

FORTIFICATION OF STIRRED YOGHURT WITH SOME MICROELEMENTS USING NATURAL SOURCES TO IMPROVE ITS NUTRITIONAL VALUE.

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ABSTRACT

The aim of this research is to fortificate the stirred yoghurt with some microelements and natural antioxidants to improve its nutritional value. The control was stirred yoghurt made from buffalo milk. Stirred yoghurt fortified with 5% oat and some fruits (mango, banana and strawberry jam) were prepared and their physicochemical, chemical and microbiological properties and some microelements (Si, Fe, Mn, Zn and Cu) content of resultants products were investigated.

***The data revealed that** addition of oat flour slightly increase in pH value but these values were decreased with the addition of fruits. Also the lower in protein contents cause lower in fat while the higher in fat, fiber and carbohydrate contents were higher than control.*

Mineral analyses of Si, Mn, and Fe contents were great difference between all treatments as they ranged between (28.71-36.51) for Si, (4.61-5.26) for Mn, (3.51-4.11) for Fe and (3.31-3.61) ppm for Zn. Concerning the control, the values obtained were (14.71), (0.91), (0.71), (3.61) for Si, Mn, Fe and Zn respectively. The sensory evaluation showed that addition of fruits improved the total acceptability.

***Conclusively,** oat flour can be used as a good natural source in fortified yoghurt with micronutrients to produce yoghurt with high nutritional and functional value.*

Key words: Fortification, Stirred Yoghurt, Microelements, Natural Sources, Nutritional Value.

INTRODUCTION

Functional foods are one of the most important challenges of this country to prevent chronic diseases (Ya-Wen Zeng, *et al.*, 2013).

Food fortification is one of the most necessary processes to improve the nutrients quantity and its quality in food. The most common method is adding micronutrients (essential trace elements, antimicrobials, vitamins and antioxidants) to food. Human body needs various micronutrients, as silicon (Si), zinc (Zn), manganese (Mn) and iron (Fe) for their functional properties. Silicon, zinc, copper and manganese are positively related to bone mass, (Jugdaohsingh, 2007). Despite their presence in small concentrations in the human body, they are playing an important role in the growth.

Silicon (Si) is the third most abundant trace element of the human body and is particularly helpful to connective tissues bone, blood vessels, hair, nails and skin. It additionally seems to lower plasma lipids and protect from atherosclerotic (Sripnnyakorn *et al.* 2005). Foods derived from plants, as cereals are foods that have high levels of silicon, in contrast, foods from animal sources like meat and dairy products have low levels of silicon (Jugdaohsingh, 2007). There is limited information on the silicon concentration of foods because of difficulties related to the analytical procedures needed for silicon analysis and there is a restricted knowledge for African and Egyptian milks and their products.

Zinc (Zn) is another mineral that has to be absorbed in tiny amounts to keep humans healthy. Zinc is crucial for body growth, development and maturation tissue repair as well as resistance to illnesses. Zinc is a vital mineral for elderly and the youngsters. It can be found in poultry, meats, specifically organ meats and seafood. Though rare, a decrease in the percentage of zinc can lower the growth in youngsters, delay wound healing in individuals of all ages, reduce resistance to infection in adults. The body requires 15.0 milligrams of zinc per day.

Iron (Fe) is a component of the muscles and also red blood cells that help in the transportation of oxygen through the body. Iron is important in certain enzymes and the formation of hemoglobin, immune activity, several proteins and enzymes that maintain physiological state, protection against the actions of free radicals and correct functioning of the liver.

Copper (Cu) is a very important element of the melanin that helps to give color for the hair, skin, and eyes. The use of copper supplements helps in protection against graying of the hair. Thus whereas it is usually overlooked as

an antioxidant mineral, it will defend the integrity of those cells and keeps you trying young. It also maintains the color of your eyes and is crucial, together with zinc, to keep your eyes fantastically colored into your adulthood. Copper deficiency is rare, but can occur in people who have chronic diarrhea or who are severely undernourished.

Manganese (Mn) is a trace mineral that is important to life. The human body contains about 15 to 20 milligrams of it. Adults need solely concerning about 2 mg manganese per day. Most of it is found in the bones, with the rest distributed throughout the body in tissues just like the kidneys, liver, pancreas, pituitary glands and adrenal glands.

Unfortunately, Milk and dairy products have a poor content of these elements and there is not enough information about a private in the African and Egyptian food. On the opposite, most people in underdeveloped or developing countries suffer from micronutrients deficiency and enriched food merchandise can dramatically cut back the nutritional diseases. Therefore, the consumption of fortified food is demanding. Because of the high consumption rate of dairy products like yogurt, fortification of these products will effectively prevent or reduce diseases related to nutritional deficiencies.

One of the most important functional foods widely consumed is yoghurt because of its bioavailability, high digestibility and proteolytic activities. The market currently offers a vast array of yoghurt to suit all palates and meal occasions. They are available in a very type of fat contents (e.g. luxury, low-fat, virtually fat-free), flavors (e.g. natural, fruit, cereal) and textures (e.g. liquid, set, smooth), can be consumed as a part of a meal or a snack or as savory food or a sweet and are available all year-round (Dairy Council, 2016).

Many studies on supplementation of yoghurt with dietary fiber (Damian and Olteanu, 2014), micronutrients (Sazawal *et al.*, 2013), and omega-3 polyunsaturated fatty acids (McCowen *et al.*, 2010) were carried out, but studies on fortification with microelements still limited as oat is a rich source of microelements and soluble non digestible fiber. It contains high level of silicon as well as iron and manganese (Ahmad *et al.*, 2014).

Therefore, the aim of this study to improvement the natural value and healthy benefits of final product.

MATERIALS AND METHODS

Buffalo milk: was obtained from Mahalat Moussa station, the starter: of *streptococcus thermophilus* and *lactobacillus bulgaricus* were from Chr. Hansen were obtained from the Unit of Milk Industry, Animal production research Institute, The oat flour: The rolled oats (*Avena sativa*) was obtained from local market and The fruits including: Mango (*Mangifera indica L.*): Mango Sukari cultivar and banana as well as Strawberry (*Fragaria ananassa*) jam were purchased from the local market.

Fruits preparation: fresh fruits were washed and allowed to dry at room temperature.

Yoghurt treatments with oat flour were carried out to reach the suitable proportions of oat flour (2.5, 5, and 7.5%) to be used for making oat yoghurt. According to the most palatable taste the protein 5% was the best natural yoghurt (the control) was prepared from fresh skim milk mixed with 5% skim milk powder to increase total solids in the final milk mixture was blended. For yoghurt with oat treatment, fresh skim milk was mixed with 5% oat flour as a substitute to skim milk powder (T1).

The mixture was heated at 85°C for 10 min. and then rapidly cooled to 45°C, the activated starter was added at a rate 3%. At this point, the yoghurt was left overnight in a refrigerator. The yoghurt coagulum was broken manually by means of a perforated stirrer, by stirring the coagulum twenty five times in slow helicoidally movements. This was done in order to insure that the yoghurt coagulum was completely broken and that whey incorporation was promoted. After this operation, the stirred yoghurt was circulated through the plate heat exchanger where it was cooled down by the cold water stream. Then the samples of 100 g stirred yoghurt were filled into plastic cups and stored in the refrigerator (5°C) for 15 days. Treatments of oats yoghurt with fruits:

T₂: 85 g stirred yoghurt with oats +15 g mashed mango pulp

T₃: 85 g stirred yoghurt with oats +15 g mashed banana pulp

T₄: 85 g stirred yoghurt with oats +15 g strawberry jam

Chemical analysis of milk sample and stirred yoghurt treatments were determined for total solids, protein, ash and crude fiber according to A.O.A.C (2012).

pH values were determined using a digital pH meter (Jenway 3505 pH meter). Carbohydrate content of all samples was determined as a calculation.

Fat was determined by Gerber method for milk and cheese samples, while Fat of oat flour, fruits and all stirred yoghurt treatments was analyzed

by using Soxhlet method. Fat content was analyzed according to Ling (1963).

Protein content of all samples was determined by using micro Kjeldahl methods. AOAC (2012).

Microbiological analysis: Total bacterial count and mould and yeast contents of stirred yoghurt were determined according to the method described by the AOAC (2012).

Determinations of micro and macro elements were carried out by using Agilent microwave plasma atomic emission spectrometry.

Silicon was determined in milk and stirred yoghurt treatments. Also other micro elements (Mn, Fe, Zn and Cu) were determined for stirred yoghurt treatments, as well as macro elements (Ca, P, Mg and K).

Sensory evaluations:

The sensory assessment was performed on natural stirred yoghurt and enriched stirred yoghurt prepared in fresh and during storage. The sensory panelists rated the stirred yogurt for flavor (50), body and texture, (35), appearance (15) and overall acceptability (100) according to Shahani *et al.*, (1979).

Statistical Analysis:

Sample were assayed results are given as mean + SD. The statistical analysis was carried out according to Steel *et al.*, (1980) on the results obtained from biological experiments.

Statistical significance for data was determined using a one-way analysis of variance (ANOVA) and Duncan`s Multiple Range test as well as Standard Error carried out using a SAS computer program (SAS,1987).

RESULTS AND DISCUSSION

Chemical composition of materials used in fortified stirred yoghurt

The chemical composition of oat flour, mango, banana pulps and strawberry jam which used for fortification of stirred yoghurt is recorded in Table 1. The results showed that oats contained high total solids (91.71%), protein (11.03 %), fat (6.77 %), carbohydrate (57.97 %) and ash (5.95 %). Also, it characterized by high fiber content (10.01 %). Analysis of Fruits (mango and banana) and strawberry jam demonstrated that those had high percentages in fiber content with maximum value in mango.

Table (1). Chemical composition of oats and fruits

| Composition (%) | Oat Flour | Mango Pulp | Banana Pulp | Strawberry Jam |
|-----------------|-----------|------------|-------------|----------------|
| Total solids | 91.71 | 28.71 | 24.44 | 69.10 |
| Protein | 11.03 | 1.83 | 1.11 | 1.35 |
| Fat | 6.77 | 0.83 | 0.33 | 0.72 |
| Ash | 5.95 | 1.83 | 1.11 | 0.95 |
| Fiber | 10.01 | 7.01 | 2.57 | 3.93 |
| Carbohydrate | 57.97 | 17.45 | 19.36 | 62.19 |

The high percentages in carbohydrate content and low in fat and protein were observed in fruits pulps and strawberry jam as was expected.

Table (2) showed pH values and the chemical composition of fortified stirred yoghurt treatments. It can be seen that pH value was increase with oats treatment and gradually decrease with fruit treatments.

Table (2). Chemical composition of fortified stirred yoghurt

| Composition | Treatment groups | | | | |
|------------------|-----------------------------|-----------------------------|------------------------------|-----------------------------|-----------------------------|
| | Control | T ₁ | T ₂ | T ₃ | T ₄ |
| Ph value | 4.47 ±0.01 ^{ab} | 4.58 ±0.02 ^a | 4.46 ±0.03 ^b | 4.47 ±0.01 ^b | 4.23 ±0.01 ^c |
| T.S, % | 13.02 ±0.01 ^c | 12.81 ±0.01 ^d | 15.16 ±0.02 ^{ab} | 14.56 ±0.01 ^b | 21.24 ±0.02 ^a |
| Protein, % | 5.43 ±0.05 ^a | 4.12 ±0.01 ^{ab} | 4.01 ±0.01 ^b | 3.81 ±0.05 ^{bc} | 3.86 ±0.03 ^c |
| Fat, % | 0.16 ±0.02 ^d | 0.44 ±0.01 ^b | 0.50 ±0.01 ^a | 0.43 ±0.03 ^{bc} | 0.47 ±0.02 ^{ab} |
| Ash, % | 1.09 ±0.02 ^{ab} | 1.04 ±0.01 ^{bc} | 1.13 ±0.01 ^a | 1.06 ±0.03 ^b | 1.03 ±0.02 ^c |
| Fiber, % | - | 0.60 ±0.01 ^d | 0.99 ±0.02 ^{ab} | 0.84 ±0.03 ^b | 1.02 ±0.01 ^a |
| Carbohy., % | 6.27 ±0.02 ^d | 6.64 ±0.01 ^c | 8.57 ±0.02 ^b | 8.45 ±0.02 ^{bc} | 14.90 ±0.01 ^a |
| Significant test | * | * | * | * | * |

(a,b, ...d) Means at the row with different superscripts are different ($P < 0.05$) by Duncan's multiple comparison tests

Control: Stirred yoghurt without any addition; **T₁** : Stirred yoghurt with oat flour; **T₂**: Stirred yoghurt with oat flour + mango ; **T₃** :Stirred yoghurt with oat flour + banana – **T₄** : Stirred yoghurt with oat flour + Strawberry Jam.

* $P < 0.05$.

This decrease may be due to the citric acid content in fruits (Gahruie *et al.*, 2015). Moreover all yoghurt treatments decreased in PH values during storage as shown in Table (3).

The rate of decreasing pH for all fortified treatments was lowest compared with control. It was found the total solid of treatment of oats was 12.81 % closed to control and increase in ranged from 14.56 to 21.24% with fruits addition as shown in Table (2).

Table (3). Change of pH values of fortified stirred yoghurt during storage

| Storage (day) | Treatment groups | | | | |
|------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| | Control | T ₁ | T ₂ | T ₃ | T ₄ |
| Fresh | 4.49 ±0.01 ^{Aa} | 4.57 ±0.02 ^{Aa} | 4.46 ±0.03 ^{Aa} | 4.47 ±0.01 ^{Aa} | 4.23 ±0.01 ^{Aa} |
| 3 | 4.41 ±0.02 ^{Ab} | 4.51 ±0.03 ^{Ab} | 4.41 ±0.03 ^{Ab} | 4.43 ±0.01 ^{Ab} | 4.22 ±0.03 ^{Ab} |
| 7 | 4.37 ±0.01 ^{Cc} | 4.47 ±0.01 ^{Bc} | 4.35 ±0.02 ^{Bc} | 4.39 ±0.01 ^{Ac} | 4.19 ±0.02 ^{Ac} |
| 10 | 4.31 ±0.03 ^{Cd} | 4.43 ±0.01 ^{Bb} | 4.29 ±0.01 ^{Bd} | 4.34 ±0.01 ^{Bc} | 4.12 ±0.03 ^{Bc} |
| 15 | 4.25 ±0.01 ^{Dd} | 4.41 ±0.02 ^{Cd} | 4.18 ±0.01 ^{Cd} | 4.23 ±0.03 ^{Cd} | 4.05 ±0.02 ^{Cd} |
| Significant test | * | * | * | * | * |

(a,b, ...d) Means at the row with different superscripts are different (P<0.05) by Duncan's multiple comparison test.

(A,B, ...D) Means at the column with different superscripts are different (P<0.05) by Duncan's tests multiple comparison tests.

Control: Stirred yoghurt without any addition; **T₁** : Stirred yoghurt with oat flour; **T₂**: Stirred yoghurt with oat flour + mango ; **T₃** :Stirred yoghurt with oat flour + banana – **T₄** : Stirred yoghurt with oat flour + Strawberry Jam. (A.B) Means at the column with different superscripts are different (P<0.05) by Duncan's tests multiple comparison tests.

* P<0.05.

These increases due to high content of total solids in fruits as shown in Table 1. Also, data in Table (4) revealed that total solid in both control and all treatments increased during storage period. Protein content and ash slightly decrease with oats treatments. While, the total carbohydrate increased with all oats treatments. Also, the increase in fat content of oats treatments was observed. This due to the fat content of oats was 6.77% (Table 1).

According to reported data of Sterna *et al.*, (2015), the lipid content in the oat ranged from 5.20 to 12.40 %. Fiber content found in the oats treatments (0.50 %) and increased in range 0.82 – 1.01 % with fruits Treatments.

Table (4). Change of total solids in fortified stirred yoghurt during storage

| Storage (day) | Treatment groups | | | | |
|-------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| | Control | T ₁ | T ₂ | T ₃ | T ₄ |
| Fresh | 13.02 ±0.01 ^{Dd} | 12.81 ±0.01 ^{Dc} | 15.19 ±0.02 ^{Bc} | 14.56 ±0.01 ^{Cb} | 21.24 ±0.01 ^{Ab} |
| 3 | 13.06 ±0.02 ^{Dc} | 12.86 ±0.02 ^{Db} | 15.21 ±0.03 ^{Bc} | 14.61 ±0.02 ^{Cb} | 21.26 ±0.01 ^{Ab} |
| 7 | 13.2 ±0.01 ^{Db} | 12.89 ±0.01 ^{Db} | 15.23 ±0.01 ^{Bb} | 14.64 ±0.03 ^{Ca} | 21.31 ±0.04 ^{Aa} |
| 10 | 13.13 ±0.03 ^{Ca} | 12.92 ±0.04 ^{Da} | 15.26 ±0.02 ^{Ba} | 14.65 ±0.02 ^{Ca} | 21.33 ±0.02 ^{Aa} |
| 15 | 13.15 ±0.02 ^{Ca} | 12.98 ±0.03 ^{Da} | 15.31 ±0.04 ^{Ba} | 14.71 ±0.01 ^{Ba} | 21.36 ±0.02 ^{Aa} |
| Significant test | * | * | * | * | * |

a.b, c) Means at the row with different superscripts are different ($P < 0.05$) by Duncan's multiple comparison tests.

(A,B, ...D) Means at the column with different superscripts are different ($P < 0.05$) by Duncan's tests multiple comparison tests.

Control: Stirred yoghurt without any addition; **T₁:** Stirred yoghurt with oat flour; **T₂:** Stirred yoghurt with oat flour + mango ; **T₃:** Stirred yoghurt with oat flour + banana – **T₄:** Stirred yoghurt with oat flour + Strawberry Jam.

* $P < 0.05$.

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; Ahmad *et al.*, 2014).

Table (5) illustrated that, the total bacterial counts; molds and yeasts counts in fortified stirred yoghurt were the lowest compared with control when fresh. Also, data showed that the decreasing numbers of total bacterial counts were in fortified stirred yoghurt with oat flour (T₁), treatment of strawberry (T₄) and control after 7 days of storage, and then started to increase till 15 days.

This may be due to the sensitivity of microorganisms to the produced acidity, but there was clear increase in total bacterial counts of banana (T₃) and strawberry treatments (T₄) after 7 and 15 days of storage period.

Table (5). Growth of Total bacterial counts and yeast and molds in fortified stirred yoghurt during storage period.

| Treatments | Storage period (days) | | | | | |
|----------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| | Fresh | | 7 days | | 15 days | |
| | T.C 10 ⁶ CFU/g | M&Y 10 ² CFU/g | T.C 10 ⁶ CFU/g | M&Y 10 ² CFU/g | T.C 10 ⁶ CFU/g | M&Y 10 ² CFU/g |
| Control | 1.201 | N.D | 1.41 | 5 | 5.29 | 2 |
| T₁ | 3.61 | N.D | 3.01 | 12 | 4.65 | 37 |
| T₂ | 5.1 | N.D | 1.25 | 2 | 3.21 | 65 |
| T₃ | 1.21 | N.D | 3.61 | 3 | 3.45 | 81 |
| T₄ | 3.41 | N.D | 2.49 | N.D | 2.65 | 15 |

Control: Stirred yoghurt without any addition; **T₁:** Stirred yoghurt with oat flour; **T₂:** Stirred yoghurt with oat flour + mango; **T₃:** Stirred yoghurt with oat flour + banana – **T₄:** Stirred yoghurt with oat flour + Strawberry Jam.

N.D: Not detected, M&Y: Molds and yeasts, T.C: Total bacterial Counts, CFU: Colony forming unit

Some microelements contents in fortified stirred yogurt:

Microelements including silicon, iron, manganese, zinc and copper contents in stirred yoghurt treatments are presented in Tables (6 and 7). Silicon levels in stirred yoghurt (control) and oat treatment were 14.71 ± 0.11 and 23.23 ± 0.08 ppm respectively. These results indicated that oat increased silicon content by 59 % in stirred yogurt. These results indicated that oat was a good natural source for silicon. Oat as grain contains high level of silicon as reported by Powell *et al.*, (2005).

Concerning to the treatments of oat flour with fruits, data showed that the maximum level of silicon was found in banana and mango treatments. This is due to fortification with mango and banana fruits which contain high concentration of silicon concentration as reported by Powell *et al.*, (2005). Previous work showed that banana has higher Si content, in contrast to the majority of other fruits, however, silicon uptake from banana was low (Jugdaohsingh *et al.*, 2002).

Table (6). Microelements concentrations of fortified stirred yoghurt

| Treatment groups | Concentrations of microelements ppm | | | | |
|------------------|-------------------------------------|-----------------------------|-----------------------------|-----------------------------|------|
| | Si | Mn | Fe | Zn | Cu |
| Control | 14.71 ±0.11 ^d | 0.91 ±0.05 ^b | 0.71 ±0.01 ^d | 3.61 ±0.04 ^{ab} | N.D* |
| T ₁ | 23.23 ±0.08 ^c | 4.91 ±0.02 ^b | 3.91 ±0.01 ^b | 3.62 ±0.02 ^a | N.D |
| T ₂ | 35.41 ±0.02 ^{ab} | 4.61 ±0.03 ^c | 4.11 ±0.01 ^a | 3.43 ±0.03 ^{bc} | N.D |
| T ₃ | 36.51 ±0.05 ^a | 4.66 ±0.04 ^{bc} | 4.04 ±0.02 ^{ab} | 3.3 ±0.04 ^c | N.D |
| T ₄ | 28.71 ±0.07 ^b | 5.26 ±0.01 ^a | 3.51 ±0.01 ^a | 3.51 ±0.10 ^b | N.D |
| Significant test | * | * | * | * | * |

(a,b,...) Means at the row with different superscripts are different ($P<0.05$) by Duncan's multiple comparison tests

Control: Stirred yoghurt without any addition; **T₁** : Stirred yoghurt with oat flour; **T₂**: Stirred yoghurt with oat flour + mango ; **T₃** :Stirred yoghurt with oat flour + banana – **T₄** : Stirred yoghurt with oat flour + Strawberry Jam.

N.D: Not detected.

* $P<0.05$..

Table (7). Some macro elements concentrations of fortified stirred yoghurt

| Treatments | Concentration of macro elements ppm | | | |
|------------------|-------------------------------------|----------------------|----------------------|---------------------|
| | Ca | P | K | Mg |
| Control | 1705±10 ^a | 1138±12 ^a | 2258±14 ^a | 219±3 ^{cd} |
| T ₁ | 1567±11 ^b | 911±8 ^c | 1619±15 ^d | 220±2 ^c |
| T ₂ | 1454±9 ^c | 924±5 ^b | 1629±11 ^c | 223±3 ^b |
| T ₃ | 1359±5 ^d | 802±4 ^d | 2075±12 ^b | 228±4 ^a |
| T ₄ | 1154±7 ^e | 720±5 ^e | 1615±11 ^e | 193±3 ^d |
| Significant test | * | * | * | * |

a.b) Means at the row with different superscripts are different ($P<0.05$) by Duncan's multiple comparison tests

Control: Stirred yoghurt without any addition; **T₁** : Stirred yoghurt with oat flour; **T₂**: Stirred yoghurt with oat flour + mango ; **T₃** :Stirred yoghurt with oat flour + banana – **T₄** : Stirred yoghurt with oat flour + Strawberry Jam.

* $P<0.05$.

The results showed high variations in manganese levels between fortified yoghurt treatments and control. The manganese level in control was 0.91 ± 0.05 ppm and elevated to 4.91 ± 0.02 ppm affected by oats addition. From the results, it was found that the concentration of manganese was in range 4.61 ± 0.03 and 5.26 ± 0.01 ppm 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 (Jugdaohsingh, 2007).

With regard to iron content, results should show higher increase in iron content of fortified stirred yoghurt with oat (3.91 ± 0.01 ppm) compared with control (0.71 ± 0.05 ppm).

Also, the iron content in oat and fruits treatments was observed in range of 3.51 ± 0.01 to 4.11 ± 0.01 ppm. Dairy products are poor in iron content (Gahruie *et al.*, 2015). While; iron-fortified yogurt has relatively high iron bioavailability (Woestyne *et al.*, 1991).

Concerning zinc element, the result indicated no variations in Zn content between fortified stirred yoghurt treatments and control.

Zinc element is necessary in cellular replication and the development of the immune response. Copper was not detected in all treatments.

Sensory evaluation:

The sensory properties of the stirred yoghurt were evaluated by panelists and the results are summarized in Table 8.

Table (8). Sensory evaluation of fortified stirred yoghurt

| Treatments | Flavor (50) | Body & Texture (35) | Appearance (15) | Total (100) |
|----------------------|------------------------|------------------------------------|----------------------------|------------------------|
| Control | 46 | 35 | 14 | 95 |
| T₁ | 44 | 34 | 13 | 91 |
| T₂ | 49 | 35 | 14 | 98 |
| T₃ | 46 | 35 | 12 | 93 |
| T₄ | 49 | 35 | 14 | 98 |

Control: Stirred yoghurt without any addition; **T₁** : Stirred yoghurt with oat flour; **T₂**: Stirred yoghurt with oat flour + mango ; **T₃** :Stirred yoghurt with oat flour + banana – **T₄** : Stirred yoghurt with oat flour + Strawberry Jam.

The fortified yoghurt with oat at concentration of 5 % had flavor score (44), which were lower than that for control (46). Whereas the flavor scores of fruits containing fortified yoghurt with oat and fruits ranged from 46 – 49, indicating that the fruits improved the flavor of fortified yoghurt with oat.

High total scores were received by mango pulp and strawberry jam containing yoghurt. Moreover, the overall acceptability increased with addition of fruits. Therefore, the addition of fruits in fortified stirred yoghurt with oat flour improved the sensory characteristics of end product.

Conclusively, Oat flour can be used as a good natural source in fortified yoghurt with micronutrients to produce yoghurt with high nutritional and functional value.

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تدعيم الزبادي المقلب ببعض العناصر الصغرى من مصادر طبيعية.

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تم تصنيع الزبادي (الكنترول) والزبادي المدعم بالشوفان (5%) ثم إضافة بعض الفواكه مثل (المانجو- الموز – مربى الفراولة) بعد التحضين مع التقليل الجيد حتي تتجانس الخثرة تماما. وأجريت الإختبارات الفيزيائية والكميائية والميكروبيولوجية و الحسية وتم تقدير العناصر الصغرى مثل (سيليكون – حديد – منجنيز – زنك – نحاس) في جميع المعاملات.

أظهرت النتائج أن كمية الشوفان المضافة تسبب زيادة طفيفة في قيم pH وتقل عن المعاملات المضاف لها الفواكه. وأيضاً أوضحت النتائج إنخفاض البروتين بينما زادت قيمة الدهون والألياف والكاربوهيدرات في كل معاملات الزبادي المدعم. أدت فترة التخزين إلي إنخفاض قيمة PH وزيادة طفيفة في المواد الصلبة في جميع العينات. وجد ان هناك إختلاف كبير في محتوى العناصر الصغرى بين الكنترول ومعاملات الزبادي المدعم بالشوفان والفواكه. بالنسبة للزبادي

المدعم بالشوفان والفواكه فقد احتوي علي السيليكون بمقدار يتراوح ما بين (28.71- 36.51) والمنجنيز (4.61-5.26) والحديد (3.51-4.11) والزنك (3.31-3.62) جزء من المليون.

أما بالنسبة للزبادي الطبيعي (الكنترول) فقد احتوي علي سيليكون بمقدار (14.71±0.11) والمنجنيز (0.91±0.05) والحديد (0.71±0.01) والزنك (3.61±0.04) جزء في المليون – لم يتحدد النحاس في جميع المعاملات والكنترول. وبالنسبة للتقييم الحسي تبين أن إضافة الفاكهه للزبادي المدعم بالشوفان أدت الي تحسين النكهة وزيادة القبول العام بدرجة كبيرة.

التوصية : يمكن استخدام الشوفان كمصدر طبيعي جيد في تدعيم الزبادي بالعناصر المعدنية الصغري لانتاج زبادي ذو قيمة غذائية عالية.