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MINERAL AND NUTRITIONAL CONTENTS OF HEN'S EGGS FROM DIFFERENT SOURCES IN ADEN GOVERNORATE-YEMEN

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المحتوى المعدني والغذائي في بيض الدجاج المأخوذ من مصادر مختلفة في محافظة عدن، اليمن

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ABSTRACT

Many studies are needed to be done in a nutrition field and people are advised to eat eggs daily to reduce mineral deficiencies. The purpose of this study is to evaluate the concentrations of six essential elements: Na, Mg, P, S, K, Ca and determine the nutrient contents such as; protein, lipid, ash, and moisture in the edible part of hen eggs selected from four different sources in Aden (i.e. Al-Buraiqeh, Al-Hiswah, Khormaksar, and Shaikh Othman). These elements were determined by inductively coupled plasma-optical emission spectrometry (ICP-OES). The highest concentrations of sulfur were found in hen egg samples derived from the Khormaksar (4205 ppm) and Shaik Othman (4433 ppm) regions. Moreover, the concentrations of sodium in selected raw eggs from the same regions were 3044 and 2758 ppm, respectively. On contrary, the collected egg samples from Al-Buraiqeh had in general, low levels of elements. The macro Kjeldahl method was used to determine protein in egg samples while the total lipid content was determined using the Soxhlet method and the Gerber method. The high percentage of protein content was noted in market hen eggs from Al-Hiswah (12.80%) but, the lowest percentage of protein content was derived from street hen eggs from Al-Hiswah (7.66%). For the lipid percent, the high concentration was remarked to home hen eggs from Khormaksar (12.71%) while the lowest percentage of protein content was coined for market hen eggs from Al-Buraiqeh (9.91%). This data can be attributed to hen feed specifics within different regions and the impact of environmental factors. The percentage of ash and moisture was also determined in this study. The obtained results were compared with others achieved in different countries. In all analyzed raw eggs, the concentrations of minerals and nutritional contents were safe levels.

Keywords: Minerals, Nutrient value, Proteins, Lipids, Hen's eggs, ICP-OES.

الملخص

هناك حاجة ملحة إلى إجراء دراسات متعلقة بالغذاء اليومي وينصح خبراء التغذية بتناول البيض لتعويض النقص في المعادن والمغذيات المختلفة. هدفت هذه الدراسة إلى تقييم مستويات تراكيز عناصر الصوديوم، المغنسيوم، الفسفور، الكبريت، البوتاسيوم والكالسيوم، ونسب كلا من البروتين، الدهون، الرطوبة والرماد في عينات بيض الدجاج المختارة من أربعة مواقع مختلفة في محافظة عدن (البريقة، الحسوة، خورمكسر، والشيخ عثمان) اليمن. قدرت مستويات هذه العناصر بواسطة مطياف الانبعاث الضوئي البلازمي المقترن بالحث (ICP-OES). تم تحديد النطاق الأكثر تباينًا للتركيزات، حيث بلغ أعلى محتوى للعناصر في عينات بيض الدجاج المأخوذة من منطقتي خورمكسر والشيخ عثمان لعنصري الكبريت (4205، 4433 جزء لكل مليون) والصوديوم, (3044، 2758 جزء لكل مليون) على التوالي بينما احتوت عينات البيض من منطقة البريقة في الغالب على مستويات منخفضة من باقي العناصر. كما استخدمت طريقة ماكروكيلدال لتحديد نسبة البروتين في عينات البيض، وتم تحديد محتوى الدهون الكلي باستخدام طريقتين: طريقة سوكسليت وطريقة جيربر. وكانت النسبة العالية المتحصل عليها من محتوى البروتين في عينات بيض الدجاج المأخوذ من سوق الحسوة (12.80٪) بينما أقل نسبة من محتوى البروتين كانت في بيض الدجاج المأخوذ من شوارع منطقة الحسوة (7.66٪). بلغت نسبة الدهون في بيض الدجاج المنزلي الذي تم جمعه من منطقة خورمكسر حوالي (12.71%)، بينما كانت النسبة في بيض الدجاج المأخوذ من سوق البريقة تساوي (9.91%). ربما يعزى هذا التباين إلى نوع الأغذية التي تتغذى عليها الدجاج في المناطق المختلفة وكذا تأثير العوامل البيئية المختلفة. كما اشتملت الدراسة على تحديد نسبة الرماد والرطوبة. وتم مقارنة نتائج هذه الدراسة مع نتائج دراسات أخرى في بلدان متعددة. اظهرت نتائج الدراسة أن مستويات المعادن والمغذيات كانت آمنة.

الكلمات المفتاحية: المعادن، القيمة الغذائية، البروتينات، الدهون، بيض الدجاج، مطياف الانبعاث الضوئي البلازمي المقترن بالحث الضوئي.

1. INTRODUCTION

Hen's eggs have been regarded as a primary item and very nutritious food for human consumption since they contain the majority of nourishment as recommended to be taken daily with a specific amount [1,2]. This most important food provides nutrients, proteins, vitamins (B_1, B_2, B_{12}, niacin, biotin, choline, pantothenic acid, A, E, K, and D), and microelements (Se, I, Zn, Cu, Mn, and Fe) [2]. The egg yolk contains lipid, cholesterol, conjugated proteins, and some micronutrients, whereas the albumen (egg white) is mostly water, with simple proteins, minerals, and water-soluble vitamins [3]. Eggs diet are a significant source of metals [4-6] including macro-elements (Na, Mg, P, S, Cl, K, and Ca) which are required in huge amounts and found in greater proportion in living organisms' tissues [7]. They play critical roles from zygote to senility [8]. Minerals are also involved in the activation of some enzymes in the body [9,10]. The human body's immune system relies on a balanced diet rich in several nutrients [11], such as proteins and lipids, which are present in every part of the egg, but a major portion is present in the egg white and yolk. All proteins are excellent sources of amino substances containing nitrogen atoms [12]. Lipids help organs structurally and insulate nerves, and are also an excellent source of two types of fatty acids (saturated and unsaturated) [13]. Eggs have a high nutritional value as a food, not only because of the quantity and ratios of nutrients they contain but also because of their bioavailability and chemical characteristics that enable them to satisfy human nutritional demands [14-17]. Due to the great importance of some metals and the properties of a hen's egg, which is a basic food ingredient, this present study was conducted to monitor the content of some minerals and nutrients such as proteins, lipids, ash, and moisture in three types of hen eggs (home, street, and market) selected from various locations in Aden city, Yemen. Not just to monitor, but also to compare the results with others mentioned in the previous studies to guide the public on the levels of elements they need and to consume to achieve public health.

2. MATERIALS AND METHODS

2.1 Sample Collection

Two hundred and forty hen's eggs samples were randomly collected from the houses and the markets at four regions of Aden city-Yemen including Al-Buraiqeh, Al-Hiswah, Khormaksar, and Shaikh Othman. The samples were transferred into plastic bags and kept refrigerated until analyzed. Each egg was washed with deionized water and then its white and yolk were mixed and lastly analyzed without eggshell.

2.2 Chemical Reagents

The chemicals used were of experimental chemical agent grade (AR). The standard solutions were prepared from 1000 ppm and diluted with deionized water for each element. K_2SO_4, $CuSO_4$, H_2SO_4, HCl, H_3BO_3, petroleum ether, and amyl alcohol were obtained from BDH (England). NaOH was supplied from Sigma-Aldrich (Sweden). The indicator was prepared by mixing methyl red (0.2%) with bromocresol Green (0.2%).

2.3 Applied Analytical Methods

The measurement of Na, Mg, P, S, K, and Ca in the egg samples was carried out using a Thermo Scientific (iCAP 6000 series, USA) inductively coupled plasma-optical emission spectrometry (ICP-OES) instrument supported by Qtera ISDS software and the standard procedure was applied as mentioned in [18]. On one hand, the total protein in egg samples was determined by Kjeldahltherm BÜCHI (Type K-434; Switzerland). Mixed eggs white and yolk were digested with 18M H_2SO_4 so that they released nitrogen and analyzed by a suitable titration technique.

The amount of protein present was calculated from the nitrogen concentration of eggs [19]. On the other hand, lipid content was determined by two methods, the Soxhlet method and the Gerber method [20]. The percentage of the ash content was determined according to the Association of Official Analytical Chemists [21,22] using Muffle Furnace (Type MF 120; Turkey). The percentage of the moisture in the studied egg samples was determined according to [21] by drying samples in an electric oven (Hermannpaulser**;** Germany).

2.4 Sample Pre-Treatment

2.4.1 Determination of Mineral Concentrations

This method describes the preparation of samples to determine metals in egg samples. Each egg was washed with deionized water. From raw eggs, only white and yolk were mixed in a 200 ml beaker. About 5 g ± 0.001 of the mixed sample were weighed and digested with 6 ml of HNO_3(65%) and 2 ml of H_2O_2 (29%) in a 100 ml beaker and covered with a watch glass. After 30 min, the beaker was placed on a hot plate up to 140 °C until achieving the complete decomposition of the sample. Then, the total volume was reduced to nearly 3 ml, cooled, and filtered into a 50 ml calibrated flask with deionized water using Whatman 42 filter paper [23-25].

2.4.2 Determination of the Crude Protein Content

Eggs white and yolk were digested with a strong acid so that nitrogen was released and determined by a suitable titration technique. The amount of protein present was then calculated from the nitrogen concentration of digested raw eggs. This is usually considered to be the standard method of determining protein concentration [19].

2.4.3 Determination of Total Fat Content

To determine the crude lipid content in egg samples, the Soxhlet method, a semicontinuous extraction method was used. The solid egg sample (usually, dried and pulverized) was placed in a thimble in the chamber and then, was completely submerged in the hot solvent for about 10 minutes before both the extracted lipid and solvent were siphoned back into a boiling flask reservoir. The lipid content was determined by measuring either the weight loss of the egg sample in the thimble or by the weight gain of the flask reservoir [26]. In the Gerber method, the concentrated sulfuric acid was pipetted into the Gerber bottle by using a Gerber pipette. The homogenized egg samples were weighed and diluted in deionized water. The sample was poured directly onto the acid in the Gerber bottle and amyl alcohol was added to the bottle. After mixing centrifuging the fat was calculated from a calibrated scale of the Gerber bottle. All the measurements were done in triplicates [27,28]. The preparation and digestion of raw egg samples were done at the Chemistry Department Laboratories-Faculty of Education of Aden.

3. STATISTICAL ANALYSIS

The (Genstat 12) software was used in two-way statistical analysis (two-way ANOVA) to analyze results at a significant level ($P<0.05$). The standard deviation (± SD) was calculated after replication at least three times. The least significant difference (L.S.D) was calculated between the averages and the statistical analysis was made using the complete random design.

4. RESULTS AND DISCUSSION

The current study focused on mineral and nutritional contents in raw egg samples collected from Aden-Yemen. Six essential elements that are sodium (Na), magnesium (Mg), phosphorus (P), sulfur (S), potassium (K), and calcium (Ca) were explored in three types of hen eggs (home, street, and market hen eggs) as represented in Tables 1 and 2 and Fig. 1. The highest variable range of concentration of elements was determined in hen egg samples derived from Khormakser and Shaik Othman regions. Whereas, raw egg samples from Al-Buraiqeh region mostly contained low levels of elements. The percentages of proteins, lipids, ash, and moisture in hen's eggs were denoted in Tables 3 and 4 and Fig. 2.

4.1 Raw Egg Mineral Contents

The concentrations of minerals were compared to others determined in literature studies and showed significantly some differences/similarities values in eggs. The maximum sodium level was recorded in Khormaksar (3044 ppm) for home hen eggs. Whereas, the minimum sodium level was determined in street hen egg samples of Shaik Othman and Al-Hiswah (1084 and 1088 ppm), respectively (see Table 1 and Fig. 1.1). The overall mean concentration of sodium (2075.3ppm) in Table 2 was higher than the 1540 ppm reported in the United Kingdom [29]. However, the overall mean sodium concentration of (2075.3 ppm) in four regions (Al-Buraiqeh, Al-Hiswah, Khormaksar, and Shaikh Othman) is low, especially when compared to the literature study by Kiliç et al in Turkey [30], who discovered a sodium concentration of 4329 ppm may clear the fact that the feed mixtures had almost identical content of this element. The data in Table 1 declares that the high average level of magnesium in Khormaksar home hen eggs (249.9 ppm) could be due to the various foods hens feed at home. On the other side, the low mean concentration of magnesium was found in Al-Hiswah and Shaik Othman street hen eggs (94.1 ppm) and (96.2 ppm) respectively, Fig. 1.2. The overall mean concentration of magnesium was 181.33ppm (Table 2) less than that reported by Hashish et al. [31] in Egypt 388.1, 442.6 ppm in conventional and home-produced eggs, respectively, and fewer than the concentration in Brazil [32] (681, 674 ppm). Otherwise, the recent overall mean concentration was similar to those observed by Chowdhury et al. [33] in Bangladesh, who found (119.22 and 221.29 ppm) in commercial and local hen eggs, respectively and also parallel to the result (120 ppm) achieved in Spain by Moreiras et al. [34] but higher than the value 103 ppm reported in the literature by

Rubio et al. in Island [35]. Following the analysis, phosphorous levels determined in samples of Shaik Othman were found distinct significantly higher (1754 ppm), but a low phosphorous level (824.1 ppm) was found in the Al-Hiswah region. The high concentration of phosphorous in market hen eggs from Shaik Othman may be due to the corn and soybean meal diets for the hens at the farms for egg production (1240 ppm). On the other hand, a high concentration of phosphorous in all home hen eggs was due to whole grains such as millet, whole-wheat bread, rice, and maize. The overall mean level of phosphorus (1258.1 ppm) reported in this study (Table 2) was less than the values reported by Zhu and Zhao in China [36]. They summarized those phosphorus concentrations were (4152 ppm and 4058 ppm) in hen eggs from conventional and free-range systems, respectively [36]. The highest mean sulfur content (4433 ppm) was identified in Shaik Othman's market hen eggs, whereas the lowest concentration was reported in Al-Hiswah's street hen eggs (1144 ppm) as was in Fig. 1.4. The overall sulfur content in a certain study (3066.3 ppm) was higher than 849.92 ppm, the amount of sulfur summed up in sulfur-containing amino acids, by English in Canada [37]. In other investigations, the diet of laying hens that supplemented with soybean meals enriched with some elements influenced the transfer of elements to eggs, in particular at increased dosing [38].

Table(1): Mean concentrations of minerals in egg samples (ppm±SD)* dry weight

Parameters	Al-Buraiqeh	Al-Hiswah	Khormaksar	Shaik Othman	Mean±SD
			Na		
Home Hen Eggs	1915±4.0	1564±3.0	**3044±4.0**	2220±3.0	2186 ±7.07
Street Hen Eggs	1452±9.0	1088±2.0	2338±4.0	**1084±3.0**	1490 ±10.48
Market Hen Eggs	2819±5.0	2302±4.0	2323±4.0	2758±6.0	2550 ±9.64
L.S.D**for types					4.00

			Mg			
Home Eggs	Hen	227.7±1.5	162.4±2.0	**249.9±1.0**	186.6±0.4	206.6 ±2.72
Street Eggs	Hen	112.0±1.2	**94.1±0.06**	197.1±0.4	96.21±0.4	124.8 ±1.33
Market Eggs	Hen	237.1±0.2	175.2±0.3	192.6±0.3	245.4±1.0	212.6 ±1.10
L.S.D for types						0.80
			P			
Home Eggs	Hen	1523±7.0	1254±8.0	1565±6.0	1564±7.0	1476 ±2.72
Street Eggs	Hen	1106±10	888.7±7.0	1471±10	1049±4.0	1128.7 ±1.32
Market Eggs	Hen	1260±5.0	**824.1±0.7**	840±3.0	**1754±12**	1169.6 ±1.10
L.S.D for types						5.58
			S			
Home Eggs	Hen	2946±8.0	2218±3.0	4205±5.0	3791±9.0	3290 ±13.37
Street Eggs	Hen	2098±8.0	**1144±5.0**	3447±7.0	1438±15	2032 ±19.05
Market Eggs	Hen	4125±4.0	3312±3.0	3638±6.0	**4433±10**	3877 ±12.68
L.S.D for types						6.00
			K			
Home Eggs	Hen	2211±7.0	1784±5.0	2591±4.0	2751±4.0	2334 ±10.29
Street Eggs	Hen	1360±12	**863.7±5.5**	2519±10	992.1±3.1	1434 ±16.84
Market Eggs	Hen	2577±4.0	2391±8.0	2250±2.0	**2896±5.0**	2529 ±10.44
L.S.D for types						5.00
			Ca			
Home Eggs	Hen	997.97±0.18	741.57±0.20	**1274.00±0.57**	1177.00±0.17	1047.63 ±0.84
Street Eggs	Hen	776.27±0.88	482.37±0.60	964.93±0.33	**374.60±0.66**	649.54 ±1.29
Market Eggs	Hen	1117±0.10	1046.00±0.42	897.60±0.14	1269.33±0.25	1082.48 ±0.51
L.S.D for types						2.97

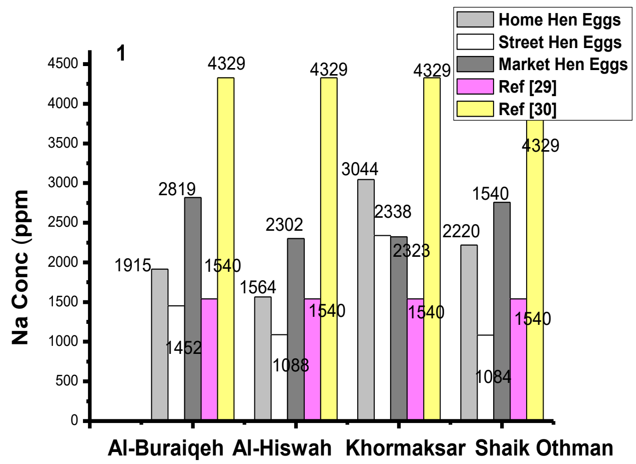
**ppm±SD: Concentration in part per million unit ± standard deviations; the minimum and maximum values (in bold) are for the particular element.*

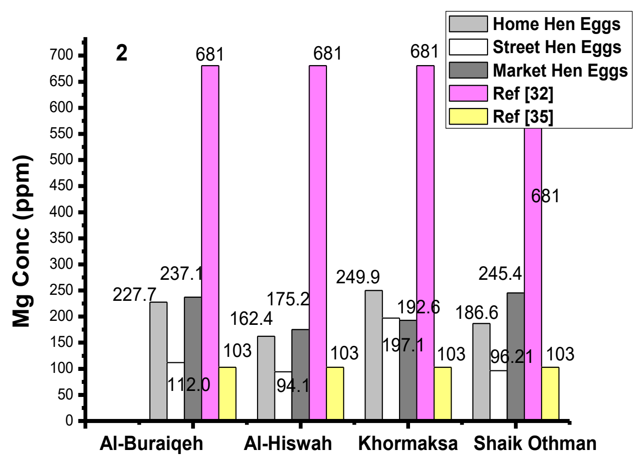
***L.S.D: Least significant difference of mean values for whole eggs types at (P<0.05).*

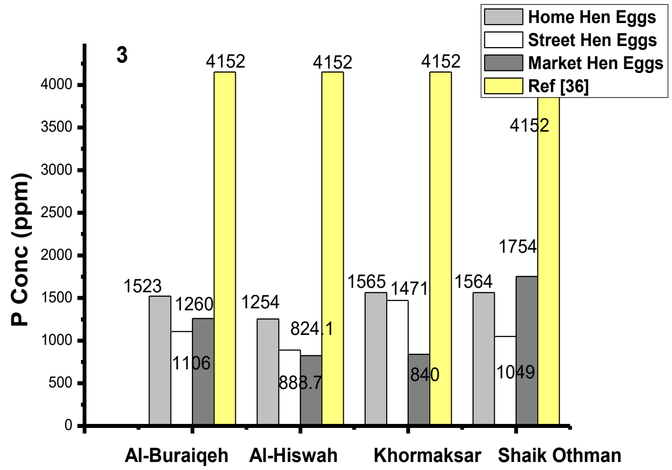
Table(2): Comparison of the overall mean concentrations of elements in the current study with the values cited in the literature (in ppm)

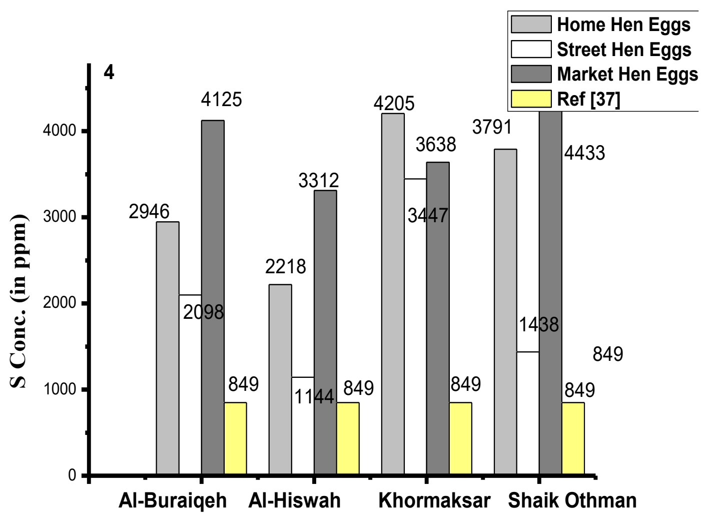
Element	Overall mean concentration for types (ppm±SD)	UK [29]	Turkey [30]	Egypt [31]	Brazil [32]	Bangladesh [33]	Spain [34]	Island [35]	China [36]	Canada [37]	Island [39]
Na	2075.3±9.06	1540	4329	-	-	-	-	-	-	-	-
Mg	181.33±1.72	-	-	388.1 and 442.6	681 and 674	119.22 and 221.29	120	103	-	-	-
P	1258.1±1.71	-	-	-	-	-	-	-	4152 and 4058	-	-
S	3066.3±15.03	-	-	-	-	-	-	-	-	849.92	-
K	2099±12.52	-	-	-	674	-	1300	-	-	-	-
Ca	926.55±0.88	-	-	2297-2588	-	-	570	-	-	-	174

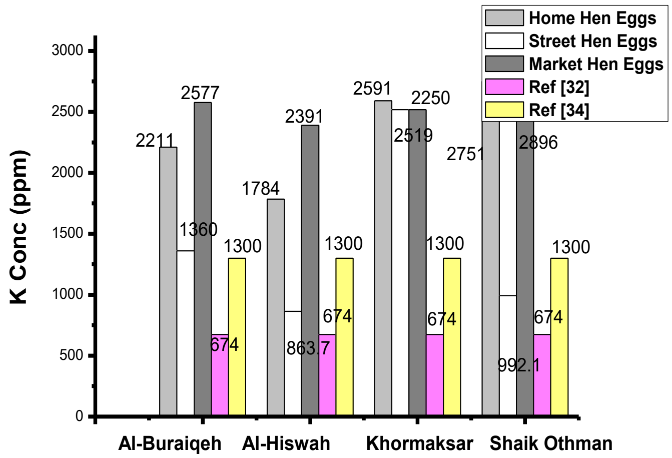
For potassium element, the highest mean concentration (2896 ppm) was discovered in Shaik Othman's market hen eggs, while the lowest mean potassium concentration (863.7 ppm) was identified in Al- Hiswah's street hen eggs (Table 1, Fig. 1.5). The potassium concentrations in Al-Buraiqeh, Al-Hiswah, and Shaik Othman's (street hen eggs) were higher than those reported in Spain by Moreiras et al. [34], who concluded that potassium concentration was 1300 ppm in whole raw hen eggs. However, the overall average level of potassium concentrations in hen eggs (home, street, and market) in this study was very high (2099 ppm), especially when compared with those reported by de Freitas et al. [32] from Brazil, who reported that potassium content was 674 ppm in home-produced eggs.






3
Home Hen Eggs
Street Hen Eggs
Market Hen Eggs
Ref [36]
P Conc (ppm)
0
500
1000
1500
2000
2500
3000
3500
4000
1523
1106
1260
4152
1254
888.7
824.1
4152
1565
1471
840
4152
1564
1049
1754
4152
Al-Buraiqeh
Al-Hiswah
Khormaksar
Shaik Othman


4
Home Hen Eggs
Street Hen Eggs
Market Hen Eggs
Ref [37]
S Conc. (in ppm)
0
1000
2000
3000
4000
2946
2098
4125
849
2218
1144
3312
849
4205
3447
3638
849
3791
1438
4433
849
849
Al-Buraiqeh
Al-Hiswah
Khormaksar
Shaik Othman



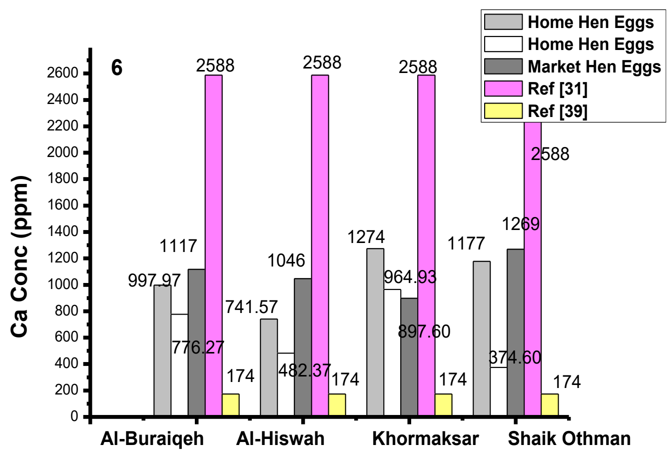


Figure (1): Concentrations of sodium, magnesium, phosphorus, sulfur, potassium, and calcium in egg samples were collected from four different areas.

Calcium was detected as high concentrations in Khormaksar's home hen eggs (1274 ppm), while the lowest mean calcium concentration was identified in Shaik Othman's street hen eggs (374.60 ppm) as plotted in Fig. 2.6. The recorded value for the overall mean concentration of calcium (926.55ppm) in eggs white and yolk was lower than reported by Hashish et al. [31] in Egypt who found that calcium levels ranged from 2297 to 2588 ppm. The overall mean concentration of our samples was also linked to those reported in the literature. A low value had been reported by

Rubio et al. [39] in Island (174 ppm). However, the sources of interaction effects were unknown, and no other studies had looked at differences in egg mineral concentration caused by interactions between the hen's rearing system and other factors [40]. Furthermore, hen eggs should consume to maintain public health [41,42].

4.2 Nutrient contents of eggs

Tables 3 and 4 and Fig. 2 illustrate the percentages studied in different hen's egg samples with data obtained by other authors in different countries. In the recent work, the protein content among the egg types followed the order: market hen eggs (12.48%) > home hen eggs (9.64%) > street hen eggs (8.80%). On contrary, the mean value of protein among four areas was: Al-Hiswah (9.59%) < Shaik Othman (10.20%) < Khormaksar (10.70%) ≈Al-Buraiqe (10.73%). The overall average percentage of protein (Table 4) in hen eggs (home, street, and market) was (10.30**%**). Furthermore, the overall mean percentage of protein in our study was lower than that conducted in the literature (12.1-48%) [43-47]. The high percentage of protein in all market hen eggs compared to other types of hen eggs in different areas could be due to the hens' nutrition in the farms as there are a variety of different protein sources that are suitable for use in hen diets, such as corn, wheat bran, soybean meal, and the feed ingredients may contain essential amino acids [48].

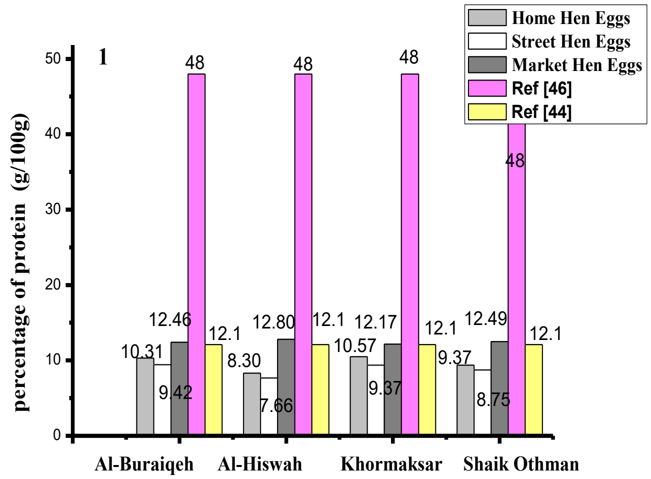
Table(2): Percentage of the proteins, lipids, ash, and moisture in egg samples (g/100g; Mean ± SD)*

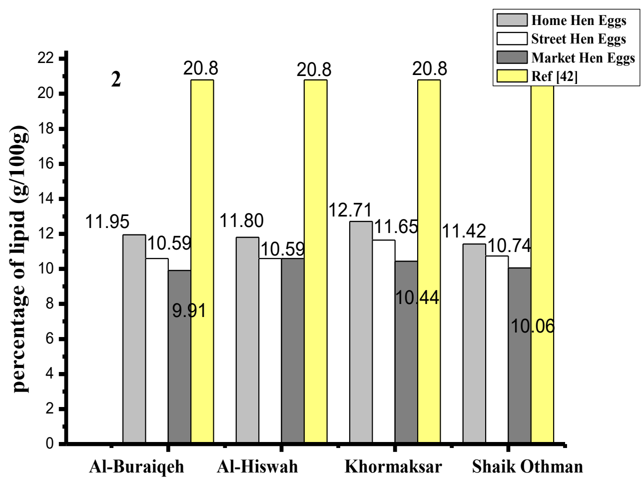
Parameters	Al-Buraiqeh	Al-Hiswah	Khormaksar	Shaik Othman	Mean±SD
			Proteins		
Home Hen Eggs	10.31±0.38	8.30±0.63	10.57±0.00	9.37±0.00	9.64 ±0.74
Street Hen Eggs	9.42±0.17	**7.66±1.17**	9.37±0.18	8.75±0.62	8.80 ±1.35
Market Hen Eggs	12.46±0.34	**12.80±0.48**	12.17±0.49	12.49±0.31	12.48 ±0.83
L.S.D for types					0.43
			Lipids		
Home Hen Eggs	11.95±0.13	11.80±0.23	**12.71±0.68**	11.42±0.13	11.97±0.74
Street Hen Eggs	10.59±0.47	10.59±0.35	11.65±0.13	10.74±0.35	10.90 ±0.69
Market Hen Eggs	**9.91±0.26**	10.59±0.80	10.44±0.23	10.06±0.37	10.25± 0.95
L.S.D for types					0.31
			Ash		
Home Hen Eggs	0.84±0.08	0.80±0.03	**1.02±0.02**	0.90±0.07	0.89 ± 0.11
Street Hen Eggs	0.79±0.08	**0.78±0.09**	0.83±0.04	**0.78±0.08**	0.80 ± 0.15
Market Hen Eggs	0.96±0.21	0.92±0.06	0.81±0.03	0.95±0.06	0.91 ± 0.23
L.S.D for types					0.06
			Moisture		
Home Hen Eggs	73.40±2.46	67.65±4.25	**73.50±0.14**	70.14±0.94	71.17 ± 5.0
Street Hen Eggs	70.90±0.38	68.78±3.10	72.63±1.23	72.00±1.10	71.08 ± 3.5
Market Hen Eggs	70.05±1.50	72.20±0.14	**64.05±0.73**	71.28±0.76	69 ± 1.8
L.S.D for types					1.55

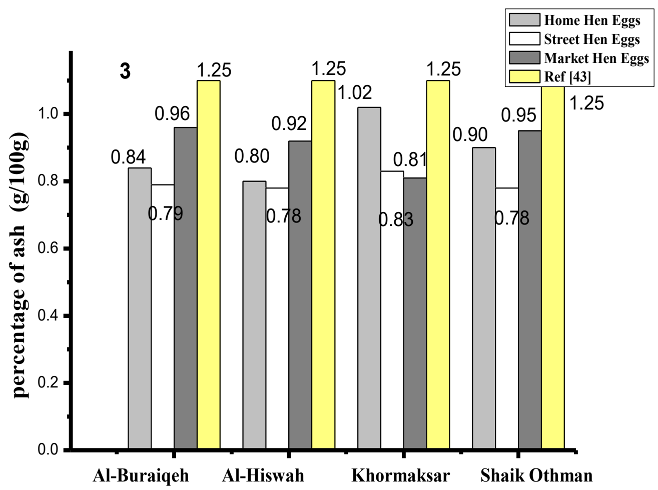
* The values in bold indicate the smallest and highest readings.

The changing variations in lipid content detected between street, home, and market were not statistically significant as represented in Table 3 and Fig. 2.2. The high percentage of lipid (12.71%) in the home hen eggs of Khormaksar may be due to the hens' constant feeding of trash-cooked rice. The percentage of lipid reported in our study was similar to those previously reported by Kralik & Kralik[48], which found that the percentages of lipid in eggs were 10.7-11.6%, except that the percentage of lipid in market hen eggs of Al-Buraiqeh was slightly lower (9.91%), and the percentage of lipid in home hen eggs of Khormaksar was slightly higher than the range mentioned in Croatia [48]. The overall mean percentages of lipid (Table 4) in all samples of this study were about half of the percentage of lipid reported by Yoshida et al. in

Japan in some types of food eaten by the Japanese, where it was (20.8%) [42]. As shown in Table 3 and Fig. 2.3, the greatest percentage of ash content in the analyzed egg samples was discovered in Khormaksar home hen eggs (1.02%), while the lowest percentage of ash content was identified in Al-Hiswah and Shaik Othman street hen eggs (0.78%). The overall average percentage of ash in hen eggs (home, street, and market) in Table 4 was 0.8666% lower than the percentage of ash in Italy [43] reported by Federico et al. who found that the percentages of ash in eggs were 1.25%. The home hen eggs of Khormaksar had the greatest percentage of moisture content of the investigated egg samples (73.50%), whereas the market hen eggs of Khormaksar had the lowest percentage of moisture content (64.05 %) with the overall percent equals 70.41% (see Tables3 and 4, Fig.2.4). The decrease in moisture content in Khormaksar market hen eggs might be attributable to storage circumstances such as temperature and humidity, as well as the time spent in storage where water can escape through the eggshell [49]. There were no statistically significant differences between home hen eggs and street hen eggs, but significant differences appeared between market hen eggs and other types of egg samples. In terms of the percentage of moisture in raw eggs white and yolk reported in this study, the moisture contents in home hen eggs and street hen eggs from Khormaksar and home hen eggs from Al-Buraiqeh were similar to those found by Kralik & Kralik [48], who reported that the moisture content in the studied egg samples was 72.5-75.0%, while the rest our hen egg samples from various areas showed a low moisture content.


1
Home Hen Eggs
Street Hen Eggs
Market Hen Eggs
Ref [46]
Ref [44]
percentage of protein (g/100g)
0
10
20
30
40
50
48
48
48
48
12.46
10.31
9.42
12.1
12.80
8.30
7.66
12.1
12.17
10.57
9.37
12.1
12.49
9.37
8.75
12.1
Al-Buraiqeh
Al-Hiswah
Khormaksar
Shaik Othman


2
Home Hen Eggs
Street Hen Eggs
Market Hen Eggs
Ref [42]
percentage of lipid (g/100g)
0
2
4
6
8
10
12
14
16
18
20
22
20.8
20.8
20.8
11.95
10.59
9.91
11.80
10.59
12.71
11.65
10.44
11.42
10.74
10.06
Al-Buraiqeh
Al-Hiswah
Khormaksar
Shaik Othman



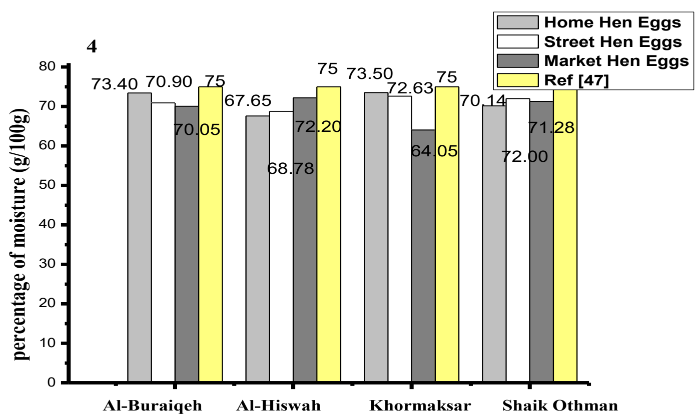


Figure (2): Percentage of protein, lipid, ash, and moisture in egg samples.

Table (4): Comparison of the overall mean percentages of protein, lipid, ash, and moisture in egg samples (g/100g; Mean±SD) with published values.

Element	Overall mean concentration for types (mean%±SD)	Croatia [47]	Poland [45]	Italy [46]	Japan [42]	(Italy} [43]	Spain [44]
Proteins	10.30±0.97	12.5-13.5 %	17%	48%	-	17.19%	12.1%
Lipid	11.04±0.79	-	-	-	20.8%		-
Ash	0.8666±0.16	-	-	-	-	1.25%	-
Moisture	70.41±3.43	72.5-75.0%	-	-	-	-	-

5. CONCLUSION

The concentrations of minerals and nutritional value in egg samples showed quite different, depending on the rich nutrition system of hens and other factors such as the impact of environmental, physiological reasons, and husbandry practices. From the results obtained in this study, it can be concluded that the studied egg samples contain significant and safe levels of all types' analyzed eggs. Sodium (Na), magnesium (Mg), phosphorus (P), sulfur (S), potassium (K), and calcium (Ca) concentrations were almost similar compared to the other mineral elements determined in literature values. These elements should be used in a method that is more accurate in terms of the level of detection (ppm, ppb). Inductively coupled plasma-optical emission spectrometry (ICP-OES) was used for the total concentration analyses. The researchers also observed differences in the ratios of proteins, lipids, ash, and moisture in raw egg white and yolk samples. These results support the consideration of raw eggs as an excellent food for human consumption and the researchers, in this work, stated strongly on performing quality control regulations and new quality control aspects based on internal egg quality by the authorities in the market that may have an impact on the health of the consumer.

DATA AVAILABILITY

The original data are available upon request from the corresponding author.

COMPETING INTERESTS

The authors declare that they have no conflict of interest.

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LIST OF ABBREVIATIONS

NO.	Abbreviation	Scientific Name
1	Na	Sodium
2	Mg	Magnesium
3	P	Phosphor
4	S	Sulfur
5	K	Potassium
6	Ca	Calcium
7	ppm	Part Per Million
8	SD	Standard Deviation
9	L.S.D	Least Significant Difference

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