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Determination of toxic, trace and minor elements content in local Kurdish yoghurt samples

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Abstract

The concentrations of toxic , minor and trace elements in local Kurdish yoghurt samples collected from different markets in Halabja governorate ,Kurdistan region ,Iraq were determined in this study. Results indicated that Aluminum (Al), Titanium (Ti) and Lead (Pb) have the highest concentration among other toxic trace elements in yoghurt samples. The concentration of these elements were 523.34 - 106.1, 438 - 325 and 4.36 – 0.4 µg kg^{-1} for Al, Ti and Pb respectively. Concentrations of trace elements Be, V, Li, Cs and Co in local yoghurt samples were 16.63 – 2.32 , 1.33 - 0.02, 11.71 - 0.83 ,13.3 - 0.18 and zero µg kg^{-1} respectively . Zinc had the highest value among other miner elements in yoghurt samples .Zn concentration found in local yoghurt was between 5807.99 – 20945.1 µg.kg^{-1}.

Introduction

Milk is one of the most valuable and natural food materials. It is a fluid rich in fat and protein produced by mammals to feed their newly born before they are able to eat other types of food. According to evidence, animal milk has been used as a food material since around 5000 BC *[1]*.

Fermentation is a process used to produce new food products depending on the action of enzymes which break down organic substances into smaller compounds. As a result of this process, new kinds of products are formed , which are more healthy, flavored and storable for a longer time *[2]*.

Yogurt is one type of fermented dairy products which is consumed widely in Iraq and other parts of the world and it is a product result from heat treated milk by the action of starter which consists of *Streptococcus salivarius ssp. thermophilus* and *Lactobacillus delbrueckii ssp. Bulgaricus [3]*.

The raw material for yoghurt fermentation is generally cow's milk or the milk from other mammals such as goat, sheep, camel, buffalo, etc. In cow's milk the milk solids non-fat level (MNSF) is 8.5-9% of which around 4.5% lactose, 3.4% protein and 0.7% minerals, and each of these components are vital for the production of a satisfactory yoghurt *[2]*.

Similar to milk, Yoghurt, provide the human body with different types of nutrients ,like proteins, minerals and vitamins .Beside that yoghurt can consume by people suffering from lactose intolerance *[2]*.

Minerals are essential for human body activities. The level of different kinds of elements in milk and other dairy products is depending on the biological, environmental and nutritional status of animals. Furthermore, technological treatments, geographical localization and the quality of feed material are very important for the level of minor and trace elements in dairy products *[4]*.

In Kurdistan , yoghurt is called Mast ,and considered the most popular fermented dairy product which produced from cow milk or a mixture of sheep and goat milk using the traditional method.

The traditional method for producing yogurt include, milk heat treating at 95–98 ° C for about 20 minutes, cooling, inoculating with crude starter culture and incubation . All these treatments are carried out using local and available tools which make this yoghurt contaminated with different types of chemical and microbiological hazards.

A very limited research data are available on mineral profiles of local Kurdish yoghurts, especially mineral levels. Therefore, the aim of this study was to quantify the levels of different mineral elements in commercially marketed Kurdish yoghurts .

Material and method

A.Yoghurt samples collection

A total of 27 samples of yoghurt were collected from 9 different markets in Halabja governorate ,Kurdistan region ,Iraq from the period between March to April 2017(3 samples from each market).The samples were transported directly to lab and dried at 105 ° C till constant weights were reached. Samples were kept on tubs and sent to University of Nottingham ,UK for analysis .

B.Yoghurt samples hydrolysis

Yoghurt samples were hydrolyzed as described by Bizzi ,*et al. [5]* as fellow : 0.4 g of yoghurt samples were weighed in microwave digestion vessels followed by adding 3ml nitric acid (HNO3 Trace analysis grade >68%), 2 ml of Hydrogen peroxide (H_2O_2, Trace analysis grade, 30) and 3 ml of Mili-Q water.The resulting mixture were digested for 45 minutes using microwave (1500W, 10 min ramp time, 20 min holding time 140°C, 15 min cooling time 55°C). After digestion process completed , 7ml of Mili-Q water was added to reach 15 ml of digest solution volume.

C.Element analysis

The Multi element analysis was carried out using Inductively coupled plasma mass spectrometry (ICP-MS) system (Model iCAPQ; Thermo Scientific, Bremen, Germany) equipped with auto sampler (Cetac ASX-520) at the University of Nottingham (UK). The 5 ppb of Ge, Re and Ir in 4% methanol and 2%Nitric acid solution used as an internal standard and all multi elements standards (SCP Science manufacturer; USA, Major elements 10, 20, 30 ppm and Minor elements 20,40,100 ppb) applied as an external standards*[6]*.

Statistical analysis

Ccomparisons among the means were carried out by using Least Significant Difference (LSD) test at the significant level of 0.05 .

Results and discussion

In this study, elements found in yoghurt were classified as toxic (Al , Ti, Pb ,As, Cd, Ti) , trace (Be, V, Li, Cs, Co) and minor (Zn, Cu , Sr , Rb ,Ba, Mn ,Mo , Se ,Cr) *[6]* .

Toxic elements in yoghurt

The levels of potentially toxic trace elements include (Al , Ti, Pb ,As, Cd, Ti) are summarized in table 1. Al, Ti and Pb have the highest concentration among other toxic trace elements. The concentration of these elements were 523.34 - 106.1, 438 - 325 and 4.36 – 0.4 µg kg^{-1} for Al, Ti and Pb respectively. Llorent-Martínez, *et al. [7]* recorded that Al concentration in yoghurt samples were between 100-800 µg kg-1 while Razaei , *et al. [8]* found that yoghurt contain 186 µg kg^{-1} of Al. Al concentration in yoghurt samples in this study was higher in comparison with other toxic elements and this is maybe due to the fact that yoghurt is traditionally manufactured using aluminum pots and this element migrates from pots to yoghurt during the development of product acidity *[9]*.

Titanium (Ti) concentrations in this study (438 - 325 µg kg^{-1}) was close to the concentration found by Sanal and Güler *[10]* Turkish yoghurt which was 420 µg kg-1. The daily intake of Ti was estimated at 0.022 mg

for yoghurt. Titanium is non toxic even in large doses and does not play any natural role inside the human body *[11]*.

Lead concentration found in this study was low in comparison with the results of de Andrade, *et al. [12]* who reported that Pb concentrations in yoghurt samples were 35.4 - 210 µg kg^{-1} and the results of Hashemi, *et al. [9]* who recorded that Pb concentration in Iranian yoghurt was 237 µg kg^{-1} . The main sources of the presence of Pb in dairy products are environmental sources such as atmospheric deposition, automobile exhausts, E-waste, and industrial effluent *[13]*. Maximum level of Pb in these study was 4.36 µg kg^{-1} and it considered safe according to Codex Alimentarius, international food stander FOA/WHO *[14]* which mention that the maximum level of Pb in food is 20 µg kg-1.

Arsenic (As) detected in local yoghurt samples was between 0.94 – 0.32 µg kg-1 , and this level is higher the 0.2 µg kg-1 detected by Khan, *et al. [6]* in yoghurt samples. WHO *[15]* estimated that 70 kg adult can consume 3.5 mg of As daily and thence local yoghurt samples considered safe .

Table 1. Concentration of toxic heavy metals (µg kg^{-1}) found in local Kurdish yoghurt samples.

	Concentration µg kg^{-1}					
Sample	***Al***	***Ti***	***Pb***	***As***	***Cd***	***Tl***
Y1	152.11	362.04	2.97	0.39	n.d	n.d
Y2	523.34	438.62	4.36	0.4	n.d	n.d
Y3	255.37	363.32	1.48	0.33	n.d	n.d
Y4	333.43	396.00	1.5	0.35	n.d	n.d
Y5	200.83	383.89	0.40	0.32	n.d	n.d
Y6	131.60	393.91	2.61	0.43	n.d	n.d
Y7	106.10	430.39	1.8	0.94	n.d	n.d
Y8	404.25	347.91	1.73	0.53	0.02	n.d
Y9	265.80	235.15	0.71	0.49	0.02	n.d
LSD(0.05)	33.2	17.707	0.354	0.105		

Arsenic present naturally in milk and it is secreted in milk, or provided as part from external contamination *[16]*.

Cadmium (Cd) detected in only 2 samples of yoghurt and its concentration was low (0.02 µg kg-1) in comparison with 220 µg kg-1 found in yoghurt by Sanal and Güler *[10]*.

Thallium (Tl) did not detected in local yoghurt samples and this is related to the fact that Thallium concentration depends directly on thallium concentrations in the soil, which can be transferred from soils to plants readily and accrues in food chain *[10]*.

Trace elements in yoghurt

The levels of potentially trace elements are summarized in table 2.

Beryllium (Be) detected level in local yoghurt samples were between 16.63 – 2.32 µg.kg^{-1} and there were significant differences in Be level between yoghurt samples . This result is higher than Be concentration found by Khan, *et al. [6]* in yoghurt which was 1.92 µg.kg^{-1} . Exposure to Be for long time is dangerous because this element can be carcinogenic for human *[10]*.

Vanadium (V), is an essential trace element *[15]*. We found that our yoghurt samples contained 1.33 - 0.02µg.kg^{-1} of Vanadium. Khan, *et al. [6]* recorded 5.67 µg.kg^{-1} of V in yoghurt samples . The amount of vanadium in human milk was found to be 0.1-0.2 µg.kg^{-1} *[17]* vanadium is an essential nutrient for rats .Its deficiency may result in growth depression, weakness of reproduction and disorders in lipid metabolism.

Vanadium is also essential for soil nitrogen-fixing microorganisms It may play a significant role in human nutrition *[15]*.

In low doses, lithium acts as a nutrient necessary for cobalamin (B12) and folic acid transport and uptake, neuromodulation, and in many biochemical pathways in human body *[18]*. Li level in this study was 11.71 - 0.83 μg.kg^{-1}and this result is close to the result of Khan, *et al. [6]*who recorded 8.41 μg.kg^{-1} of Li in yoghurt.

Cesium (Cs) was detected at level between 13.3 - 0.18 μg.kg^{-1} and this result is close to the result of Khan, *et al. [6]*who reported 9.87 μg.kg-1. Cesium is not likely to affect the health, but large amounts of gamma radiation, from sources such as radioactive cesium, could damage cells and might also cause cancer *[6]*.

Cobalt (Co) was not detected in all local Kurdish sample in this study .

Table 2. Concentration of trace elements (μg kg^{-1}) found in local Kurdish yoghurt samples.

	Concentration μg kg^{-1}				
Sample	***Be***	***V***	***Li***	***Cs***	***Co***
Y1	16.63	0.08	3.12	0.23	n d
Y2	2.42	1.33	2.91	0.19	n d
Y3	2.77	0.07	3.67	0.40	n d
Y4	15.70	0.32	2.78	0.18	n d
Y5	3.06	0.02	3.59	0.27	n d
Y6	2.6	0.76	11.71	0.21	n d
Y7	13.45	0.07	9.54	13.30	n d
Y8	2.32	0.27	10.25	0.93	n d
Y9	5.26	0.31	0.83	0.78	n d
LSD(0.05)	1.86	0.199	0.663	0.34	

Minor elements in yoghurt

Minor elements are needed in small concentrations for normal growth and development of human body *[15]*.Table 3 show the concentrations of minor elements in local Kurdish yoghurt samples.

Zinc(Zn) is necessary for growth of body and many other physiological processes *[19]*.

Zinc value found in local yoghurt was between 5807.99 – 20945.1 μg.kg^{-1}, and this concentration is higher than1600 μg.kg^{-1} of Zn reported by Elham, *et al. [20]*and below 7890 μg.kg^{-1} of Zn reported by Hashemi, *et al. [9]*.

Copper(Cu) is important for the action of many cellular enzymes, iron absorption and many other physiological roles in human body *[15]*.

In this study we found that Cu concentration ranged between 51.85 – 11.18 μg.kg^{-1} . This result is lower than result recorded by Abdulkhaliq,*et al. [21]* who found 792 μg.kg^{-1} of Cu in yoghurt . This difference of Cu result in yoghurt might have been resulted from the differences in the composition of milk used for making yoghurt *[22]*.

Strontium‘s role in human body are similar to calcium. Strontium helps to keep bone thickness and reduce bone loss *[23]*. Hernandez and Park *[22]* mentioned that goat yoghurt contained 1333 μg.kg^{1} of strontium *(*Sr*)* and this result is higher than the concentration of Sr we found in this study which was between 1133.59 – 321.32 μg.kg^{-1}.

This difference in strontium level in yoghurt is directly related to the amount of strontium in milk which results from difference in Sr concentration in animals diet and environment *[24]*.

Rubidium (Rb) concentration in local yoghurt samples ranged between 2198.08 - 440.62 μg.kg^{-1} ,while Barium (Ba) , Manganese(Mn) , and Molybdenum (Mo) concentrations were 171.46 – 81.95 , 93.43 –

13.09 and 40.77 – 23.21 µg.kg-1 respectively. Manganese helps the body form connective tissue, bones, blood clotting factors, and sex hormones, while Molybdenum is important for good oral health *[15]*.
Selenium (Se) is important to body health as it incorporated into selenoproteins, act as antioxidant and functioning of the immune system*[25]*.

Table 3. Concentration of minor elements (µg kg^{-1}) found in local Kurdish yoghurt samples.

	Concentration µg kg^{-1}								
Sample	***Zn***	***Cu***	***Sr***	***Rb***	***Ba***	***Mn***	***Mo***	***Se***	***Cr***
Y1	4751.75	11.18	540.35	511.15	171.46	16.78	28.88	4.79	0.61
Y2	5807.99	14.99	559.25	640.22	133.32	28.09	31.17	15.17	1.18
Y3	4279.82	27.83	425.08	496.57	162.93	15.20	27.12	7.38	3.52
Y4	3921.77	32.83	321.32	538.82	100.47	14.12	23.21	7.78	1.56
Y5	4525.43	21.79	354.23	440.62	109.02	13.09	40.77	7.94	1.67
Y6	5037.93	51.85	1133.59	715.25	172.16	35.87	34.55	15.17	0.89
Y7	5138.64	43.77	819.17	2198.08	143.95	93.43	38.88	25.07	0.57
Y8	4418.16	46.85	450.90	568.18	160.83	17.54	23.63	8.92	0.54
Y9	2946.10	12.39	331.85	257.77	81.95	28.41	20.84	6.07	2.54
LSD(0.05)	105.69	3.437	38.824	38.802	24.696	11.66	10.855	3.894	0.609

In local yoghurt samples ,Se ranged between 25.07 – 4.79 µg.kg-1 and this value is close to the results of Pappa, *et al*. *[26]* who recorded that selenium concentration in yoghurt samples in Greek market was 23.6 µg.kg^{-1} .Chromium (*Cr*) is in body for biosynthesis of glucose tolerance factor *[27]*.
Highest Cr concentration in yoghurt samples in this study was 3.52 µg.kg^{-1} , while the lowest concentration was 0.54 µg.kg^{-1} .This result is lower than the results found by Tarakccedil and Dag *[28]* who mentioned that Turkish traditional yoghurt contained 170 µg.kg^{-1} of Chromium.

Conclusions

This study showed very important details about the safety and quantity of different types of minerals in local Kurdish yoghurt samples .Our results showed that yoghurt contained different concentrations of toxic elements. Al was the most abundant elements in all samples .Beside that yoghurt are important source for other trace and minor minerals .

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