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MINERAL CONTENTS IN PORK AND EDIBLE OFFAL FROM INDIGENOUS PIGS

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Abstract
Meat is one of the most nutritious foods that humans can consume, and is defined as the flesh (skeletal muscles) of animals used as food. In addition to protein and fat, meat is a significant source of several micronutrients (minerals and vitamins). Edible offal is also a form of meat which is used as food, but which is not skeletal muscles, and in general possesses higher contents of some micronutrients, especially minerals and vitamins, than muscular tissue. Minerals are the inorganic elements other than carbon, hydrogen, oxygen and nitrogen, which remain behind in the ash when food is incinerated. They are usually divided into two groups – macrominerals (main elements) and microminerals (trace elements) or into three groups – main elements (macrominerals), trace elements (microminerals) and ultra-trace elements. The aim of this paper is to provide an overview of the existing literature on the content of nine most abundant minerals (potassium, phosphorous, sodium, magnesium, calcium, zinc, iron, copper and manganese) in the major raw pork meat cuts (tenderloin, ham, loin and shoulder) and edible offal (tongue, heart, lungs, liver, spleen, kidney, brain and spinal cord) from indigenous pigs. The mineral levels in raw pork meat and pig edible offal are variable, ranging from 175.7 to 463.8 mg/100g for potassium; 159 to 502.0 mg/100g for phosphorous; 38.11 to 158.4 mg/100g for sodium; 8.3 to 28.5 mg/100g for magnesium; 4.61 to 26.02 mg/100g for calcium; 0.67 to 6.47 mg/100g for zinc; 0.55 to 45.59 mg/100g for iron; 0.10 to 0.825 mg/100g for copper; and from 0.0038 to 0.338 mg/100g for manganese.

1. INTODUCTION

Minerals. Minerals are the inorganic elements other than carbon, hydrogen, oxygen and nitrogen, which remain behind in the ash when food is incinerated. They are usually divided into two groups – macrominerals (main elements) and microminerals (trace elements) or into three groups – main elements (macrominerals), trace elements (microminerals) and ultra-trace elements. Many minerals are essential for plants, animals and humans. The main elements (Na, K, Ca, Mg, Cl, P, S) are essential for human beings in amounts >50 mg/day. Trace elements (Fe, I, F, Zn, Se, Cu, Mn, Cr, Mo, Co, Ni) are essential in contents of <50 mg/day. Ultra-trace elements are: Al, As, Ba, Bi, B, Br, Cd, Cs, Ge, Hg, Li, Pb, Rb, Sb, Si, Sm, Sn, Sr, Tl, Ti and W (Reilly, 2002; Belitz et al., 2009). Minerals have diverse functions (electrolytes, enzyme constituents, building materials in bones and teeth) in the human body and they must be obtained from diet because they cannot be synthesized. The main functions of minerals in the human body are shown in Table 1 (The National Academy of Sciences, The Health and Medicine Division, USA, 2018). Dietary reference intake (DRI) is the general term for a set of reference values used to plan and assess nutrient intakes of

Table 1. Main functions of minerals in the human body

Mineral	Function
K	Maintains fluid volume inside/outside of cells and thus normal cell function; acts to blunt the rise of blood pressure in response to excess sodium intake, and decrease markers of bone turnover and recurrence of kidney stones
P	Maintenance of pH, storage and transfer of energy and nucleotide synthesis
Na	Maintains fluid volume outside of cells and thus normal cell function
Mg	Cofactor for enzyme systems
Ca	Essential role in blood clotting, muscle contraction, nerve transmission, and bone and tooth formation
Zn	Component of multiple enzymes and proteins; involved in the regulation of gene expression
Fe	Component of haemoglobin and numerous enzymes; prevents microcytic hypochromic anaemia
Cu	Component of enzymes in iron metabolism
Mn	Involved in the formation of bone, as well as in enzymes involved in amino acid, cholesterol, and carbohydrate metabolism

Table 2. Dietary reference intake for minerals

Life stage group	K (mg/d)	P (mg/d)	Na (mg/d)	Mg (mg/d)	Ca (mg/d)	Zn (mg/d)	Fe (mg/d)	Cu (mg/d)	Mn (mg/d)
I: 0−6 months	400	100	120	30	200	2	0.27	0.20	0.003
I: 7−12 months	700	275	370	75	260	3	11	0.22	0.6
C: 1−3 years	3000	460	1000	80	700	3	7	0.34	1.2
C: 4−8 years	3800	500	1200	130	1000	5	10	0.44	1.5
M/F: 9−13 years	4500	1250	1500	240	1300	8	8	0.70	1.9/1.6
M/F: 14−18 years	4700	1250	1500	410/360	1300	11/9	11/15	0.89	2.2/1.6
M/F: 19−30 years	4700	700	1500	400/310	1000	11/8	8/18	0.90	2.3/1.8
M/F: 31−50 years	4700	700	1500	420/320	1000	11/8	8/18	0.90	2.3/1.8
M/F: 51−70 years	4700	700	1300	420/320	1000/1200	11/8	8/8	0.90	2.3/1.8
M/F: >70 years	4700	700	1200	420/320	1200	11/8	8/8	0.90	2.3/1.8
P: 14−18 years	4700	–	1500	–	1300	–	–	–	–
P: 19−50 years	4000	–	1500	–	1000	–	–	–	–
P: ≤18 years	–	1250	–	400	–	12	27	1.00	2.0
P: 19−30 years	–	700	–	350	–	11	27	1.00	2.0
P: 31−50 years	–	700	–	360	–	11	27	1.00	2.0
L: 14−18 years	5100	–	1500	–	1300	–	–	–	–
L: 19−50 years	5100	–	1500	–	1000	–	–	–	–
L: ≤18 years	–	1250	–	360	–	13	10	1.30	2.6
L: 19−30 years	–	700	–	310	–	12	9	1.30	2.6
L: 31−50 years	–	700	–	320	–	12	9	1.30	2.6

mg/d – milligram/day; I – infants; C – children; M/F – males/females; P – pregnancy; L – lactation.

healthy people. Health authorities in most countries have established recommendations for daily intake levels of essential minerals. DRI of nutrients vary by age and gender. DRI for minerals (K, P, Na, Mg, Ca, Zn, Fe, Cu and Mn) recommended by The National Academies (The National Academy of Sciences, The Health and Medicine Division, USA, 2019) are shown in Table 2. The importance of minerals as food ingredients depends not only on their nutritional and physiological roles. They contribute to food flavour and activate or inhibit enzyme-catalysed and other reactions, and they affect the colour and texture of food (Belitz et al., 2009).

Pork meat. In living animals, muscles are essential for maintaining the shape of the body in a particular position. Even standing still requires muscular activity. Without normal muscle tone, as during sleep or anaesthesia, maintenance of posture is not possible. Muscles also enable the body of an animal to bend and systematically move and change the support of its limbs, thereby altering its relation to its environment. Such movement, when suitably coordinated, results in specific actions such as locomotion. Both posture and movement are basic to the survival of an animal (Davies, 2004). There are two general types of muscle – striated and smooth – with this nomenclature derived from the microscopic appearance. Striated muscle has striations, while smooth does not. Striated muscle can be further subdivided into skeletal and cardiac. Skeletal muscle, as the name implies, is generally attached to the skeleton. It contains the other tissue types (nerve, epithelia, connective tissue) to a much lesser extent than other tissues and organ systems. Skeletal muscle is the single largest organ mass in the vertebrate body (Swartz et al., 2009).

The conversion of muscle to meat is a complex process involving many biochemical and physical changes. Muscle tissue is converted from an extensible, metabolically active system to one that is inextensible and quiescent in regard to its biochemical reactions. The speed and extent of *post-mortem* metabolism has a profound effect on the properties of the muscle and its subsequent use for food (Greaser, 2001).

Consumption of meat is generally synonymous with human development. Meat is one of the most nutritious foods that humans can consume, and is defined as the flesh (skeletal muscles) of animals used as food (Jensen et al., 2004; Lawrie and Ledward, 2006). Red meat includes beef, veal, pork and lamb (fresh, minced and frozen) (Williamson et al., 2005). Pork meat is the most widely consumed meat in the world, and the consumption has been steadily increasing (Williamson et al., 2005; FAOSTAT, 2019).

Pork meat quality is known to be influenced by a number of *pre-* and *post-mortem* factors. Quality of pork primarily depends on multiple interactive effects of genotype (genetic background, presence of unfavourable alleles at the major genes hal and RN^-), rearing conditions (feeding level, housing and environmental conditions, production system), pre-slaughter handling, and carcass and meat processing (Rosenvold and Andersen, 2003; Olsson and Pickova, 2005).

Meat quality has six dimensions: nutritional quality, sensory quality, technological quality, hygienic quality, toxicological quality and immaterial quality. The nutritive factors of meat quality include proteins and their composition, fats and their composition, micronutrients (minerals and vitamins), utilisation, digestibility and biological value (Honikel, 1999; Olsson and Pickova, 2005).

In a broad sense the composition of meat can be approximated to 75% of water, 19% of protein, 3.5% of soluble, non-protein, substances and 2.5% of fat (Lawrie and Ledward, 2006). In addition to protein and fat, meat is a significant source of several micronutrients (minerals and vitamins).

The nutrient levels in foods are variable. The major sources of variability in nutrient composition are the wide diversity of soil and climatic conditions (geographical origin), seasonal variations, physiological state and maturity, as well as cultivar and breed (Greenfield and Southgate, 2003). The continuous innovations in the breeding systems, rearing practices, feeds composition, changes in slaughtering methods and ageing, largely contribute to induced changes in the content of some of micronutrients in meat (Lombardi-Boccia et al., 2005; Greenfield et al., 2009). According to Hermida et al. (2006), the average mineral contents in tissue depend, in part, on the type of cut (anatomical location of a muscle, i.e., its function in the body), the age of the animal and various other factors. Greenfield and Southgate (2003) concluded that the major sources of variation in animal products are the proportion of lean to fat tissue and the proportion of edible to inedible materials (bone and gristle). Variations in the lean-fat ratio affect the levels of most nutrients, which are distributed differently in the two fractions.

Pig edible offal. Animal by-products, or offal, include all parts of a live animal that are not part of the dressed carcass. Noncarcass material such as skin, blood, bones, meat trimmings, fatty tissues, feet, and internal organs of slaughtered pigs contribute to a wide variety of products including human or pet food or processed materials in animal feed, fertilizer or fuel (Toldrá et al., 2012). In general, the total by-products range from 10 to 30% of the live weight of pig (Ockerman and Basu, 2004).

Animal by-products fall into two categories — edible and inedible. Biologically, most noncarcass material is edible if the product is cleaned, handled and processed appropriately. The yield of edible by-products from pig varies tremendously depending on sex, live weight, fatness and methods of collection (Ockerman and Basu, 2004).

Edible by-products can be categorized as edible organs, glands, and edible fats (Spooncer, 1988; Ockerman and Basu, 2004). Edible offal, sometimes called "variety meat" or "fancy meat," includes the liver, heart, kidney, tongue and other products (other organs, intestines and stomach) frequently used as edible by-products (Ockerman and Basu, 2004). Therefore, edible offal is also a form of meat which is used as food, but which is not skeletal muscles. According to Serbian Regulation (1985), the edible offal of a slaughtered pig, removed during carcass dressing, includes: tongue, heart, lungs, liver, spleen, kidney, brain, spinal cord, testicles, blood, part of the stomach and colon and intestines.

While muscle foods are the more commonly consumed portion of animal, edible by-products such as the entrails and internal organs are also widely consumed (Toldrá et al., 2012). What is considered edible in one region may be considered inedible in another. Many factors influence the consumption of edible offal such as custom, religion, palatability and reputation. Edible offal are often different from skeletal tissue in structure, composition, functional and sensory properties (Spooncer, 1988; Ockerman and Basu, 2004). In general, they have a good nutritional value due to the high protein and low fat levels, as well as good content in minerals and vitamins (Nollet and Toldrá, 2011).

Edible by-products from pig slaughter are part of the diet in different countries worldwide (Nollet and Toldrá, 2011), as a component of kitchen-style food preparations or as processed meat products (Ockerman and Basu 2004; Toldrá et al., 2012). The structure of the edible offal clearly influences the possible uses of these products. Brains are usually prepared for the table rather than for use in manufactured meat products. Because of soft texture, brains are blanched to firm the tissue before proceeding with other cooking methods. Hearts are used as table meats. Whole heart can be stuffed in a variety of ways and roasted or braised. Sliced heart meat is grilled or sautéd. Heart meat is also used in sausages and manufactured meats. Kidneys are used whole or sliced, and generally either grilled, sautéd or braised, but they are not used to any extent in manufactured meat products. Liver is the most widely used edible offal and is used in many types of manufactured meat products. Livers from pigs are better suited to manufactured meats, particularly liver sausages paté because they have a strong flavour. Pig lungs are mainly used to make stuffings and some types of sausages and manufactured meat. They have limited other uses but may be braised either whole or cubed. Spleens are minced and used in stuffings or manufactured meats. Tongues are used fresh or salted and generally boiled or braised, as well as may be canned (Ognjanović et al., 1985; Spooncer, 1988).

2. MINERAL CONTENTS OF RAW PORK MEAT FROM THE INDIGENOUS PIGS

Corresponding data for the mineral (K, P, Na, Mg, Ca, Zn, Fe, Cu and Mn) contents of the major skeletal muscles/muscle groups (tenderloin, ham, loin and shoulder) from the indigenous pigs are shown in Table 3. These muscles/muscle groups represent the main muscle mass (main raw pork meat cuts) of a pig. Among the skeletal muscle tissues (muscle groups – raw pork meat cuts), potassium is the most abundant mineral, followed by phosphorous, sodium, magnesium, calcium, zinc, iron, copper and manganese.

Table 3. Mineral contents (mg/100g) of raw pork meat from the indigenous pigs

Source	Pig genotype	Rearing system	Live weight (kg)	Muscle/ muscle group	K	P	Na	Mg	Ca	Zn	Fe	Cu	Mn
Galián et al., (2007)	CM	C	138.2	LL	310.44	198.84	40.59	19.22	5.21	2.18	4.61	0.42	–
	CMxIB	C	141.8		327.21	200.26	44.33	22.36	5.66	2.16	8.15	0.55	–
Galián et al., (2009)	CM	O	>125	LL	351.0	206.0	46.7	24.1	5.9	1.4	3.0	0.2	–
			<125		367.8	211.1	50.8	25.0	6.4	1.5	2.7	0.2	–
		I	>125	LL	309.6	197.8	42.4	19.6	5.3	2.1	4.3	0.4	–
			<125		336.1	196.2	58.3	23.1	6.7	1.8	3.5	0.3	–
Poto et al., (2007)	CM	O	110	LL	349.33	205.4	39.98	21.99	5.48	1.43	4.30	0.37	–
	CMxIB				364.41	214.73	46.41	23.56	5.55	1.70	5.87	0.59	–
	CMxLW				351.56	208.39	38.11	22.10	4.61	1.49	5.68	0.44	–
Tomović et al., (2014)	SBM	FR	up to 150	PM	421.7	216.8	61.3	25.1	5.98	2.89	2.45	0.170	0.022
				SM	380.4	219.4	80.0	24.1	8.27	2.51	1.95	0.143	0.021
				LD	376.7	201.1	55.9	22.4	6.00	2.15	1.35	0.098	0.017
				TB	393.7	197.7	65.1	24.2	6.81	3.83	1.64	0.140	0.021
Tomović et al., (2016d)	SBM	C	up to 100	PM	303	228	58.4	22.8	7.38	3.25	2.74	0.15	–
				SM	297	224	53.1	24.7	7.68	3.47	1.85	0.11	–
				LTL	296	224	50.3	23.5	5.46	2.35	1.08	0.10	–
				TB	286	218	59.2	22.6	6.22	3.90	3.26	0.14	–
Tomović et al., (2016c)	WM	C	up to 150	LL	291	218	45.1	19.3	7.92	1.84	0.94	0.063	0.0082
	DWM				298	226	42.2	19.5	6.24	1.64	0.55	0.050	0.0059
Despotović et al., (2018a)	WM	C	up to 180	LL	334	228	40.2	25.4	5.85	1.79	0.73	0.064	0.0061
	(DWM)WM				339	227	41.4	25.4	6.16	1.68	0.63	0.043	0.0038
Tomović et al., (2016a)	BS	SO	up to 130	Loin	339	198	50.6	27.8	7.10	3.06	2.07	0.099	0.020
				Ham	346	206	58.4	28.5	7.00	4.66	2.69	0.137	0.024
				Shoulder	316	181	60.7	25.0	7.77	5.43	2.76	0.150	0.025
				Neck	267	159	58.8	21.7	6.91	5.19	2.36	0.120	0.020

CM – Chato Murciano; IB – Iberian; LW – Large White; SBM – Swallow-Belly Mangalica; WM – White Mangalica; D – Duroc; BS – Black Slavonian; C – commercial; O – outdoor; I – indoor; FR – free-range; SO – semi-outdoor; LL – *M. longissimus lumborum*; PM – *M. psoas major*; SM – *M. semimembranosus*; LD – *M. longissimus dorsi*; TB – *M. triceps brachii*; LTL – *M. longissimus thoracis et lumborum*.

Overall, there are large variations in the mineral contents of pork meat, ranging from 267 to 421.7 mg/100g for potassium; 159 to 228 mg/100g for phosphorous; 38.11 to 80.0 mg/100g for sodium; 19.22 to 28.5 mg/100g for magnesium; 4.61 to 8.27 mg/100g for calcium; 1.4 to 5.43 mg/100g for zinc; 0.55 to 8.15 mg/100g for iron; 0.10 to 0.170 mg/100g for copper; and from 0.0038 to 0.025 mg/100g for manganese (Table 3). For a number of items listed, no values for manganese were available.

3. MINERAL CONTENTS OF RAW PIG EDIBLE OFFAL FROM THE INDIGENOUS PIGS

Corresponding data for the mineral (K, P, Na, Mg, Ca, Zn, Fe, Cu and Mn) contents of various raw pig edible offal tissues (tongue, heart, lungs, liver, spleen, kidney, brain and spinal cord) are shown in Table 4. Overall, there are large variations in the mineral contents. Potassium is the highest for spleen (383.4-463.8 mg/100g), followed by spinal cord (317.1-377.4 mg/100g), brain and liver (253.2-387.8 mg/100g and 277.4-359.0 mg/100g, respectively), kidney (247.7-266 mg/100g), tongue (245.8-256.9 mg/100g), heart (175.7-285.2 mg/100g) and lungs (222.5-225.6 mg/100g). With the exception of spinal cord, with phosphorus content of somewhat higher than 500 mg/kg (501.4-502.0 mg/100g), the phosphorus content is highest in brain, where it ranges from 354.2 to 359.9 mg/100g. Liver is next highest in phosphorus content (315-406.5 mg/100g), followed by spleen (301.4-313.3 mg/100g), kidney (225.8-296.8 mg/100g), lungs (208.7-252.7 mg/100g), heart (171.4-232.3 mg/100g) and tongue (173.0-209.3 mg/100g). Furthermore, lungs (144.1-158.4 mg/100g) and kidney (127.7-157.2 mg/100g) are the highest in sodium content. The content of sodium in spinal cord ranges from 125.8 to 146.0 mg/100g, while in brain it ranges from 123.3 to 142.3 mg/100g. Sodium is lowest in heart (82.5-110.8 mg/100g), tongue (87.7-91.8 mg/100g), spleen (83.0-94.5 mg/100g) and liver (71.6-80.2 mg/100g). Contents of magnesium are similar for liver (20.4-28.5 mg/100g), heart (20.0-24.7 mg/100g), kidney (17.7-25.5 mg/100g), spleen (18.0-20.7 mg/100g) and tongue (17.4-18.1 mg/100g). The content of magnesium in lungs and brain ranges from 13.8 to 14.0 mg/100g and from 10.0 to 15.0 mg/100g, respectively. Spinal cord is the lowest in magnesium content (8.3-14.2 mg/100g). For given raw pig edible offal, spinal cord is markedly the highest in calcium content (17.21-26.02 mg/100g). Other raw edible offal (lungs: 12.99-20.84 mg/100g; brain: 7.60-18.74 mg/100g; tongue: 10.32-12.79 mg/100g; kidney: 9.61-13.02 mg/100g; liver: 5.89-13.59 mg/100g; heart: 8.00-8.55 mg/100g; spleen: 5.36-6.07 mg/100g) do not differ markedly in calcium content. Liver is the richest source of zinc, and values range from 5.34 to 6.47 mg/100g. Values for spleen, kidney, brain, tongue, heart and lungs are in the ranges: 3.15-3.32 mg/100g, 2.24-3.74 mg/100g, 1.56-3.97 mg/100g, 2.13-2.41 mg/100g, 1.61-2.83 mg/100g and 1.95-2.09 mg/100g, respectively. Spinal cord is the lowest in zinc content (0.67-0.79 mg/100g).

Liver and spleen are the best sources of iron. Values range from 20.24 to 45.59 mg/100g for liver and from 23.43 to 27.49 mg/100g for spleen Also, lungs, kidney and heart are the rich source of iron, with a content ranging from 6.37 to 8.81, from 5.96 to 9.33 and from 4.48 to 6.81 mg/100g, respectively

Table 4. Mineral contents (mg/100g) of raw edible offal from the indigenous pigs

Source	Edible offal	K	P	Na	Mg	Ca	Zn	Fe	Cu	Mn
Tomović et al., (2016b) Swallow-Belly Mangalica pigs, up to 150 kg live weight	Tongue	245.8	173.0	87.7	17.4	12.79	2.13	2.56	0.238	0.036
	Heart	285.2	171.4	93.0	20.0	8.55	1.61	4.48	0.320	0.035
	Lungs	222.5	208.7	158.4	13.8	20.84	2.09	6.37	0.118	0.033
	Liver	359.0	344.5	80.2	20.4	13.59	5.34	33.58	0.365	0.267
	Spleen	463.8	301.4	83.0	18.0	5.36	3.15	27.49	0.205	0.045
	Kidney	247.7	225.8	157.2	19.1	13.02	2.24	5.96	0.393	0.123
	Brain	387.8	354.2	142.3	10.0	18.74	1.56	3.82	0.319	0.048
	Spinal cord	377.4	501.4	146.0	8.3	26.02	0.67	1.78	0.206	0.045
Tomović et al., (2016a) Black Slavonian pigs, up to 130 kg live weight	Heart	248	186	82.5	24.7	8.00	2.35	6.81	0.373	0.043
	Liver	301	315	71.6	28.5	7.84	6.47	45.59	0.379	0.254
	Kidney	266	256	127.7	25.5	9.61	3.16	9.33	0.362	0.152
Despotović et al., (2018b) Swallow-Belly Mangalica pigs, up to 100 kg live weight	Tongue	256.9	209.3	91.8	18.1	10.32	2.41	2.98	0.264	0.035
	Heart	175.7	232.3	110.8	21.8	8.32	2.83	5.10	0.391	0.039
	Lungs	225.6	252.7	144.1	14.0	12.99	1.95	8.81	0.154	0.032
	Liver	277.4	406.5	75.1	20.5	5.89	6.36	20.24	0.825	0.338
	Spleen	383.4	313.3	94.5	20.7	6.07	3.32	23.43	0.141	0.052
	Kidney	261.4	296.8	152.8	17.7	11.17	3.74	6.24	0.633	0.214
	Brain	253.2	359.9	123.3	15.0	7.60	3.97	2.51	0.440	0.050
	Spinal cord	317.1	502.0	125.8	14.2	17.21	0.79	2.30	0.257	0.060

Iron values are similar for brain (2.51-3.82 mg/100g) and for tongue (2.56-2.98 mg/100g). The lowest amount of iron is for spinal cord (1.78-2.30 mg/100g). Copper is the highest for liver (0.365-0.825 mg/100g). Otherwise, it is in the range: 0.362-0.633 mg/100g (kidney), 0.319-0.440 mg/100g (brain), 0.320-0.391 mg/100g (heart), 0.238-0.264 mg/100g (tongue), 0.206-0.257 mg/100g (spinal cord), 0.141–0.205 mg/100g (spleen) and 0.118–0.154 mg/100g (lungs). Of the raw pig edible offal with values for manganese, liver and kidney contain the highest amounts. Content ranges from 0.254 to 0.338 mg/100g in liver and from 0.123 to 0.214 mg/100g in kidney. The remaining raw pig edible offal contain less than 0.1 mg/100g manganese. Manganese levels in spinal cord, brain, spleen, heart, tongue and lungs range from 0.032 mg/100g (lungs) to 0.060 mg/100g (spinal cord) (Table 4).

4. CONCLUSIONS

The mineral levels in raw meat and edible offal from the indigenous pigs are variable, ranging from 175.7 to 463.8 mg/100g for potassium; 159 to 502.0 mg/100g for phosphorous; 38.11 to 158.4 mg/100g for sodium; 8.3 to 28.5 mg/100g for magnesium; 4.61 to 26.02 mg/100g for calcium; 0.67 to 6.47 mg/100g for zinc; 0.55 to 45.59 mg/100g for iron; 0.10 to 0.825 mg/100g for copper; and from 0.0038 to 0.338 mg/100g for manganese.

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DECLARATION OF CONFLICTING INTERESTS

We have no conflict of interest to declare.

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