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Fortification of Stirred Yogurt with Certain Microelements Using Natural Sources.

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ABSTRACT

The present study is concerned the fortification of stirred yogurt with certain microelements to improve its nutritional value. The normal stirred yoghurt and stirred yoghurt fortified with 5 % oats, mango, banana fruits, or strawberry jam were prepared .The impacts of fortification on physicochemical characteristics of yogurt fortified with some microelements (silicon, iron, manganese, zinc and copper) were investigated. The results revealed that pH value increased with the increase of added oats and decreased with the fruit addition. Advancing storage period decreased pH values and slightly increased total solids in all samples. Data also showed decrease in protein content, while an increase in the contents of fat, fiber and carbohydrate of the fortified stirred yoghurt. Mineral analyses showed pronounced differences in the total microelements content between the normal stirred yoghurt and stirred yoghurt with oats and fruits. The microelements contents of stirred yoghurt with oats or fruits as ppm were in the range: Silicon (28.70- 36.50), manganese (4.60-5.25), iron (3.50–4.10), zinc (3.30-3.60). Concerning the natural stirred yoghurt the values obtained (in ppm): silicon (14.70), manganese (0.90), iron (0.70) and zinc (3.60). However, copper was not detected in all treatments. Concerning the sensory evaluation, addition of fruits improved flavor and total acceptability. Therefore, using oats is recommended as a good natural source to fortify yoghurt with silicon, manganese and iron in making good nutraceutical stirred yoghurt.

Keywords: oats, stirred yoghurt, silicon, manganese, iron, zinc, chemical composition, sensory properties.

INTRODUCTION

Food fortification is an important means in order to improve the nutritive quality of food. Incorporating one or more of essential nutrients with food in an increased concentration to levels higher than normal is known as fortification. This could be done to prevent and correct the insufficiency of one or more nutrients in the society or specific population groups (Gahruie *et al.*,2015).

Iron (Fe), silicon (Si), zinc (Zn) and manganese (Mn) were required for their functional property. The daily intake of nutritive microelements of bone (silicon, manganese, zinc, copper) is positively associated with bone mass, (Jugdaohsingh, 2007). These elements mostly are insufficient in the human diet of the societies in Egypt and African countries. Therefore, importing and consumption of fortified food is increasing.

Enrichment of dairy products with these microelements will effectively prevent or at least diminish the occurrence of diseases associated with the nutritional deficiencies. Yoghurt is a widely consumed functional food because of its high digestibility, bioavailability, and proteolytic activities (Shaboo and Ahmad, 2011).

Many different Yogurts varieties are now available to suit all palates and demand of different consumers. For example, various textures (e.g. liquid, set, smooth), fat contents (e.g. luxury, low-fat, virtually fat-free) and flavors (e.g. natural, fruit, cereal), can be consumed as a snack or part of a meal, as sweet or savory food which are available all year-round.(Dairy Council, 2016). (Nutrition scientists have mentioned that) Using natural sources(fruits, cereal, etc.) to enrich food products is one way to improve the overall nutrient intake of food with the least side effects (Nestle, 2013).

Cereal as oats is a rich source of microelements; it contains high level of silicon as well as iron and manganese. Moreover, the fruits as mango, banana and strawberry are important ingredients of human diet that contain essential nutrients and high level of microelements (USA, 2017).

Researches on bioactive functional yoghurt include studies on the supplementation of dietary fiber (Damian, 2014), micronutrients (Sazawal *et al.*, 2013), and omega-3 polyunsaturated fatty acids (McCowen*et al.*, 2010). But the studies on microelements are still limited. Therefore, the aim of this study was to fortify stirred yoghurt with some microelements to improve its nutritional value using natural sources, and measured the quality characteristics of the resultant products.

MATERIALS AND METHODS

Cow skim milk (9% T.S) was obtained from theUnit of Milk Industry**,** Animal Production Research Institute, Agricultural Research Center, Giza, Egypt. The starter used consisted of *Streptococcus thermophiles* and *Lactobacillus delbrueckii subsp. bulgaricus* being obtained from the Unit of Milk Industry, Animal Production Research Institute Production. The rolled oats (*Avena sativa*) (Origin Germany) was obtained from the local market, it was ground and analyzed. The chemical composition of oats was represented in Table (1). Mango fruit (*Mangiferaindica* L.) Sukari cultiva type, banana fruit and strawberry jam were obtained from the local market Egypt,

Fresh fruits were washed and allowed to dry at room temperature. For mango fruits, fully mature fruits were sliced without peeling, and the seeds were discarded. The slices were blended well. For banana, the banana was peeled, cut into small sizes and mashed using masher. Chemical composition of the fruits and strawberry jam were indicated in Table (1).

Table 1. Chemical composition of oats and fruits

Composition (%)	Oats	Mango	Banana	Strawberry jam
Total solids	91.70	28.70	24.43	69.09
Protein	11.02	1.82	1.10	1.34
Fat	6.78	0.82	0.32	0.71
Ash	5.94	1.82	1.10	0.94
Fiber	10.00	7.00	2.56	3.92
Carbohydrate	57.96	17.44	19.35	62.18

Pilot experiments were carried out to attain the proper concentration of oats (2.5, 5. 7.5 %) to be used for making oats yoghurt. The best portion (5%) was used according to the palatable taste.

Natural yoghurt (the control) was prepared from fresh skim milk mixed with 5% skim milk powder to increase total solids in the final milk, and the mixture was blended. For making yoghurt with oats, fresh skim milk was mixed with 5% oats as a substitute to skim milk powder (T_1) as shown in Table (2). The mixture was heated at 85°C for 10 min. and then rapidly cooled to45°C, the starter was added at rate 3% and incubated at 43–45 °C until the yoghurt coagulum was formed, and the desired pH value (pH 4.4–4.6) was reached within 3–4 h. The yoghurt was then kept overnight in a refrigerator. The yoghurt coagulum was broken manually by means of a perforated stirrer; by stirring the coagulum twentyfive times in slow helicoidally movements. This was done in order to insure that the yoghurt coagulum was completely broken, and the whey incorporation was promoted. The stirred yoghurt was then circulated through the plate heat exchanger, where it was cooled down by the cold water stream.Then the samples of stirred yoghurt filled into 100g plastic cup.

T_2: 85 g stirred yoghurt with oats + 15 g mango

T_3: 85 g stirred yoghurt with oats + 15 g banana

T_4: 85 g stirred yoghurt with oats +15 g strawberry jam

Three replicates were carried out for each treatment. The resultant stirred yoghurt samples were stored in refrigerator at 5±1°C for 15 days. The samples were analyzed for pH and total solids when fresh and after 3, 7, 10 and 15 days intervals during cold.

Table 2. The formula of natural yoghurt and yoghurt with oats

Substances (%)	Control	T_1
Skim milk	92	92
Skim milk powder	5	-
Oats powder	--	5
Starter	3	3

Control: natural yoghurt without any addition
T_1 : yoghurt with oats

All samples were analyzed for their chemical composition (total solids, protein, lactose and ash) and pH according to AOCA (2007). Fat was analyzed by using Soxhlet method. Carbohydrate content was calculated by deference.

The microelements contents of the examined samples were analyzed using Agilent microwave plasma atomic emission spectrometry after microwave- assisted digestion with nitric acid. The measurement of light intensity is made at a specific wavelength of the element.

The sensory assessment was performed on natural stirred yogurt and fortified stirred yoghurt prepared in fresh and during storage.The sensory panelist consisted of member's dairy department's staffs. The panelists rated the stirred yogurt for flavor (50), body and texture, (35), appearance (15) and overall (100).

RESULTS AND DISCUSSION

Table (3) show pH values and the chemical composition of fortified stirred yoghurt treatments. It was observed that the pH value increased in oats treatment, and gradually decreased with fruit treatments. This decrease mhght be due to the organic acid content in the fruits (Gahruiea *et al.,* 2015). Moreover all yoghurt treatments decreased in the pH values during storage as shown in Table (4).

The rate of decrease of the pH in all treatments was lower, compared with control. It was found that the total solids of treatment of oats was 12.80 ± 0.01%, which is closed to control, and increased in the ranged from 14.55 ± 0.01 to 21.23 ± 0.02 % with fruits addition as shown in Table (3).

This increase might be due to the high content of total solids in fruits as shown in Table (3). Also, data in Table (4) revealed that total solids in both control and all treatments increased during the storage period.

Protein content decreased in yogurt treated with oats. However, the results showed an increase in carbohydrate content of all treatments. It was also observed an increase in fat content of oats treatments. This is due to the fat content of the added oats which was6.76 % (Table1). **Sterna** *et al,* (2015) stated that the lipid content in the oats ranged from 5.20 to 12.40 %. The ash content slightly decreased in all treatments, except mango treatment (T_2).

Fiber content found in the oats treatments (0.50 %), while increased in the range of 0.82 – 1.01 % with fruits treatments. These results attributed to high content fiber in oats and fruits as shown in Table (1), which were in line with the previous studies (Forster *et al.,* 2003; and Ahmad *et al*., 2014).Yoghurt with fiber increases health benefits and improves its functionality, also improves body and texture of yoghurt (Forster *et al.,* (2003); and Ahmad *et al*., (2014) and Gahruiea *et al.,*2015)

Table 3. Chemical composition of fortified yogurt

Composition	Treatments				
	Control	T_1	T_2	T_3	T_4
pH value	4.48 ± 0.01	4.56 ± 0.02	4.45 ± 0.03	4.46 ± 0.01	4.22 ± 0.01
T.S %	13.01 ± 0.01	12.80± 0.01	15.15± 0.02	14.55 ± 0.01	21.23 ± 0.02
Protein %	5.42 ± 0.05	4.11 ± 0.01	4.00 ± 0.01	3.80 ± 0.05	3.85 ± 0.03
Fat %	0.15 ± 0.02	0.43± 0.02	0.49 ± 0.01	0.42 ± 0.02	0.46 ± 0.03
Ash %	1.08 ± 0.02	1.03 ±0.01	1.12 ± 0.01	1.05 ± 0.03	1.02 ± 0.02
Fiber %	-	0.50 ± 0.01	0.98 ± 0.02	0.83 ± 0.03	1.01 ± 0.01
Carbohydrate %	6.26 ± 0.02	6.63± 0.01	8.56 ± 0.02	8.44 ± 0.02	14.89 ± 0.01

Contro l: stirred yoghurt without any addition **T_1: stirred yoghurt with oats** **T_2: stirred yoghurt with oats + mango**
T_3: stirred yoghurt with oats + banana **T_4: stirred yoghurt with oats + Strawberry Jam**

Table 4. Change of pH values of fortified stirred yoghurt during storage (days)

Storage (day)	Treatments				
	Control	T_1	T_2	T_3	T_4
Fresh	4.48±0.01	4.56±0.02	4.45±0.03	4.46±0.01	4.22±0.01
3	4.40±0.02	4.50±0.03	4.40±0.03	4.42±0.01	4.21±0.03
7	4.36±0.01	4.46±0.01	4.34±0.02	4.38±0.01	4.18±0.02
10	4.30±0.03	4.42±0.01	4.28±0.01	4.33±0.02	4.11±0.03
15	4.25±0.01	4.40±0.02	4.19±0.01	4.23±0.03	4.05±0.02

Table 5. Change of total solids in fortified stirred yogurt during (15 days)

Storag e (day)	Treatments				
	Control	T_1	T_2	T_3	T_4
Fresh	13.01±0.01	12.80±0.01	15.18±0.02	14.55±0.01	21.23±0.01
3	13.05± 0.02	12.85±0.02	15.20±0.03	14.60±0.02	21.25± 0.01
7	13.10±0.01	12.88±0.01	15.22±0.01	14.63±0.03	21.30±0.04
10	13.12±0.03	12.91±0.04	15.25±0.02	14.65±0.02	21.32±0.02
15	13.14±0.02	12.97±0.03	15.30±0.04	14.70±0.01	21.35±0.02

Microelements contents of silicon, iron, manganese, zinc and copper contents in stirred yoghurt and the treatments were represented in Table (6). Silicon levels in the stirred yoghurt (control) and oats treatment were 14.7 and 23.22 ppm, respectively. It was noticed that silicon oats increased level by 59 % in stirred yogurt.

These results indicated that oats was a good natural source for silicon. Oats as cereal contains high level silicon. Concerning to the treatments oats with fruits, data showed that the maximum level of silicon found in banana and mango treatments. These related to mango and banana fruits which contain high level of silicon concentration as reported by Powell *et al.,* (2005). The importance of silicon in human bone formation and connective tissue was indicated. Banana have high Si content, in contrast to the majority of other fruits, however, silicon uptake from bananas was low (Jugdaohsingh *et al.* 2002 Jugdaohsingh, (2007).).

The results showed high variations in manganese levels between fortified yoghurt treatments and control. The manganese level in control was 0.90 ppm and elevated to 4.90 ppm affected by oats addition. It was found that the concentration of manganese was in range 4.60 - 5.25 in oats with fruits treatments, with maximum value in strawberry treatment, followed by banana and mango treatments. Manganese and silicon are necessary for bone health.

With regard to iron content, results indicated that high increase of iron content of fortified stirred yoghurt with oats (3.90 ppm), compared with control (0.70ppm).

Also, the iron content in oats and fruits treatments was observed in range of 3.50 ± 0.01 to 4.10 ± 0.01 ppm. It was clear that addition of fruit to oats treatment improved iron content. Iron carries oxygen to the cells and is necessary for the production of energy, synthesis of collagen and the proper functioning of the immune system.

While, iron deficiency anemia is responsible for an estimated 20 percent of all maternal mortality in Africa. (WHO, 2015).

Concerning zinc, the result indicated novariations in Zn content between fortified stirred yoghurt treatments and control. Zinc is particularly necessary in cellular replication and the development of the immune response. Zinc also plays an important role in growth; it has a recognized action on more than 300 enzymes by participating in their structure or in their catalytic and regularity actions (Salgueiro *et al*., 2002) Copper was not detected in all treatments.

Table 6. Microelements contents of fortified stirred yoghurt

Treatments	Concentrations of Microelementsppm				
	Si	Mn	Fe	Zn	Cu
Control	14.70±0.11	0.90±0.05	0.70±0.01	3.6 0±0.04	ND
T_1	23.22±0.08	4.90±0.02	3.90±0.01	3.61±0.02	ND
T_2	35.40±0.02	4.60±0.03	4.10±0.01	3.42±0.03	ND
T_3	36.50±0.05	4.65±0.04	4.03±0.02	3.30±0.04	ND
T_4	28.70±0.07	5.25±0.01	3.50±0.01	3.50±0.1	ND

ND: not detected

Range percentage of daily intake per serving fortified yoghurt (200g)

The observed concentration of Si, Fe, Mn and Zn in service amount of stirred yoghurt and fortified yoghurt (200g), were compared with the recommended limit as shown in Table (7). The daily intake ranges of silicon (20–50 mg/day) for adults, iron (10 to 15 mg/day), manganese (2 to 5 mg/day) and zinc (12 to 15 mg/day) for adult. From Table (7), it was found the range of daily intake per serving supplemented stirred yoghurt with oats was 9.29 to 23.22 % for silicon, and increased with fruit treatments to be 11.48 to 36.50 %. (WHO, 2004 and EFSA, 2009).

For manganese the ranges were 19.60 to 49.00 % for oats yoghurt. These percentages elevated with strawberry treatments to be 21.00- 52.50 %. These percentages of both minerals were higher than those of iron and zinc in serving fortified yoghurt treatments.

With regard of zinc in serving fortified yoghurt in most treatments was closed to control. While, iron in serving yoghurt highly affected by addition of oats and fruits.

Table 7. Range percentage of daily intake per serving fortified stirred yoghurt (200g)

	Range percentage daily intake (per serving)			
	Si	Mn	Fe	Zn
Control	5.88-14.70	3.60– 9.00	1.40 -0.93	6.00 - 4.80
T_1	9.29–23.22	19.60- 49.00	5.20- 7.80	4.80– 6.00
T_2	14.16-35.40	18.60-46.50	5.47–8.20	4.56- 5.70
T_3	14.60-36.50	46.00-18.40	5.40–8.10	5.55-4.44
T_4	11.48-28.70	52.50-21.00	4.67-7.00	4.67- 5.83

Sensory evaluation:

The sensory properties of the stirred yoghurt were evaluated by panels and the results are summarized in Table (8). The fortified yoghurt with oats at concentrations of 5 % gained flavor score 45, which were lower than those for control (47). Whereas the scores of fruits containing fortified yoghurt with oats and fruit ranged from 47- 49, indicating that the fruits improved the flavor of fortified yoghurt with oats. High scores were received by mango and strawberry jam-containing yoghurt. Moreover, the overall acceptability increased with addition of fruits. Therefore, the addition of fruits in fortified stirred yoghurt with oats improve the sensory characteristics.

Table 8. Sensory evaluation of fortified stirred yogurt

Treatments	Flavor (50)	Body & Texture (35)	Appearance (15)	Total (100)
Control	47	34	14	95
T_1	45	33	13	91
T_2	49	34	14	97
T_3	47	34	12	93
T_4	49	34	14	97

CONCLUSION

It could be concluded that oats is a good source to fortify yoghurt with silicon, manganese and iron. Addition of fruits improved the flavor and total acceptability. Thus, oats with fruits (mango, banana, strawberry jam) produce good nutritional and functional stirred yoghurt.

REFERENCES

Ahmad, M.; Gul-Zaffar, Z. A. Dar and Habib, M. (2014). A review on Oat (*Avena sativa* L.) as a dual-purpose crop. Academic J.Vol. 9(4), pp. 52-59.

AOAC (2007). Association of Official Analytical Chemists. Official Methods of Analysis 18th Ed., Washington, D.C, USA

Dairy Council (2016) - Phone: 020 7025 0569 - Email: info@dairycouncil.org.uk - Web: www.milk.co.uk

Damian, C. and Olteanu, A.(2014). Influence of dietary fiber from pea on some quality characteristics of yoghurts .Journal of Agro alimentary Processes and Technologies 2014, 20(2), 156-160

EFSA, (European Food Safety Authority), (2009). Calcium silicate and silicon dioxide/silicic acid gel added for nutritional purposes to food supplements. The EFSA Journal (2009) 1132, 1-24

Forster, M.; Rodríguez1, E.R.; Martín, J.D. andDíaz Romero,C.(2003). Distribution of Nutrients in Edible Banana Pulp .Food Technol. Biotechnol.41 (2) 167-171.

Gahruie, H. H.; Eskandari, M.H.; Mesbahi, G. and Hanifpour, M.A.(2015).Scientific and technical aspects of yogurt fortification: food Science and Human Wellness 4, 1–8

Jugdaohsingh, R, Anderson, SHC; Tucker, KL; Elliott, H, Kiel DP, Thompson RPH and Powell, JJ (2002). Dietary silicon intake and absorption.Am J ClinNutr 75, 887–893.

Juhdaohsingh, R. (2007). Silicon and bone health. J. Nutr. Health Aging 11 (2), 99 -110.

McCowen, K.C.; MD, MRCPI1,MD.; Pei Ra Ling, P.MD1; Eric Decker,E.D.; Djordjevic, D.; Roberts,R.F; J.N. Coupland, J.N. and Bistrian, B.R.MD(2010).A Simple Method of Supplementation of Omega-3 Polyunsaturated FattyAcids: Use of Fortified Yogurt inHealthy Volunteers.Nutrition in Clinical Practice 25 (6) 641-645.

Powell, J.J.; McNaughton, S.A; Juhdaohsingh, R.; Anderson,S.H.C; Dear, J.; Khor, F. ; Mowatt, L; Gleason, K.L.; Sykes, M. ; Thompson, R.P.H; Bolton-Smith, C. and Hodson, M.G. (2005).A Provisional database for the silicon content of foods in the United Kingdom. British J. Nutrition, 94, 804 – 812.

Salgueiro, M.;. Zubillaga, M., B.; . Lysionek, A.E.; Caro, R.A. Weill, R. and Boccio,J.R.(2002).The role of zinc in the growth and development of children. Nutrition, 18 (6): 510–519.

Shaboo A. and Ahmad S. B. (2011). Changes in yoghurt fermentation characteristics, and antioxidant potential and in vitro inhibition of angiotensin-1 converting enzyme upon the inclusion of peppermint, dill and basil. LWT-Food Sci. Technol.; 44:1458–1464.

Sterna,V.; Zute, S.; Jansone, I; Linda Brunava,L. and Kantane,I.(2015).The Chemical Composition of New Oat Varieties and Breeding Lines Created in Latvia. Acta. Biol. Univ. Daugavp. 15 (2)367-373.

Sazawal.S.; Habib, A.A. Dhingra, U.; Dutta,A.; Dhingra, P.; Sarkar, A.; Deb,S. ; Alam, J. Husna , A. and Black , R.E.(2013).Impact of micronutrient fortification of yoghurt on micronutrient status markers and growth – a randomized double blind controlled trial among school children in Bangladesh. Public Health, 13: 514.

USDA (2017). United States Department of Agriculture Food Composition Databases. Software developed by the National Agricultural Library v.3.7.1 2017-03-29.

WHO (2004). Guidelines for drinking water quality, 3rd edition, Vol. 1, World Health Organization, Geneva.

WHO (2015). The global prevalence of anaemia in 2011. Geneva: World Health Organization.

تدعيم - اليوجهورت المقلب ببعض العناصر الصغرى من مصادر طبيعية

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تعانى معظم سكان البلاد النامية من نقص فى العناصر الصغرى فى المنتجات الغذائية ، وتساهم المنتجات المدعمة فى الحد بشكل كبير من سوء التغذية . ولذلك تهتم هذه الدراسة بتدعيم اليوجهورت (المقلب) ببعض العناصر الصغري من مصادر طبيعية لتحسين القيمة الغذائية ودراسة تأثيرها على الخواص الطبيعية والكيميائية للمنتج. وقد تم تصنيع اليوجهورت المقارنة (الكنترول) واليوجهورت المدعم بالشوفان (5 %) ثم إضافة بعض الفاكهة (المانجو – الموز – مربي الفراولة) بعد التحضين مع التقليب الجيد حتى تتجانس الخثرة تماما. وأجريت الإختبارات الفيزيائية والكيميائية وتم تقدير بعض العناصر الصغري (سيليكون – حديد – منجنيز – زنك – نحاس) فى جميع المعاملات. وقد أظهرت النتائج أن كمية الشوفان المضافة تسبب زيادة طفيفة فى قيم pH وتقل مع المعاملات المضاف لها الفاكهة. وقد أدت فترة التخزين إلى انخفاض قيمة رقم الحموضة وزيادة طفيفة فى المواد الصلبة لجميع العينات. أظهر تقدير محتوى المنتج من العناصر الصغرى التى تم تقديرها إختلافاً كبيراً بين الكنترول ومعاملات اليوجهورت المدعم بالشوفان والفواكهة. بالنسبة لليوجهورت المدعم بالشوفان والفاكهة كانت النتائج (كجزء فى المليون) كالتالي: السيليكون (28.70- 36.50) والمنجنيز (4.60 - 5.25) والحديد (3.50 – 4.1) والزنك (3.30 – 3.60). وكانت القيم المتحصل عليها فى المقارنة سيليكون (14.70) والمنجنيز (0.90) والحديد (0.70) والزنك (3.60) . ولم يتواجد النحاس فى جميع المعاملات والكونترول. وقد أدى استخدام الفاكهة الى تحسين الخواص الحسية ومن ثم يمكن إستخدام الشوفان كمصدر طبيعي جيد فى تدعيم اليوجهورت بالسيليكون والمنجنيز والحديدلإنتاج منتج صحى ذو قيمة غذائية ووظيفية عالية .