Food Chemistry **45** (1992) 269–277

Mineral and trace element contents in bread

Felib Y. Iskander

Nuclear Engineering Teaching Laboratory, Department of Mechanical Engineering, University of Texas, Austin, TX 78712, USA

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Karen R. Davis

Department of Bacteriology and Biochemistry, Food Research Center, University of Idaho, Moscow, Idaho 83843, USA

(Received 1 October 1991; revised version received and accepted 2 March 1992)

Nineteen different bread varieties baked at 13 different locations in Egypt, from Aswan at the far South to Edfina on the Mediterranean Sea, were collected. These breads were formulated with wheat and/or corn flour with or without other ingredients such as fenugreek or okra. Sixteen elements were measured by instrumental neutron activation analysis (INAA). The overall average concentrations of these elements in the investigated breads were as follows (in μg/g): Br, 5·06; Ca, 326; Cl, 2062; Cr, 0·95; Co, 0·044; Fe, 54·0; K, 2086; Mg, 692; Mn, 11·6; Na, 1709; Rb, 1·6; Sb, 0·040; Sc, 0·01; Se, 0·28 and Zn, 11·5. No As was detected in any of the bread types investigated. Assuming an average daily intake of 500 g, bread delivers 15–35% of RDA for Ca; 29–69% for K; 62–100% for Mg; 1–100% for Na; 33–77% for Zn; 43–100% for Se; 73–100% for Cr and 100% for Fe and Mn.

INTRODUCTION

The importance of measuring the mineral content in bread in relation to the nutritive value has been realized. The literature lists the concentrations of macrominerals, trace elements and toxic elements in German breads (Pfannhauser, 1989; Brueggemann & Ocker, 1990); Hungarian bread (Schamschula *et al.*, 1988; Kardos *et al.*, 1989); Australian bread (Frady *et al.*, 1989); Italian bread (Stacchini *et al.*, 1989); Chinese bread (Ye, 1989); Iraqi bread (Jawad *et al.*, 1989) and Malawian breads (Ferguson *et al.*, 1989). Several papers have been published on various aspects of quality of Middle Eastern Breads, and little is found in the literature about the mineral, trace element and toxic element content of Egyptian bread (Kouhestani *et al.*, 1969; Reinhold, 1971; Ter-Sarkissian *et al.*, 1974; Tabekhia & Toma, 1979; Damir *et al.*, 1982; Faridi *et al.*, 1983).

Bread is the staff of life in Egypt, and cereals provide up to 70% of the calories and two thirds of the protein intake for rural Egyptians (Anon., 1966; Nawar, 1979). The cost of bakery bread is intentionally kept low by the Ministry of Supply so that no Egyptian should be hungry. Estimates are that there may be 200 different types of breads in Egypt that vary in ingredients used or in baking techniques. There may be breads that have the same ingredients, but that are called different names in different locations. Likewise, there may be breads that have the same name but differ in formulation. Although wheat (*Triticum Aestivum*) and corn (*Zea mays*) constitute the main cereal in bread making, some of the other breads are made with barley (*Hordeum volgare*), sorghum (*Sorghum volgare*) or millet (*Setaria sp.*). These are primarily dry land crops grown on the north shore near the Mediterranean Sea.

The balady bread is sourdough pocket bread and is baked and used throughout Egypt. It has a coarser texture, a characteristic sourdough flavor, and the crumb layer is very thin. The ingredients and types of balady bread baked at the various locations were quite different in proportion, as shown in Table 1. The loaves are different in size, degree of hydration, texture, flavor, and thickness of crumb layer. Bread doughs are flattened using several techniques such as pounding with the fingers, using a roller or tossing on a wooden disk lined with wheat bran.

Amh is the Arabic word for wheat. Amh-nashif, or dry wheat bread, is a cracker-like bread whereas

Food Chemistry 0308-8146/92/$05.00

Table 1. Sample location, bread formulations (for batch made with 20 kg flour), the use of dung as fuel and the number of loaves in composite sample

Sample location	Bread type	Flour (kg)					Yeast (g)	Salt (g)	Water (liters)	Use of dung	No. of loaves
		72% Ext	82% Ext	Corn	Okra	Fenugreek					
Balady											
Brug El-Arab	Bakuun	20·00	—	—	—	—	50	200	18·00	no	1
Kafe Kazal	Mabbotot	—	15·00	5·00	—	—	200	200	17·00	yes	2
Kafr Kazal	Kabbouri	—	15·00	5·00	—	—	200	200	17·00	yes	2
Nazlah	Manottot	6·00	16·00	—	—	—	50	200	20·30	yes	2
Beni Suef	Balady	12·00	8·00	—	—	—	40	128	23·60	yes	3
Amh											
Edfina	Fallahi	—	20·00	—	—	—	50	200	12·00	no	2
El-Omaid	Amh-Nashif	—	15·00	5·00	—	—	60	240	16·00	no	2
El-Omaid	Amh-Tari	20·00	—	—	—	—	200	200	16·00	no	2
Nubaria Sta.	Amh-Nashif	16·00		4·00	—	—	100	200	22·00	yes	1
Shamsy											
Beni Suef	Shamsy	12·00	8·00	—	—	—	40	128	18·00	no	3
Other wheat based breads											
Edfina	Rokak	20·00		—	—	—	50	200	12·00	no	3
El-Alemain	Majordag	—	20·00	—	—	—	—	—	10·00	no	2
Durunka	Faish	—	20·00	—	—	—	20	200	17·50	no	2
Durunka	Rushda noodles	14·00	6·00	—	—	—	100	200	17·00	?	1
Aswan	Fiti	—	20·00	—	—	—	—	—	30·00	no	2
Bettaw											
Beni Suef	Bettaw	—	15·00	4·85	—	0·15	—	—	20·00	no	2
AL-Borgaya	Bettaw	—	—	19·64	—	0·36		182	14·00	no	2
Magousa	Bettaw	—	1·48	18·24	—	0·28	—	190	13·00	yes	2
Mashouah											
Sentimeh	Rok rouk	5·33	2·67	10·67	1·33	—	—	210	18·70	yes	3

amh-tari is a soft pocket bread similar to the balady bread. In some locations amh bread may contain rice flour. One of the most popular breads among the Egyptians in upper Egypt is the shamsy or sun bread. This bread is very similar to the small San Francisco sourdough bread, and has different formulations. The loaf is rounded and has a firm, white crumb. The shamsy or sun bread dough is placed on a disk-shaped 'makrassa' in the sun to ferment. Other wheat-based breads are the Bedouin's majordag and the Nubian's fiti bread. Majordag bread from El-Alemain is a Bedouin bread made from flour, water, and a little salt. It is made into a stiff dough and is rolled into thin, flat circles which are baked on a griddle directly over the fire. The fiti bread is made from a batter, much like pancakes. The bread is thin and soft.

The bettaw bread is called 'mehrahra' in some locations. It is a thin, crisp flat bread that could be up to 50 cm in diameter. It contains fenugreek (*Trigonella foenugreekum*) flour in a proportion of 1–3% of the corn flour. Corn flour, in some locations, is substituted with cheaper locally produced wheat flour or with sorghum or millet. The okra flour is thought to give the dough better handling properties. The other corn-based bread is the okra-containing mashtouah. Mashtouah contains both local and imported flour, corn flour, okra flour and, in some cases, a sourdough starter.

The fuel used for bread baking could be anything that burns; corn stalks, rice straw, scrap lumber, and dung briquettes. In some locations, the oven is constructed of bricks with an iron hearth and is heated by a burner that can use either diesel or kerosene fuel.

This study was undertaken to provide data on the concentration of 16 major elements and trace elements in 19 different bread types using instrumental neutron activation analysis. These elements are As, Br, Ca, Cl, Cr, Co, Fe, K, Mg, Mn, Na, Rb, Sb, Sc, Se and Zn. Also it was undertaken to compare, when applicable, the average daily intake of these elements to the RDA values.

MATERIALS AND METHODS

Samples of bread, flour, and bran represent 13 villages from Aswan in the south to El-Alemain in the north (Fig. 1). Three loaves of each bread type were collected and the weight was determined at the time of collection. The bread was dried in a pasta dryer overnight at 60°C, weighed again, and pulverized in a blender. Most samples were processed within one day of collection.

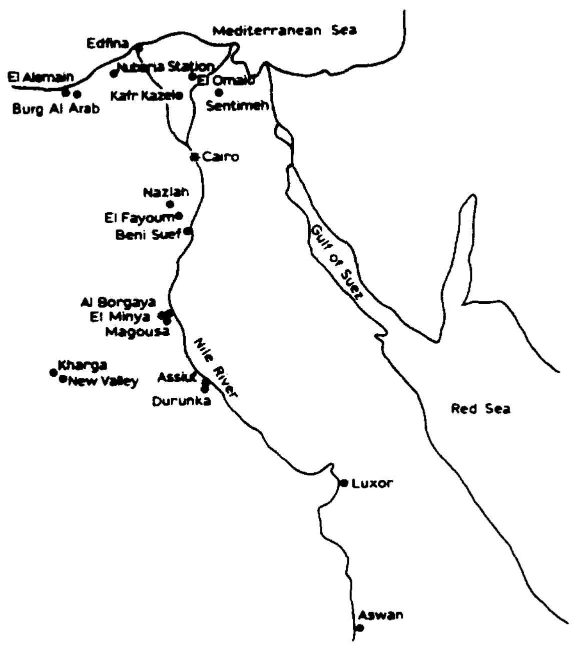

Fig. 1. Sampling locations.

The ground samples were sealed in plastic bags and kept in frozen storage. The loaves were composited and a representative portion of the composite was subjected to INAA. In spite of all precautions it was observed that one or more of the loaves were unfit for analysis due to either spoilage or insect infestation. The number of loaves in each sample composite is given in Table 1. In addition, samples of flour (wheat flour 72% extraction, 82% extraction, wheat and okra mix, corn, corn and fenugreek mix), bran (from wheat and corn) and fenugreek seeds were also subjected to INAA. Analysis was also conducted on grains from two wheat, corn and sorghum varieties. The grain varieties examined are not necessarily the same as used for making the bread samples under investigation.

For elemental measurements 300–500 mg of sample was thermally sealed into a 2/5-dram high purity polyethylene vial (Olympic Plastics, Inc., CA). Each vial was in turn sealed in a 2-dram polyethylene vial. Several standards were used for comparison and these include Standard Reference Materials from the National Institute of Standards and Technology (Bovine Liver, Wheat Flour, Rice Flour, Citrus Leaves, Tomato Leaves and Oyster Tissue) and standards prepared from high purity materials (>99·999%). The sealed samples, blanks and standards were irradiated in the TRIGA Mark I on the campus of the University of Texas at Austin, at an approximate neutron flux of 2×10^{12} n cm^{-2} s^{-1}. The nuclear reaction used, half-life of the indicator radionuclide and gamma ray monitored are given in Table 2. Samples were irradiated twice; the first time it was performed for 3 min using the pneumatic transfer facility which allows the delivery of a sample to and from reactor core in less than 20 s. At the end of the irradiation period the outside 2-dram vial was replaced by a non-irradiated vial to minimize unwanted background radiation. Counting for gamma rays was in-itiated in less than 1 min from the time-out-of-reactor. Ca and Mg samples were counted for 3 min. After 20–40 min had elapsed the samples were re-counted again for 15 min to measure Cl and Mn. The second irradiation was performed for 8 h using the rotary specimen rack facility. After a decay period of 24–36 h (to allow for the decay of short-lived isotopes) the samples were counted for 1 h to measure As, Br, K and Na. Samples were then stored for a period of 4–6 weeks to allow for the decay of unwanted isotopes. Finally, samples were counted for 8 h to measure Cr, Co, Fe, Rb, Sb, Sc, Se and Zn. The detection system for gamma rays includes a high purity germanium detector with a relative efficiency of 30% for the 1·33 MeV ^{60}Co line, with resolution of 1·9 keV. The detector was connected to a 4096 pulse-height multichannel analyzer.

Table 2. Nuclear reaction, indicator radionuclide, gamma ray monitored and irradiation, decay and counting time

Element	Nuclear reaction and indicator nuclide	Half-life	γ-ray monitored (keV)	Irradiation time	Decay time	Counting time
As	$^{75}As\ (n,\gamma)\ ^{76}As$	26·3 h	559·1	8 h	24–36 h	1 h
Br	$^{81}Br(n,\gamma)^{82}Br$	35·3 h	776·5	8 h	24–36 h	1 h
Ca	$^{48}Ca\ (n,\gamma)^{49}Ca$	8·72 min	3 084·4	3 min	30–60 s	3 min
Cl	$^{37}Cl(n,\gamma)^{38}Cl$	37·2 min	1 642·4	3 min	20–40 min	15 min
Cr	$^{50}Cr(n,\gamma)^{51}Cr$	27·70 days	320·1	8 h	28–35 days	8 h
Co	$^{59}Co(n,\gamma)^{60}Co$	5·271 years	1 332·5	8 h	28–35 days	8 h
Fe	$^{58}Fe(n,\gamma)^{59}Fe$	44·516 days	1 099·2	8 h	28–35 days	8 h
K	$^{41}K(n,\gamma)^{42}K$	12·36 h	1 524·6	8 h	28–35 days	1h
Mg	$^{26}Mg(n,\gamma)^{27}Mg$	9·45 min	1 014·4	3 min	30–60 s	3 min
Mn	$^{55}Mn(n,\gamma)^{56}Mn$	2·578 h	846·8	3 min	20–40 min	15 min
Na	$^{23}Na(n,\gamma)^{24}Na$	14·96 h	1 368·8	8 h	24–36 h	1 h
Rb	$^{85}Rb(n,\gamma)^{86}Rb$	18·65 days	1 076·7	8 h	28–35 days	8 h
Sb	$^{123}Sb(n,\gamma)^{124}Sb$	60·20 days	1 691·0	8 h	28–35 days	8 h
Sc	$^{45}Sc(n,\gamma)^{46}Sc$	83·81 days	889·3	8 h	28–35 days	8 h
Se	$^{74}Se(n,\gamma)^{75}Se$	120·0 days	264·7	8 h	28–35 days	8 h
Zn	$^{64}Zn(n,\gamma)^{65}Zn$	243·8 days	1 115·5	8 h	28–35 days	8 h

Table 3. Concentration of As, Br, Ca, Cl, Cr, Co, Fe and K in 19 different Egyptian breads (dry weight bases)

Sample location	Bread type	As ($\mu g\ g^{-1}$)	Br ($\mu g\ g^{-1}$)	Ca ($\mu g\ g^{-1}$)	Cl ($\mu g\ g^{-1}$)	Cr ($\mu g\ g^{-1}$)	Co ($ng\ g^{-1}$)	Fe ($\mu g\ g^{-1}$)	K ($\mu g\ g^{-1}$)
Balady									
Brug El-Arab	Bakuun	< 1	6·8	560	4 760	0·39	43	38·1	2 170
Kafe Kazal	Mabbotot	< 0·7	5·18	389	1 990	1·9	44	94	2 880
Kafr Kazal	Kabbouri	< 1	9·18	443	5 070	< 0·3	34	49·9	2 570
Nazlah	Manottot	< 0·6	6·82	439	1 610	< 0·3	44	49·3	2 430
Beni Suef	Balady	< 1	13·2	490	3 940	0·59	130	164	3 860
Amh									
Edfina	Fallahi	< 0·3	3·59	246	381	< 0·3	33	37·9	2 070
El-Omaid	Amh-Nashif	< 0·6	3·47	260	1 510	0·29	27	44·9	2 410
El-Omaid	Amh-Tari	< 0·5	4·59	256	1 710	0·34	22	37·4	2 190
Nubaria Sta.	Amh-Nashif	< 1	6·87	512	5 470	1·43	79	75·2	2 660
shamsy									
Beni Suef	shamsy	< 0·8	10·7	435	3 630	< 0·4	28	39·2	1 870
Other wheat based breads									
Edfina	Rokak	< 0·4	4·96	535	477	0·46	58	39·3	2 220
El-Alemain	Majordag	< 1	6·55	350	6 440	1·7	45	120	2 190
Durunka	Faish	< 0·3	3·09	289	640	0·7	480	39·2	1 960
Duranka	Rushda noodles	< 1	5·65	448	4 050	0·81	150	74·9	2 660
Aswan	Fiti	< 1	6·54	489	3 570	2·43	130	114	2 540
Bettaw									
Beni Suef	Bettaw	< 0·8	10·2	391	3 310	0·39	41	62·5	1 980
AL-Borgaya	Bettaw	< 0·3	3·02	318	447	< 0·4	88	86·3	3 530
Magousa	Bettaw	< 0·3	1·21	315	515	0·33	63	106	4 510
Mashouah									
Sentimeh	Rok rouk	< 0·5	2·82	430	1 230	< 0·3	63	74·5	3 270
RDA (mg day^{-1})		—	—	800	1700–5100	0·05–0·2	—	10–18	1 525–4 515

RESULTS AND DISCUSSION

The average daily bread intake in Egypt varies by location (village versus city), life style (upper class versus peasant) and by the type and weight of bread consumed (shamsy bread weighing 400–500 g versus balady bread weighing 100–150 g.). However, a conservative estimate, by the author, sets the daily intake of four to six loaves of balady bread or one loaf of shamsy bread. This corresponds to 400–600 g on a dry mass basis. To calculate the average daily intake of the studied mineral from the various bread types examined, a daily intake of 500 g will be used throughout the discussion. Also, the recommended daily allowance (RDA) for minerals and trace elements, as given by Spallholz (1989), will be used. Tables 3 and 4 show the concentrations of As, Br, Ca, Cl, Cr, Co, Fe, K, Mg, Mn, Na, Rb, Sb, Sc, Se and Zn in the 19 bread types investigated. The contents of the above mentioned elements in some materials used in bread formulation are listed in Table 5.

Calcium, chlorine, potassium, magnesium and sodium

According to Spallholz (1989), these minerals, together with phosphorus and sulfur, represent the macrominerals that constitute more than 99% of all essential minerals of the human body. They function as principal electrolytes for ionic and osmotic balance, to strengthen the endoskeleton and to provide structure to proteins.

Calcium

The concentration of Ca in the types of bread investigated ranges from 246 $\mu g\ g^{-1}$ (Fallahi bread) to 560 $\mu g\ g^{-1}$ (Bakuun bread), with an average of 326 $\mu g\ g^{-1}$. These upper and lower Ca concentrations corresponding to 123–280 mg of Ca day^{-1}, which is 15–35% of the RDA for an adult male (Fig. 2). These two types of bread were made with wheat flour. The addition of dry powdered okra to wheat flour considerably increases the concentration of Ca (Table 5), and this may modify the Ca content of the product. An exceptionally high concentration of Ca (1690 $\mu g\ g^{-1}$) was observed in fenugreek; however, the three types of bettaw bread formulated with fenugreek can only provide 20–24% of the RDA for Ca. The Ca concentration in rye, white enriched and whole wheat breads was reported by Gormican (1970) as 960, 1280 and 740 $\mu g\ g^{-1}$ on wet weight bases.

Chlorine

Chlorine, essentially as chloride, is abundant in various foodstuffs and numerous salts such as NaCl, KCl and

Table 4. Concentration of Mg, Mn, Na, Rb, Sb, Sc, Se, and Zn in 19 different Egyptian breads (dry weight bases)

Sample location	Bread type	Mg (μg g^{-1})	Mn (μg g^{-1})	Na (μg g^{-1})	Rb (μg g^{-1})	Sn (μg g^{-1})	Sn (μg g^{-1})	Se (μg g^{-1})	Zn (μg g^{-1})
Balady									
Brug El-Arab	Bakuun	832	12·6	4 220	1·31	< 20	4	0·49	14·0
Kafe Kazal	Mabbotot	1 150	22·6	1 950	4·66	30	12	0·3	15·9
Kafr Kazal	Kabbouri	886	15·4	4 650	0·7	< 20	10	< 0·2	14·9
Nazlah	Manottot	887	15·1	1 160	0·8	< 10	9	0·2	14·3
Beni Suef	Balady	1 610	13·8	3 090	< 1	31	46	< 0·3	21·1
Amh									
Edfina	Fallahi	494	14·5	48·9	< 2	< 20	5	< 0·2	12·9
El-Omaid	Amh-Nashif	665	9·41	1 090	< 0·8	< 10	5	< 0·2	11·2
El-Omaid	Amh-Tari	767	8·06	1 350	0·91	< 10	4	< 0·1	9·8
Nubaria Sta.	Amh-Nashif	862	19·6	4 480	1·32	< 10	15	0·18	13·2
shamsy									
Beni Suef	shamsy	567	13·5	2 620	1·37	32	5	< 0·2	11·3
Other wheat based breads									
Edfina	Rokak	589	13·9	184	< 0·1	< 20	4	< 0·1	12·8
El-Alemain	Majordag	919	12·7	5 450	1·05	< 20	3	0·29	13·8
Durunka	Faish	746	17·9	190	< 1	30	6	0·17	18·8
Durunka	Rushda noodles	1 250	24·2	2 980	1·76	40	4	0·26	17·7
Aswan	Fiti	794	22·1	4 250	1·95	< 50	8	0·25	11·7
Bettaw									
Beni Suef	Bettaw	701	15·2	2 550	< 1	29	13	< 0·2	11·3
AL-Borgaya	Bettaw	1 240	8·71	131	1·51	< 20	17	< 0·2	22·5
Magousa	Bettaw	1 340	11·5	209	< 1	70	24	< 0·2	23·2
Mashouah									
Sentimeh	Rok rouk	1 000	13·6	617	< 1	35	12	< 0·2	21·3
RDA (mg day^{-1})		300	2·5–5·0	900–2700	—	—	—	0·05–0·2	15

$CaCl_2$. The concentration of Cl in the types of bread investigated ranges from 381 μg g^{-1} (Fallahi bread) to 6440 μg g^{-1} (Majordag bread), with an average of 2062 μg g^{-1}. If table salt used in bread formulation is the major source of Cl, one might expect to see the Amh-Nashif bread from Al-Omaid with the highest Cl concentration since it was formulated with the highest table salt content. This may indicate NaCl is not the major source of Cl in some of the samples examined. It was noticed that wheat grain, bran and flour contain higher concentrations of Cl compared to corn and sorghum. Breads examined can provide from 0·22 to 3·22 g of Cl day^{-1} compared to the RDA of 1·7–5·1 g for Cl.

Potassium

Potassium is widely present in food. The RDA for K is 1525–4515 mg. The concentration of K in the investigated bread types ranged from 1960 μg g^{-1} (Faish bread from Durunka) to 3860 μg g^{-1} (Balady from Beni-Suef) with an average value of 2062 μg g^{-1}. Thus the intake from the bread types investigated ranges from 1·0 to 2·3 g of K day^{-1}. Spallholz (1989) estimated that the average daily intake of K from the diet is 1·8–5·6 g. The average concentration of K for the Egyptian breads investigated in this study is within the concentration range of 850–2330 μg K g^{-1} reported for several other bread types (Czarnecki & Kritchevsky, 1980).

Magnesium

The concentration of Mg in the Egyptian breads investigated ranges from 494 μg g^{-1} (Fallahi bread) to 1610 μg g^{-1} (Balady bread from Beni-Suef), with an average concentration of 692 μg g^{-1}. The various types of bread investigated can provide from 247 to 805 mg day^{-1}, which almost satisfies the RDA for Mg of 300 mg. Magnesium deficiency in healthy people is rare, as food usually contains enough Mg to meet the RDA of this mineral. The average concentration of Mg in the Egyptian bread types investigated is higher than that of some wheat-based bread types reported by Gormican (1970) to range from 420 to 590 μg g^{-1}.

Sodium

Whole wheat, white enriched and rye bread were reported to contain 5070–8730 μg Na g^{-1} (Gormican, 1970; Czarnecki & Kritchevsky, 1980). It is likely that table salt included in bread formulation can be considered as the main source of Na in bread. The concentration of Na in the various types of bread investigated ranges from 48·9 μg g^{-1} (Fallahi bread) to 5450 μg g^{-1} (Majordag bread), with an average concentration of

Table 5. Concentration of As, Br, Ca, Cl, Cr, Co, Fe, K, Mg, Mn, Na, Rb, Sb, Sc, Se and Zn in flour, wheat, corn and other components used in the formulation of Egyptian breads

Material analyzed	As (μg g^{-1})	Br (μg g^{-1})	Ca (μg g^{-1})	Cl (μg g^{-1})	Cr (μg g^{-1})	Co (ng g^{-1})	Fe (μg g^{-1})	K (μg g^{-1})	Mg (μg g^{-1})	Mn (μg g^{-1})	Na (μg g^{-1})	Rb (μg g^{-1})	Sb (ng g^{-1})	Sc (ng g^{-1})	Se (μg g^{-1})	Zn (μg g^{-1})
Flour																
Wheat 72% extract	< 0·4	5·8	191	652	< 0·3	14	27·9	2 288	536	8·21	124	< 0·9	10	4	< 0.2	14·i
Wheat 82% extract	< 0·3	2·88	225	497	< 0·4	16	29·9	2 340	674	18·5	37·3	1·19	< 20	6	< 0.2	15·1
Wheat + okra	< 0·3	1·43	608	603	< 0·4	20	50·5	5 010	1 160	19·3	50·9	< 1	19	8	< 0.1	26·8
Corn	< 0·3	1·15	194	464	< 0·5	56	56·6	3 960	1 210	8·77	83·7	< 1	< 20	11	< 0.2	22·4
Corn + 1% fenugreek	< 0·7	13·3	274	649	< 0·6	29	73·1	3 600	1 330	10·8	294	< 1	25	18	< 0.2	19.8
Bran																
Wheat	< 0·3	5·11	446	397	< 0·3	32	35·3	3 830	1 280	49·8	45·8	2·26	< 20	3	< 0.2	23.5
Corn	< 0·2	0·78	221	346	< 0·4	36	86	3 870	1 170	17·1	64·1	< 1	23	20	< 0.1	24.4
Fenugreek	< 0·4	3·29	1 690	1 020	< 0·3	64	86	12 200	1 720	17·4	536	2·79	41	14	< 0.2	27.3
Wheat																
Variety a	< 0·1	4·95	562	494	< 0·2	24	37·7	3 040	1 260	31·0	14·7	1·98	< 13	1	0.58	18.8
Variety b	< 0·3	7·05	397	527	< 0·4	15	42·5	4 060	1 340	38·7	15·8	1·94	< 20	2	0.50	21.3
Corn																
Variety a	< 0·1	1·83	28·9	ND	< 0·2	8	14·5	2 730	ND	5·23	1·35	< 0·6	28	< 1	< 0.2	13.6
Variety b	< 0·1	1·88	31·3	ND	< 0·2	3	14·7	3 220	ND	4·83	1·04	1·55	31	< 1	< 0.2	12.5
Sorghum																
Variety a	< 0·2	4·01	127	126	< 0·2	3	33·5	9 350	1 680	17·5	11·1	0·78	32	2	< 0.1	19
Variety b	< 0·2	1·7	123	179	< 0·3	5	27	3 910	1 500	11·9	6·12	1·81	31	2	0.17	17.7

ND, not determined.

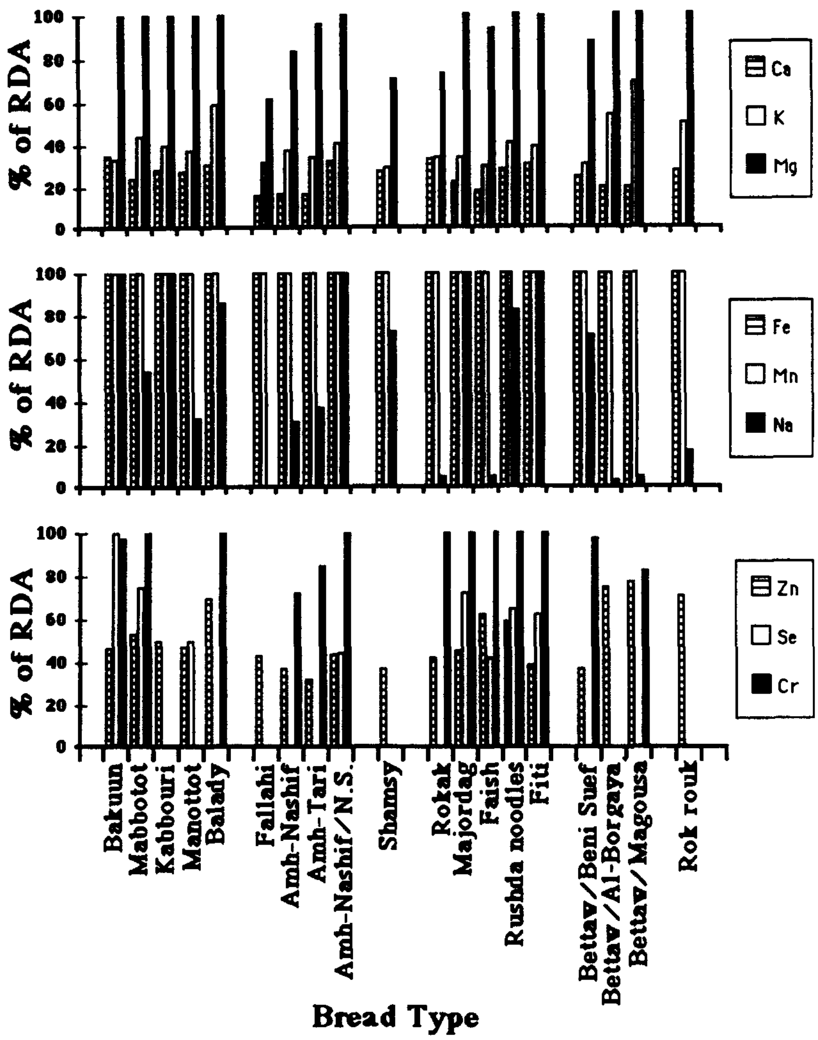

Fig. 2. Mineral concentration in 19 Egyptian bread types as percentage of RDA.

1709 $\mu g\ g^{-1}$. The various types of bread investigated can provide from 0·24 to 2·7 g day^{-1}. Based on the bread formulation given in Table 1, the dough for Fallahi bread should contain 2438 $\mu g\ g^{-1}$ Na. With the loss of water upon baking the concentration of Na will increase. This seems at variance with the measured concentration of Na of 48·9 $\mu g\ g^{-1}$. One possible explanation for that is the use of rock salt for bread formulation; thus NaCl is not homogeneously distributed throughout the dough. This explanation is substantiated by the low Cl concentration for the same bread type. The average Na concentration for all the bread types investigated is 1709 $\mu g\ g^{-1}$. This corresponds to 0·85 g day^{-1} which provides approximately 100% of the RDA of 0·90–2·7 g.

Iron, zinc, selenium, manganese, chromium and cobalt

These minerals are identified as being essential trace elements for higher animals and humans, and are found in cells and tissues as components of active site of enzymes or as regulators of enzymatic activity. These minerals are also known as micro (or trace) minerals (Spallholz, 1989).

Iron

The concentration of iron in the 19 bread types investigated ranged from 37·4 (Amh-Tari) to 164 $\mu g\ g^{-1}$ (Balady, from Beni-Suef) with an overall average concentration of 54·0 $\mu g\ g^{-1}$. It is likely that the balady bread from Beni-Suef was prepared with flour enriched with iron. Home made breads baked by home grown cereals are likely to show less iron content. However, all types of bread investigated can provide the RDA for Fe. It was observed that corn flour and flour made of wheat and okra had higher iron contents. Also, fenugreek shows a higher concentration of iron. The iron content of the examined Egyptian breads is higher than the 15–38 μg Fe g^{-1} reported for some American baked breads (Gormican, 1970).

Zinc

The Bettaw bread from Magousa shows the highest concentration of zinc, 23·2 $\mu g\ g^{-1}$, which corresponds to 11·6 mg of Zn per day. the lowest Zn concentration (9·8 $\mu g\ g^{-1}$) was observed in Amh-Tari bread from El-Omaid, which corresponded to 4·9 mg day^{-1}. The investigated bread types can provide from 33 to 77% of RDA for Zn. Corn grains contain less Zn than wheat or sorghum. The concentrations of Zn in several breads were reported in other studies to range from 5·7 to 13·4 μg g^{-1} (Osis *et al.*, 1972) and 7·5–17 μg g^{-1} (Gormican, 1970).

Selenium
Of the 19 breads investigated, only seven types were found to contain Se above the detection limit of the method under the current experimental conditions. The average concentration of Se for these seven bread types ws 0·28 μg g^{-1} which corresponded to 0·14 mg Se per day. This value is within the RDA for Se (0·05–0·2 mg day^{-1}). Bakuun bread contains 0·49 μg g^{-1} which is equivalent to 0·25 g day^{-1}. This is more than the upper limit of the RDA for Se, and further investigation is needed to examine more bread samples and bread types from this location to confirm this finding and to, if possible, identify the source of Se. However, a higher concentration of Se was reported for whole wheat and other breads baked in Germany where Se concentration was reported as high as 60 μg g^{-1} (Brueggemann & Ocker, 1990).

Manganese
The RDA for Mn is 2·5–5·0 mg and the average overall Mn concentration in the bread type investigated is 11·6 μg g^{-1} for an average intake of 5·8 mg day^{-1}. This is similar to the results presented by Gormican (1970) for whole wheat bread with a Mn concentration of 17 μg g^{-1}. All breads examined can provide 100% of the RDA for Mn. It was observed that several bread types can provide more than 200% of the RDA for Mn. However, dietary Mn is poorly absorbed (1–4%) and Mn toxicity is rare.

Chromium
The highest concentration of Cr was observed for Fiti bread from Aswan (2·43 μg g^{-1}) with a daily intake of 1·2 mg. This value is more than six times the RDA for Cr. However less than 1% of Cr intake is actually absorbed in the intestinal tract, and the dietary intake of Cr ranges from 11 to 820 μg day^{-1} (Spallholz, 1989). Thirteen out of the 19 bread types examined can provide 83% or more of the RDA for Cr.

Cobalt
The concentration of Co in the 19 bread types ranges from 22 to 130 ng g^{-1} with an average of 44 ng g^{-1}, for an average daily intake of 22 μg of Co per day. No RDA value for Co is set, and Co *per se* is not considered an essential nutrient. An essential role of Co is its incorporation into vitamin B_{12}. Fenugreek showed the exceptionally higher concentration of Co of 86 ng g^{-1}. Wheat grains contained 15–24 ng of Co per g, which is high compared to less than 10 ng g^{-1} for corn and sorghum. Also, wheat and corn bran showed higher concentrations of Co compared to the grains.

Arsenic, bromine, rubidium, antimony and scandium

Although arsenic may be considered as an ultratrace element, none of the samples investigated, whether bread, flours or grains, showed any As.

The concentration of Br ranges from 1·21 μg g^{-1} (Bettaw bread from Magousa) to 13·2 μg g^{-1} (Balady bread from Beni-Suef). The overall average concentration of Br for the 19 bread types investigated is 5·06 μg g^{-1}. This corresponds to a daily intake of 2·53 mg of Br.

Rubidium was detected in eleven out of the 19 bread types with concentration ranges from 0·7 μg g^{-1} (Kabbouri bread) to 4·66 μg g^{-1} (Mabbotot bread) with an average daily intake of 0·8 mg. Among the different flour and grain analyzed for Rb, wheat bran shows the highest concentration of 2·26 μg g^{-1}. Among the various materials investigated and used in bread formulation, Fenugreek was found to contain 64 ng Rb g^{-1}, the highest concentration of all.

The highest concentration of Sb was 70 ng g^{-1} (Bettaw from Magousa) for a daily intake of 35 μg, and only eight bread types were found to contain Sb. The concentration of Sb in flour and grains ranged from 10 to 41 ng g^{-1}. Antimony is listed among those elements 'present in food for which there is no reliable evidence to show an essential need in the diet of animal or human' (Committee on Dietary Allowances, 1980).

Scandium was found in all bread types investigated with a concentration ranging from 10 ng g^{-1} (Kabbouri bread) to 46 ng g^{-1} (Balady bread from Beni-Suef). Thus the daily intake from bread ranges from 5 to 23 μg.

CONCLUSIONS

The 19 different types of Egyptian bread investigated in this study contain sufficient macrominerals and trace elements to provide, either in part or all, the minimum requirement of these elements as indicated by the RDA values. Figure 2 shows that on average the Egyptian breads can provide 15–35% of RDA for Ca; 29–69% for K; 62–100% for Mg; 1–100% for Na; 33–77% for Zn; 43–100% for Se; 73–100% for Cr and 100% for Fe and Mn. It is irrelevant, however, to discuss here the importance of macrominerals and trace elements. It is sufficient to say that their role is well known whether in bone formation for Ca (Spallholz, 1989) or in cardiovascular diseases for Cr (Virtamo & Huttunen, 1991). It is important to emphasize that the presence of an element in the diet does not necessitate its availability and absorption, since intestinal absorption may depend, among other factors, on a specific oxidation state of the element and the presence or absence of other factors such as enzymes or hormones.

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