, 2 and 4.

The concentrations of blood glucose were misplaced into the 'Saliva' column. They are now moved to the correct 'Other biological fluids' column. A full, corrected Table 1 is reproduced here.

Table 1 Components of authentic human saliva and a comparison of the normal range of the concentrations between saliva and other biological fluids

Real saliva composition		Normal range		Ref.
		Saliva	Other biological fluids	
1. Inorganic compounds	Na ⁺	20–80 mmol L ⁻¹	Plasma 145 mmol L ⁻¹	11
	K ⁺	20 mmol L ⁻¹	4 mmol L ⁻¹	
	Ca ²⁺	1–4 mmol L ⁻¹	2.2 mmol L ⁻¹	
	Cl ⁻	30–100 mmol L ⁻¹	120 mmol L ⁻¹	
	HCO ₃ ⁻	15–80 mmol L ⁻¹	25 mmol L ⁻¹	
	Phosphate	4 mmol L ⁻¹	1.2 mmol L ⁻¹	
	Mg ²⁺	0.2 mmol L ⁻¹	1.2 mmol L ⁻¹	
	SCN ⁻	2 mmol L ⁻¹	<0.2 mmol L ⁻¹	
2. Organic compounds (non-protein and lipids)	NH ₃	3 mmol L ⁻¹	0.05 mmol L ⁻¹	21–23
	Uric acid	3.38 ± 0.21 mg dL ⁻¹	Serum 6.31 ± 0.24 mg dL ⁻¹	
		217.2 ± 110.3 mol L ⁻¹		
		0.1–7.5 mg dL ⁻¹		
	Bilirubin	0.5–5.0 µmol L ⁻¹	Serum 0.2–1.2 mg dL ⁻¹	
	Creatinine	0.12 ± 0.06 mg dL ⁻¹	Serum 0.89 ± 0.17 mg dL ⁻¹	
		0.05–0.2 mg dL ⁻¹	Serum 0.6–1.5 mg dL ⁻¹	
	Glucose	4–13 mg dL ⁻¹	Blood 80–120 mg dL ⁻¹	
			Blood 88.6 ± 8.0 mg dL ⁻¹	
	Cholesterol	0.02–5.46 µmol L ⁻¹	Serum <5 mmol L ⁻¹	
3. Protein/polypeptide compounds	Lactate	0.3–1.8 mM	Serum 0.5–1.0 mM	24 25 22 and 26 27 28 and 29
		0.1 to 2.5 mmol L ⁻¹		
	α-Amylase	19–308 U mL ⁻¹ ^a	Serum 0.05–0.125 U mL ⁻¹ ^a	
		93 ± 62 U L ⁻¹ ^a		
		2.64 ± 1.8 mg mL ⁻¹		
	Albumin	0.2 ± 0.1 mg mL ⁻¹	Serum 3.5–5.5 g dL ⁻¹	
	Secretory-IgA	80–717 mg dL ⁻¹	Serum 70–400 mg dL ⁻¹	
		124.3–333.5 µg mL ⁻¹		
	Mucin group	MUC5B: 2.4 ± 1.7 U mL ⁻¹	Serum 9.9 ± 0.8 ng mL ⁻¹	
		1.19 ± 0.17 mg mL ⁻¹		
4. Hormones	Lysozyme	3–50 µg mL ⁻¹	Serum 7.4 ± 1.8 mg mL ⁻¹	23, 32 and 34
		59.7 to 1062.3 µg mL ⁻¹	Serum 4–9 µg mL ⁻¹	
	Total proteins	7.1–223.2 mg dL ⁻¹	Serum 6–8 g dL ⁻¹	
		0.9 ± 0.2 mg mL ⁻¹		
	Cortisol	3.5–27.0 mg dL ⁻¹	Serum 2–25 mg dL ⁻¹	
	Testosterone	32–55 pg mL ⁻¹	Serum 320–600 ng dL ⁻¹	
	Progesterone	Luteal phase 436 ± 34 pmol L ⁻¹	Serum male: <1 ng mL ⁻¹	
		Follicular phase 22.1 ± 2.7 pmol L ⁻¹	Serum female: 0.1–20 ng mL ⁻¹	
	Estrogen (Estradiol)	Luteal phase 20.6 ± 0.4 pmol L ⁻¹	Serum male: 15–60 pg mL ⁻¹	
			Serum female: 15–370 pg mL ⁻¹	

^a U mL⁻¹: enzymatic activity per unit (mL) of saliva.

The concentration of CaCl₂·2H₂O (ref. Fusayama-Meyer¹⁶) was given incorrectly. The concentration of NH₄Cl (ref. SAGF^{17,18}) was missing. A full, corrected Table 2 is reproduced here.

Table 2 Compositions of different artificial saliva recipes

Artificial saliva compositions		Concentration (g L ⁻¹)				
		AFNOR ^{14,15}	Fusayama-Meyer ¹⁶	SAGF ^{17,18}	Klimek ¹⁹	Shellis ¹²
1. Inorganic compounds	NaCl	6.70	0.40	0.13	0.58	—
	KCl	1.20	0.40	0.96	1.27	1.16
	Na ₂ HPO ₄	0.26	—	—	0.34	0.375
	KH ₂ PO ₄	0.20	—	0.66	0.33	0.35
	NaHCO ₃	1.50	0.10	0.63	—	0.54
	KSCN	0.33	—	0.19	0.16	0.22
					(NaSCN)	
	CaCl ₂ ·2H ₂ O	—	0.795	0.23	0.17	0.21
	Na ₂ S·9H ₂ O	—	0.005	—	—	—
	Urea	—	1.00	0.20	0.20	0.17
	NaH ₂ PO ₄ ·H ₂ O	—	0.69	—	—	—
	NH ₄ Cl	—	—	0.18	0.16	0.233
	Na ₂ SO ₄ ·10H ₂ O	—	—	0.76	—	—
	MgCl ₂ ·6H ₂ O	—	—	—	—	0.043
	Sodium citrate	—	—	—	—	0.013
2. Organic compounds	Ascorbic acid	—	—	—	0.002	—
	Glucose	—	—	—	0.03	—
	Uric acid	—	—	—	—	0.0105
	Creatinine	—	—	—	—	0.0001
	Choline	—	—	—	—	0.013
	Mixture of vitamins	—	—	—	—	0.0008
3. Protein/polypeptide compounds	Mucin	—	—	—	2.70 ^a	—
	Glycoprotein	—	—	—	—	2.5
	Alpha amylase	—	—	—	—	3 × 10 ⁵ Somogyi's unit L ⁻¹ ^b
	Albumin	—	—	—	—	0.025
	Mixture of amino acids	—	—	—	—	0.041

^a Bacto-Mucin bacteriological. ^b Somogyi's unit/L is a measure of the level of activity of amylase in blood serum. One Somogyi unit is defined as the amount of amylase required to produce the equivalent of 1 mg of glucose when acting on a standard starch solution under a defined condition.³⁸

Incorrect values were given for linear ranges, LOD and the pH of the buffers for some of the detection methods in Table 4. The specific changes relate to Phosphate (linear range and buffer pH), caffeine (LOD for the molecularly imprinted electrode and linear range for the SWNCT/CC electrode), glutathione (medium for the Prussian blue/SPE electrode and linear range for the caffeic acid/GC electrode) and uric acid (LOD). A full, corrected Table 4 is reproduced here.

Table 4 Examples of methods of electroanalytical detection available for possible salivary biomarkers (listed in Table 3)

Biomarkers	Methods	Electrodes	Linear range	LOD	Medium	Ref.
Chemicals						
Calcium	ISE	Calcium-specific electrode	2.2–8 mg per 100 mL	—	Aqueous, serum	179
Potassium	ISE	Potassium electrode with polymer membrane	115 mM–180 mM ^a	—	Whole blood, serum	180
Phosphate	AMP, CV	Molybdate anions in chitosan/GC	0.79 μM–3.96 μM 19 μM–95 μM	—	Deaerated Tris buffer (pH 7.2)	187
Cotinine	MPA	BDD	0.5 μM–100 μM	0.06 μM	PBS (pH 7.0), saliva	188
Nicotine	SWV	Anti-cotinine antibody/C-SPE	1–100 ng mL ⁻¹	1.0 ng mL ⁻¹	Serum	189
	AMP, CV	MWCNT/alumina-coated silica nanocomposite	—	1.42 μM	PBS (pH 8)	190
	AMP	TiO ₂ /GC	0 μM–5000 μM	4.9 μM	PBS (pH 7.4)	191
	CV	MWCNT/BPPG	up to 1 mM	1.5 μM	BR (pH 8)	192
	CV	CNT/SPE	10 μM–1000 μM	2 μM	Buffer (pH 7), artificial saliva	193
	DPV	BDD	0.5 μM–200 μM	0.3 μM	BR (pH 8)	194
	EIS	Polydopamine imprinted film	1 μM–25 μM	0.5 μM	PBS (pH 7.4), serum	195
	Nitrate (NO ₃ ⁻)	LSV	Cu plated-/BDD microelectrode array	1.2 μM–124 μM	0.76 μM	0.1 M Na ₂ SO ₄ (pH 3)
Nitrite (NO ₂ ⁻)	AMP	Cellulose acetate membrane/Pt Poly(1,8-diaminonaphthalene) film/Pt	1 μM–100 μM 0.5 μM–100 μM	0.5 μM 0.1 μM	Acetate buffer (pH 4.0)	197
	AMP, DPV	Carbon black paste electrode Carbon black SPE	0.01 μM–4 μM 0.1 μM–8.8 μM	0.005 μM 0.097 μM	Acetate buffer (pH 4.6)	198
Caffeine	DPV, LSV	GC	4 mM–80 mM	6 μM	Saliva, urine	199
	CV	Nafion/GC	up to 7.0 mM	0.04 μM	PBS (pH 7.0)	200
	CV, SWV	Pseudo CP	1 μM–1 mM	0.348 μM	PBS (pH 7.0)	201
	DPV	Molecularly imprinted polymer	0.5 nM–0.16 μM	90 pM	PBS (pH 6.5)	202
	DPV	SWCNT/CC	0.25 μM–0.1 mM	0.12 μM	0.01 M H ₂ SO ₄ (pH 1.7)	203
	SWV	EPPG	0.02 μM–100 μM	0.008 μM	PBS (pH 7.2), urine	204
Thiocyanate (SCN ⁻)	CV, DPV	Ag-MWCNT/GC	2.5 nM–50 nM 50 nM–1.0 μM	1.0 nM	PBS (pH 6.0), saliva, urine	205
	CV, AMP	Ag@Cu nanorods/GC	1 mM–10 mM	10 nM	PBS (pH 6.0)	206
Anti-oxidants						
Glutathione (GSH) ^b	CV	Copper hydroxide/CILE	1 μM–50 μM 0.1 mM–1.8 mM	30 nM	PBS (pH 7.0)	207
	CV, AMP	Ordered mesoporous carbon	0 mM–2.5 mM ^a	0.09 μM	PBS (pH 7.16)	208
	CV, AMP	Carbon microfiber	5 μM–65 μM ^a	0.5 μM	PBS (pH 7.5)	158
	CV	Poly(caffeic acid) nanocarbon composite/GC	0.5 μM–5.0 mM	0.5 μM	PBS (pH 7.0)	209
	CV	GC	6 μM–59 μM	1 μM	Tissue media (pH 7)	210
	CV	Prussian blue/SPE	2 μM–0.5 mM	2.0 μM	PBS (pH 7.4), blood	211
	CV	Nanocarbon paste	2 μM–120 μM ^a	2.0 μM	PBS (pH 7.5)	212
	CV	Caffeic acid/GC	>1.0 mM	2.2 μM	PBS (pH 7.0)	213
Glutathione disulfide (GSSG)	CV, SWV	CNT-SPE	10 μM–60 μM ^a	3.0 μM	PBS (pH 7.0), saliva	156
	CV	Copper hydroxide/CIL	0.4 μM–120 μM	15 nM	PBS (pH 7.0)	207
	CV, DPV	Graphene–Pt/GC	0.15 μM–34 μM	0.15 μM	PBS (pH 7.0)	214
	DPV	Nitrogen doped graphene	5.0 μM–1.3 mM	2.2 μM	PBS (pH 6.0)	215
	CV, LSV	SWCNH/GC	30 μM–400 μM	5 μM	PBS (pH 7.0)	216
Ascorbic acid	CV, DPV	Poly(acid chrome blue K)/GC	50.0–1000.0 μM	10.0 μM	PBS (pH 4.0), urine	217
	CV, DPV	Graphene–Pt/GCE	0.05 μM–12 μM	0.05 μM	PBS (pH 7.0)	214
	CE/AMP	Poly(dimethylsiloxane) (PDMS)/glass microchip	15 μM–110 μM	1 μM	MES (pH 5.5), urine	218
	DPV	Nitrogen doped graphene	0.1 μM–20 μM	45 nM	PBS (pH 6.0)	215
	SWV	Clay colloids/GC	0.5 μM–10 μM 10 μM–100 μM	0.2 μM	Citrate buffer (pH 1.0)	219
Uric acid	DPV	CIL	2.0 μM–0.2 mM	1.0 μM	PBS (pH 6.8), urine	220
	CV, DPV	Poly(acid chrome blue K)/GC	1.0 μM–120 μM	0.5 μM	PBS (pH 4.0),	217

Table 4 (Contd.)

Biomarkers	Methods	Electrodes	Linear range	LOD	Medium	Ref.
	CV, LSV	SWCNH/GC	0.06 μM –10 μM	20 nM	PBS (pH 7.0)	216
	SWV	Electrochemically activated GC	0.04 μM –2.0 μM	9 nM	0.5 M H_2SO_4 , urine	221
Therapeutic drugs						
Theophylline	CV	MWCNT/GC	0.3 μM –10.0 μM	50 nM	PBS (pH 5.8)	222
	DPV	Graphene/Nafion/GC	10 nM –1.0 μM	6.0 nM	0.1 M H_2SO_4	223
Acetaminophen (paracetamol)	DPV	Cobalt phthalocyanine NP/CP	0.4 μM –0.1 mM	0.14 μM	PBS (pH 7.4)	224
	DPV	Urchin-like CdSe microparticles/GC	μM –40 μM	0.4 μM	PBS (pH 6.0)	225
	SWV	Nafion/lead–ruthenium oxide pyrochlore	40 μM –700 μM up to 100 μM	0.1 μM	PBS (pH 3)	226
	CV	Nafion/TiO ₂ –graphene/GC	1 μM –100 μM	0.21 μM	PBS (pH 7.0)	227
	DPV	Pd/graphite oxide/GC	5 nM–0.5 μM	2.2 nM	PBS (pH 6.8)	228
	DPV	BiO/graphite SPE	0.5 μM –1.250 μM	30 nM	BR buffer (pH 2.0), saliva	229
	DPV	SWCNT–graphene/GC	0.05 μM –65 μM	38 nM	PBS (pH 7.0), serum	230
	DPV	Functionalized MWCNT	0.45 μM –90.0 μM	0.35 μM	PBS (pH 7.0), saliva	231
	SWV	CoNP/MWCNT	5.2 nM–0.45 μM	1.0 nM	PBS (pH 7.0)	232
	SWV	MWCNT/BPPG	μM –2 μM	10 nM	PBS (pH 7.5)	233
	SWV	Graphene/GC	2 μM –20 μM 0.1 μM –20 μM	32 nM	$\text{NH}_3\cdot\text{H}_2\text{O}$ – NH_4Cl (pH 9.3)	234
pH						
pH	CV	Carbon fibre microelectrode	pH 2.5–8 (buffer), pH 4–8.5 (artificial saliva)	Sensitivity: –61 mV/pH (buffer) –73 mV/pH (artificial saliva)	Buffer, artificial saliva, saliva	235
	EIS	Iridium oxide	pH 4–8	Sensitivity: –47 mV/pH (artificial saliva)	Artificial saliva	236
	ISE	Poly(3-octylthiophene-2,5-diyl) regiorandom/SPCE	pH 4–8	Sensitivity: –53.4 mV/pH (buffer)	Buffer, saliva	237
	ISE	Poly(terthiophene benzoic acid)/AuZnO _x /SPCE	pH 2–13	Sensitivity: 59.2 $\pm$ 0.5 mV/pH (buffer)	Buffer, saliva, urine	238

The methods highlighted in grey and blue have been validated in artificial saliva and real saliva, respectively. **Methods:** AMP: amperometry, CA: chronoamperometry, CE: capillary electrophoresis, CV: cyclic voltammetry, DPV: differential pulse voltammetry, EIS: electrochemical impedance spectroscopy, ISE: ion-selective electrode, LSV: linear sweep voltammetry, MPA: multiple-pulse amperometry, SWV: square wave voltammetry. **Electrodes:** BDD: boron-doped diamond, BPPG: basal plane pyrolytic graphite, CC: carbon ceramic, CIL: carbon ionic liquid, CNF: carbon nanofiber, CP: carbon paste, EPPG: edge plane pyrolytic graphite, GC: glassy carbon electrode, MWCNT: multi-walled carbon nanotube, NP: nanoparticle, SPE: screen-printed electrode, SWCNT: single-walled carbon nanotube, SWCNH: single-walled carbon nanohorn.^a Not stated in the text – values are taken from calibration curves present in the papers.

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