Enhancing the Nutritional Value of Yogurt by Fortification with Some Sesame Seeds and Flaxseed

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ABSTRACT

Set-Yogurt was made by fortification with some oil-seeds (sesame seeds ss and flaxseed fx) in different ratio (3, 5, 10 and 15%) for all. Fortification of ss and fx had a significant effect on pH value, acidity% and viscosity value and improved texture properties which, decreased wheying off of yogurt. It is enhancing a nutritional value, which increased TS via protein, fat, mineral content. Sensory properties of all fresh treatments had the highest score and were accepted after 3 and 9 days of storage. Results indicated that sesame seeds and flaxseed are consider a good source of nutrients in the diet and may have health and economic benefits due to its content of fiber, minerals, and a great effect of antioxidant activity.

Keywords: set-yogurt, sesame seed, flaxseed, nutritional value, fortification, iron%.

INTRODUCTION

Yogurt is a nutrient-dense food, but any added ingredients and production methods will determine the final nutritional content (Harmela *et al.,* 2022). Because yogurt is made from milk, it is usually a good source of high-quality protein and contains a highly bioavailable source of calcium. It can also be a source of riboflavin (B2), vitamin B12, and minerals (iodine, phosphorus, and potassium). However, it is a generally not a good source of rare elements. Metal traces such as iron, zinc, copper and manganese are particularly important (Mckinley, 2005; El-Abbadi *et al.,* 2014; Ndife *et al*., 2014; Oladipo *et al*., 2014; Williams *et al*., 2015 and Rahnama & Rajabpour, 2017). Yogurt can provide useful amounts of several nutrients which may help to ensure that micronutrient recommendations are met in vulnerable groups (Bates *et al*., 2014).

Sesame seeds are widely used in the food and nutraceutical industries in many countries due to their high oil, protein and antioxidant content, which are known to play an important role in their oxidative stability and antioxidant activity. Also, it is one of the natural health-promoting foods that have the ability to prevent various disorders like high blood pressure, cholesterol cancer and aging (Kanu *et al*., 2010).

Flaxseeds (*Linum usitatissimum*) are one of the most important oil seed crops for industrial applications. Food fortification with flaxseed has been proven to offer health benefits. Flaxseed is a functional food ingredient because of its rich contents of α-linolenic acid (ALA, omega-3, fatty acid), lignans, and fiber. Thus, flaxseeds have potential health benefits such as reduction of cardiovascular disease, atherosclerosis, diabetes, cancer, arthritis, osteoporosis, autoimmune and neurological disorders. As a functional food ingredient, flax or flaxseed oil has been incorporated into milk and dairy products (Mishra and Verma, 2013).

The aims of this study were to develop a new functional yogurt with higher nutritional value (as a source of iron). To achieve this objective, a study was conducted: enriching yogurt with oilseeds (sesame and flax seeds) as a natural source of iron.

MATERIALS AND METHODS:

Materials

Full fresh cow's milk obtained from local market, (12.1%TS, 3.1% fat and 3.5% protein). Culture preparation: culture freeze- dried lactic culture for direct vat set (DVS) (Express 0.2, thermophilic yoghurt culture YO-Flex Express), consisting of *Lactobacillus delbrueckii ssp. bulgaricus* and *Streptococcus thermophilus* for manufacture of yoghurt was obtained from Chr. Hansen's Lab., Denmark. Sesame seed (*Sesamum indicum*), its physicochemical properties were (5.26% moisture, 49.84% fat, 19.34% protein, 3.16% ash, 9.70% iron, 0.81 mg/100g V.C, 61.62% DPPH. Flaxseed (*Linum usitatissimum*), were obtained from local market (Abo Auf) the physicochemical properties were (6.59% moisture, 35.1% fat, 24.80% protein, 3.47% ash, 7.30% iron, 0.71 mg/100g V.C, 66.99% DPPH.

Methods:

Preparation of Sesame seeds.

The seeds were obtained from the local market, roasted in the oven at 25-30°C, then grind using a mixer until a finely ground texture was obtained, according to Aly *et al.* (2020) with some modification**.**

Preparation of Flaxseed.

The seeds were obtained from the local market, roasted in the oven at 50°C for 3-4 hours, then grind

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using a mixer until a finely grind texture was obtained, according to Dzuvor *et al.* (2018) with some modification.

Preparation of Set-Yogurt:

Fresh full cow milk was fortified. Therefore, divided into five equal portions. Five treatments were carried out. The first treatment is yoghurt with no additive (a control); in the second, third, fourth and fifth treatments 3%, 5%, 10% and 15% of sesame seeds & flaxseed were added and mixed with cow's milk respectively. Both control and yoghurt samples were cooled and stored in a refrigerator at (4°C) for 14 days for analysis during storage period. Yogurt was manufactured according to the protocol proposed by Tamime and Robinson (1999).

Determination of physicochemical properties: All the Yogurt samples were analyzed in triplicate for Titratable Acidity, protein, ash, moisture and total solid content by using the method of AOAC (2005). The pH value of milk and yogurt was measured using Lab, pH meter JENWAY-3505. Carbohydrates content and Nutritional value were evaluated as the formula used by Nile and Khobragade (2009).

Minerals content (Iron, Zinc, Copper), Minerals were determined using Atomic Absorption Spectrophotometer, Pyeunican SP 1900, according to Bradfield and Spencer (1965). Place 0.5- 1.0 g portions of ground plant material into 30 or 50 ml glass beakers. Place beakers into a cool muffle furnace and increase temperature gradually to 550°C. Continue ashing for 5 hours after attaining 550°C. Shut off the muffle furnace and open the door cautiously for rapid cooling. When cool, take out the beakers carefully. Dissolve the cool ash in 5 ml portions of 2 N HCL. Mix thoroughly, allow to stand for about 30 min., and use the supernatant or filter through Whatman no. 42 filter paper discarding the first portions of the filtrates.

Vitamin C, was determined by using titrimetric method with 2, 6- di-chlorophenol indophenol reagent according to AOAC (2010).

Antioxidant activity: Determination of antioxidant activity Stable 2, 2-diphenyl-1-picryl- hydrazyl radical (DPPH) was used to evaluate the antioxidant activity of tested samples according to method reported by Farrag *et al*. (2020).

Thiobarbituric acid (TBA) Oxidation products (e.g., malonaldehyde) were analyzed spectrophotometrically using a TBA test. One gram of yogurt was weighed into a glass screw-top test tube, and 9 ml of 15% (wt/vol) TBA, 0.375% (wt/vol) 4,6-dihydroxypyrimidine-2-thiol, and 0.25N HCl solution were added, mixed well, and heated in a boiling water bath for 15 min. Samples were then cooled to room temperature (20°C) and centrifuged at 7000 × g for 15 min at 20°C; absorbance was measured at 535 nm (Hekmat and McMahon, 1997).

Rheological properties

Wheying off (Syneresis) Syneresis was determined as described by Tamime *et al.* (1996).

Viscosity It was determined by using a digital Brookfield Viscometer (Model LVDV-E, Brookfield Engineering Laboratories, Inc. USA), according to Atherton and Newlander (2000).

Texture analysis:

Texture properties of yogurt was evaluated using a texture analyzer (FTC TMS-Pro, USA). Yogurt samples were evaluated in their cups, and the back-extrusion test was performed using a texture analyzer with a cylindrical probe of TA25 mm diameter for yogurt, operated at a crosshead speed of 50 mm/s Firmness, consistency and gumminess were evaluated in triplicate as described by Szezesniak *et al*. (1963) and Bourne (1978).

Microbiological analysis:

Total bacterial count was determined on Tryptone Glucose Yeast Extract Agar (Marth and Steele, 2001). Samples incubated at 32±2°C for 48 hours. Total yeasts and molds count was performed on Potato Dextrose Agar (Altas, 1993). Samples incubated at 25±2°C for up 5 days.

Sensory evaluation:

Sensory evaluation of yogurt samples were assessed by panelists from staff member of Dairy Tech. Dept. Animal production Research Institute and Dairy Sci. Department of faculty of Agric. Tanta University. Score for appearance, flavor, texture, consistency and overall acceptance were applied according to Nelson and Trout (1981).

Statistical analysis:

Using SPSS 1998 software (version 18) the data were analyzed statistically. The results were expressed as mean ± SD of triplicate and the statistical analysis per formed using two-way analysis of variance followed by Duncan tests. The level of significance was preset at $P \leq 0.05$.

RESULTS AND DISCUTION

Total solids content (TS)

Data presented in Table (1) Summarize the average of total solids % of control and the eight other functional yoghurt treatments. From these data, it was easy to detect that the value (12.50**)** compared with the other treatments. It would be noticed that TS increased in other eight functional yogurts as a result of percentage of oilseeds (sesame seeds & flaxseed) fortification. As expected, total solid content of yogurt

increased by increasing levels of oil seeds when compared to control yogurt. This may be due to the raising of total solid in sesame seeds and flaxseeds, functional yogurt fortified with (sesame seeds and flaxseeds) with higher total solid has more nutrient composition than control. These results are in line with reported by Aly *et al.* (2020), they stated that total solid increased with increasing the amount of sesame seeds powder in fermented milk.

Protein content

The protein content ranged from (3.24±0.07 to 6.22±0.70) for functional yogurt treatments compared to control yoghurt (2.71±0.51), yogurt fortified with 15% flaxseeds (T8) characterized by its high protein content compared with control and other functional yogurt treatments (Table 2), Soni *et al*. (2016) mentioned similar trend and reported that flaxseed is considerable potential source of high quality protein which important for physiological in human body. Also, Aly *et al*. (2020) reported that increase protein content of labneh when added sesame seed powder in its manufacture. Furthermore, sesame protein could be used to enrich and act as a supplement in some food especially in developing countries where protein deficiency is a major health challenge for children Morris *et al.* (2021) and Wei *et al.* (2022) where the protein in sesame is a complete protein which the ratio of essential amino acid content is very similar to that as the human body.

Table 1. TS% of yogurt fortified by (sesame seeds, flaxseeds) at fresh and during storage period.

Treatments	Storage period				
	fresh	3.days	9. days	14 days	Total
C	12.50±1.30	12.52 ±0.52	12.52±0.47	12.55±0.32	12.53 ±2.40 A
T1	15.37±0.87	15.37±0.47	15.38±1.0	15.3 9±0.72	15.37±0.98 B
T2	17.02 ±0.55	17.05±0.19	17.07±0.90	17.09±0.93	17.05±0.66 C
T3	21.50±0.13	21.51±0.15	21.51±0.17	21.53±0.12	21.52±0.21 D
T4	26.12±0.19	26.13±0.17	26.14±0.87	26.14±0.39	26.13±1.70 E
T5	14.54±0.32	14.57±0.28	14.59±0.30	14.59±0.30	14.57±0.26 B
T6	17.00±0.44	17.03±0.39	17.03±0.43	17.05±0.35	17.04±0.35 C
T7	21.00 ±0.11	21.02±4.70	21.03±0.64	21.05±0.51	21.02±2.0 D
T8	25.90±0.13	25.91±0.15	25.91±0.17	25.93±0.12	25.92±0.21 E
Total	18.91±0.96 a	18.94±2.27 a	18.95±1.0 a	18.96±1.30 a	18.94±1.49

Data means ± SD (a,b,c…etc) Means at the same row with different superscripts are different by Duncan's multiple comparison tests.

(A,B,C…etc) Means at the same column with different superscripts are different by Duncan's multiple comparison tests.

C= yogurt mad from caw's milk without any addition

T1, T2, T3 and T4 =Yogurt made with 3%,5%,10% and 15% of sesame seeds respectively.

T5, T6, T7 and T8= Yogurt made with 3%,5%,10% and 15% of flaxseeds respectively.

Table 2. Protein content of yogurt fortified by (sesame seeds, flaxseed) at fresh and during storage period.

Treatments	Storage period				
	Fresh	3.days	9 days	14 days	Total
C	2.71±0.51	2.75±0.43	2.79±0.20	2.79±0.22	2.85±0.33 A
T1	3.24±0.07	3.30±0.14	3.31±0.12	3.31±0.23	3.28±0.40 AB
T2	3.50±0.18	3.50±0.27	3.52±0.23	3.53±0.23	3.51±0.22 B
T3	4.56±0.00	4.57±0.28	4.57±0.54	4.58±0.49	4.57±0.51 C
T4	5.44±0.79	5.46±0.68	5.48±0.70	5.48±1.10	5.47±0.79 DE
T5	3.51±0.31	3.51±0.29	3.53±0.29	3.54±0.29	3.52±0.25 B
T6	4.00±0.46	4.01±0.46	4.03±0.48	4.04±0.45	4.02±0.42 BC
T7	5.01±0.12	5.03±0.12	5.03±0.08	5.10±0.05	5.04±0.09 D
T8	6.22±0.70	6.23±0.70	6.25±0.75	6.25±0.69	6.23±0.62 E
Total	4.12±0.75 a	4.25±0.75 a	4.27±0.72 a	4.49±0.86 a	4.28±0.77

Fat content

Fat contents of different treatments of yogurt samples are shown in Table (3). The present data reveals that, the fat content significantly increased with added sesame seeds (ss) and Flaxseeds (fx). The highest values were found in functional yogurt fortified with (sesame seeds and flaxseeds) compared with control yogurt. In addition, fat content increased as the proportion of powder seeds increased among different treatments and during storage period. This could be due to the fact that (sesame seeds and flaxseeds) had high fat content (Nzikou *et al.,* 2009 and Mueller *et al.,* 2010).

Ash content

From data in Table (4), it was observed that the ash content in fresh control was (1.00), while, in functional yogurt fortified ranged from (1.11 to 1.40) and (1.14 to 1.55) % for yogurt fortified with sesame seed and flaxseed respectively. All functional yogurt characterized by its high ash content compared to control. This may be attributed to high ash content in sesame seeds (3.16) % and flaxseed (3.47) %. The storage period didn′t significantly affected the ash content of all yogurt treatments. Whereas, there are significant differences in control and between all yogurt treatments as a result of the type of the seeds and added (Anonymous, 2001 and Mueller *et al*., 2010). The obtained results are in agreement with Romeih *et al*. (2014) and Aly *et al*. (2020) who reported that ash contents increased significantly as increasing the ratio of supplementation with sesame seeds and as the storage period progressed.

Carbohydrates content and Nutritive value

The nutritional values were evaluated as per the formula used by Nile and Khobragade (2009). Nutritive value= (9× percentage of fat) + (4×percentage of protein) + (4× percentage of carbohydrate) kcal/100g.

Data shown in Table (5) illustrate the effect of fortification of yoghurt with (sesame seeds, flaxseed) on carbohydrates and nutritive value. The results revealed that the nutritive value increased for all fortified yogurt treatments as compared with yogurt control, which yogurt control had the lowest value (60.96), while the highest value for yogurt fortified with 15% sesame seeds.

Table 3. Fat content of yogurt fortified by sesame seeds and flaxseed at fresh and during storage period.

	Storage period				
Treatments	**fresh**	**3.days**	**9. days**	**14 days**	**Total**
C	3.00±0.01	3.01±0.01	3.02±0.05	3.02±0.01	3.01±0.02 A
T1	4.00±0.02	4.01±0.01	4.01±0.01	4.03±0.01	4.01±0.01 B
T2	5.15±0.05	5.16±0.02	5.16±0.01	5.17±0.02	5.16±0.02 C
T3	7.22±0.10	7.23±0.05	7.24±0.10	7.24±0.10	7.23±0.08 D
T4	9.90±0.05	9.91±0.05	9.93±0.02	9.95±0.10	9.92±0.06 E
T5	3.61±0.10	3.62±0.10	3.63±0.11	3.63±0.10	3.62±0.10 AB
T6	4.20±0.00	4.20±0.23	4.21±0.10	4.22±0.05	4.21±0.09 B
T7	6.46±0.10	6.47±0.005	6.48±0.22	6.48±0.20	6.47±0.14 CD
T8	8.05±0.11	8.07±0.00	8.08±0.21	8.11±0.10	8.07±0.10 E
Total	5.17±0.05 a	5.18±0.06 a	5.19±0.09 a	5.20±0.07 a	5.18±0.067

Table 4. Ash content of yogurt fortified by sesame seeds and flaxseed at fresh and during storage period.

	Storage period				
Treatments	**fresh**	**3.days**	**9. days**	**14 days**	**Total**
C	1.00±0.01	1.00±0.00	1.02±0.13	1.04±0.12	1.01±0.16 A
T1	1.11±0.24	1.14±0.22	1.18±0.23	1.19±0.11	1.16±0.18 B
T2	1.20±0.35	1.21±0.34	1.22±0.33	1.23±0.15	1.21±0.27 C
T3	1.35±0.08	1.35±0.03	1.36±0.23	1.37±0.00	1.35±0.05 D
T4	1.40±0.08	1.43±0.03	1.45±0.23	1.45±0.00	1.43±0.23 E
T5	1.14±0.16	1.15±0.17	1.18±0.16	1.19±0.15	1.16±0.14 B
T6	1.22±0.05	1.23±0.06	1.23±0.06	1.25±0.19	1.23±0.12 C
T7	1.35±0.14	1.36±0.02	1.37±0.11	1.37±0.19	1.36±0.11 D
T8	1.55±0.10	1.56±0.05	1.57±0.19	1.58±0.52	1.56±0.40 E
Total	1.25±0.83 a	1.27±0.83 a	1.28±0.82 a	1.29±0.85 a	1.27±0.83

Table 5. Carbohydrates content and nutritive value of yogurt fortified by sesame seeds and flaxseed.

Treatments	C	T1	T2	T3	T4	T5	T6	T7	T8
Carbohydrates (g /100g)	5.80	7.02	7.12	8.08	8.92	6.29	7.40	8.03	9.81
Nutritive value (kcal/100g)	61.00	78.61	88.83	115.54	146.46	71.20	83.40	110.18	136.12

C=yogurt mad from caw's milk without any addition

T1, T2, T3 and T4 =Yogurt made with 3%, 5%, 10% and 15% of sesame seeds respectively.

T5, T6, T7 and T8= Yogurt made with 3%, 5%, 10% and 15% of flaxseeds respectively.

The nutritional value of yogurt fortified with oilseeds increases due to increase the percentage of protein, carbohydrates, fats and mineral salts in these seeds, and also depending on the increase in the percentages of seeds added.

pH values

Results from Fig. (1) reveals that the pH value of fresh yogurt ranged from (4.61 to 4.74) for all treatments then as storage progressed the pH values decreased gradually to reach of (4.55 to 4.68) by the end of storage period. There were remarkable changes in pH values in all treatments, for as the percentage of seeds increased the pH value slightly decreased for yogurt fortified with flaxseeds this was much pronounced in T5 (4.74) and T8 (4.65). The decrease in pH is probably due to lactose fermentation during storage (Bialasová *et al*., 2018).

Rheological properties of yogurt fortified by (sesame seeds and flaxseed)

Viscosity value

Data presented Fig. (2) show that yogurt fortified with (Sesame seed and Flaxseed) recorded highest value of viscosity either in fresh and at the end of storage period. The low viscosity value in T1 (control), is due mainly to the lower TS and Protein content. These results are in agreeing with that obtained by Salem *et al.* (1998) and Salem (2001). While the highest viscosity value in all functional yogurts due to the higher content of protein (Lee and Lucey, 2010) who reported that the physical and sensory properties of yoghurt gels are greatly influenced by the total solids content of the yoghurt milk, especially the protein content and fiber.

Wheying off (syneresis) values

Data in Fig. (3) illustrated that functional yogurt fortified with sesame seed and flaxseed revealed that no whey off when fresh and after 14 days except T1 and T2 (fortified with 3% and 5% of sesame seeds) respectively expelled very little amount of whey at the end of storage period (14 days). From the same data, one can easily have detected significant differences in wheying off values between control yogurt and other functional yogurt treatments. Also, significant differences were found between control and T1 and T2 during storage period. Furthermore, it is clear from these data the increase of protein content in functional yogurt treatments played a good role in decreasing the amount of whey expelled in these treatments. These results are in according with Alomery (2018). In addition, flaxseeds and sesame seeds are rich source of dietary fiber, which has a role in improving the structural properties and increasing the ability to blind water and thus reduce the amount of whey expended in functional yogurt (Mousavi *et al.*, 2019).

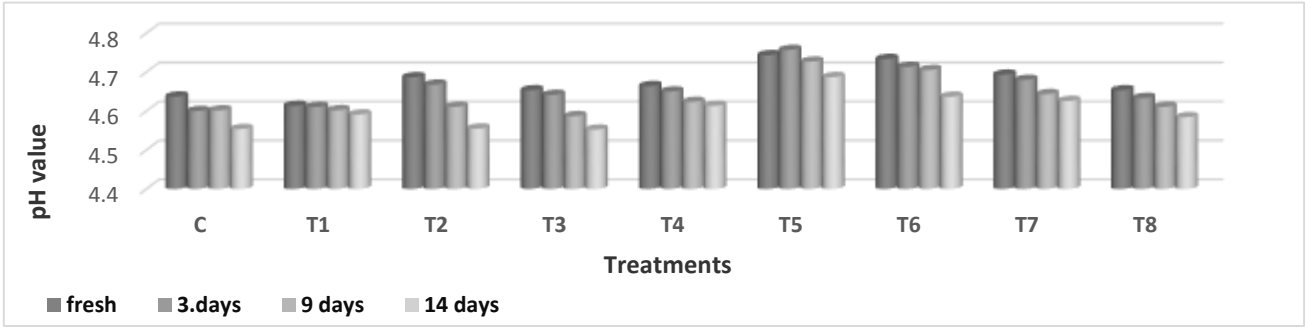

Fig. 1. pH value of yogurt fortified with sesame seeds and flaxseed at fresh and during storage period.

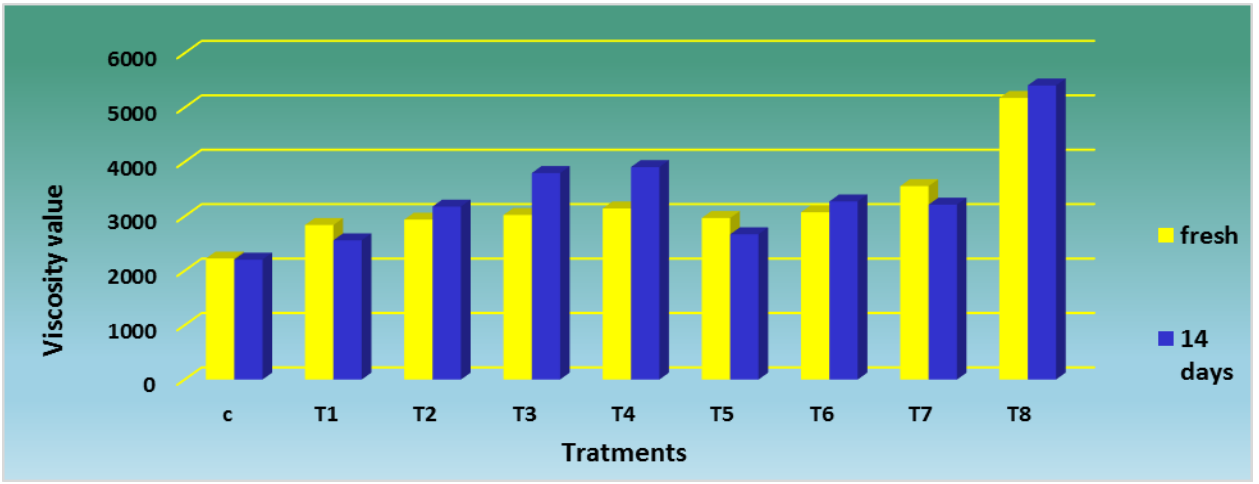

Fig. 2. Viscosity value of yogurt fortified by sesame seeds and flaxseed at fresh and at the end of storage.

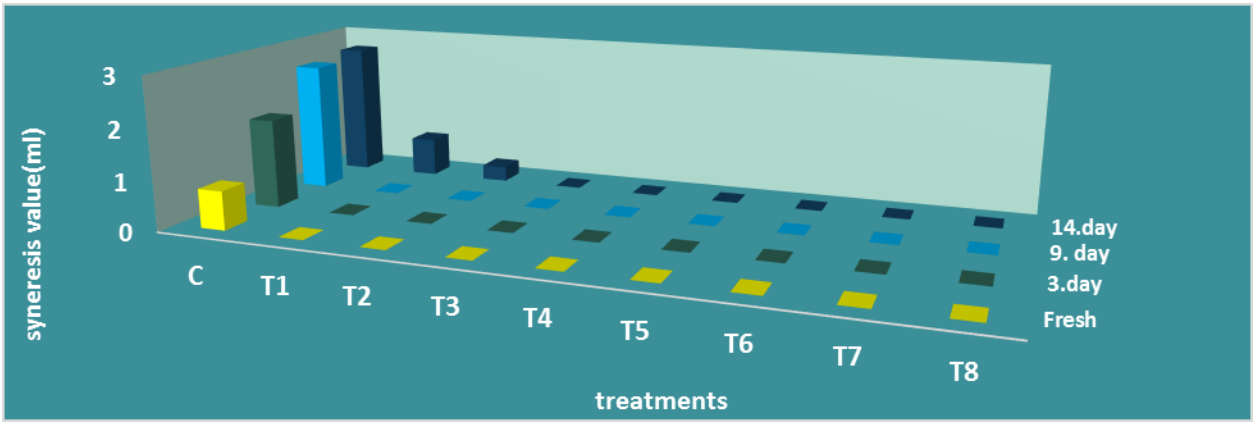

Fig. 3. Syneresis value (ml) of yogurt fortified by oil seeds (sesame seeds and flaxseed) at fresh and during storage period.

Texture properties

Some textural properties (firmness, consistency, gumminess and viscosity at 18°C) of the oily seeds fortified set-type yoghurts at fresh and at the end of storage period (14 days) were determined. Table (6) showed that oily seeds generally caused a significant difference in the textural values of the yoghurt samples compared to the yogurt control.

Firmness: The use of sesame seeds led to an increase in the firmness of yogurt compared to the control, and by increasing the used proportions of sesame, the firmness values also increased, as (T4) a sample of yogurt fortified with 15% of sesame seeds gave the largest value compared to the control .On the other hand, the use of flax seeds led to a decrease in the firmness values, as it gave T5, T6 andT7 values (148.24, 179.33 and 225.92) N respectively, compared to the control sample, this is due to flaxseeds which have an excellent effect in improving the texture of yogurt (Basiri *et al*., 2022).

Consistency: Results revealed that the use of flax seeds led to a decrease in the consistency values as compared with control and other treatments, which (3840.91, 4181.67, 4449.07, 4897.15) for T5, T6, T7 and T8 respectively, while the use of sesame seeds led to an increase in the consistency which, given the highest value of consistency as compared with control and the other treatments. On the other hand, there was a significant increase at the end of the storage period after 14 days for all treatments, these results are agreement with Bulut *et al*. (2021).

Gumminess: Data obtained from Table (6) showed that T4 had the highest cohesiveness value (487.78) when compared to all yogurt treatment, while T5 had the lowest cohesiveness value (99.50) as compared with other treatments. For all treatments at the end of storage the cohesiveness value was increased, these results are agreement with Bialasová *et al*. (2018).

Table 6. Texture properties value of yogurt fortified by sesame seeds and flaxseed at fresh and at the end of storage.

Treatments		Firmness(N)	Consistency	Gumminess
C	F.	240.77 ^{b}	5966.89 ^{d}	141.79 ^{a}
	14 D	281.50 ^{CD}	7152.60 ^{D}	179.50 ^{B}
T1	F.	591.66 ^{d}	13312.15 ^{e}	367.05 ^{c}
	14 D	702.40 ^{E}	15981.6 ^{E}	448.90 ^{D}
T2	F.	661.05 ^{e}	13349.30 ^{e}	459.31 ^{d}
	14 D	782.80 ^{F}	16022.60 ^{E}	558.90 ^{E}
T3	F.	678.04 ^{e}	13568.20 ^{ef}	468.78 ^{d}
	14 D	789.50 ^{EF}	16289.80 ^{F}	563.90 ^{EF}
T4	F.	693.24 ^{f}	13776.13 ^{f}	487.78 ^{d}
	14 D	799.90 ^{F}	16989.90 ^{G}	592.50 ^{F}
T5	F.	148.24 ^{a}	3840.91 ^{a}	99.50 ^{a}
	14 D	174.69 ^{A}	4601.68 ^{A}	120.99 ^{A}
T6	F.	179.33 ^{a}	4181.67 ^{a}	138.48 ^{a}
	14 D	218.98 ^{B}	5011.98 ^{B}	169.58 ^{B}
T7	F.	225.92 ^{b}	4449.07 ^{b}	179.48 ^{ab}
	14 D	250.40 ^{C}	5200.50 ^{BC}	267.80 ^{C}
T8	F.	269.11^{c}	4897.15 ^{c}	247.21 ^{b}
	14 D	311.69 ^{D}	5464.40	288.85 ^{CD}

Mineral contents (Fe, Cu and Zn) %

In foods mineral elements are present as salt. They combined with organic compound, e.g. iron in hemoglobin. Minerals are required for the teeth and bone formation. Minute amount of mineral elements are constituent of various regulatory compounds such as, vitamins, enzymes and hormones. For example, some enzymes require calcium for their activity as lipases and succinate dehydrogenases. Iron requiring enzymes are ferredox in catalase, indophenol oxidase, aldehyde oxidase etc. the mineral elements present in the intra and extra cellular fluid maintained water and acid-base balance. They regulate transmission of impulses and contraction of muscles. The deficiencies of minerals create many diseases in human beings (Habib *et al*., 2015). Contains pure substances in red blood cells. It plays a role in metabolic processes, maintaining connective tissue health. It is also necessary to maintain normal energy and energy levels and vitality in order to keep the hormones in balance.

The body is unable to produce copper on its own. Therefore, it must be obtained from the foods eaten. Considering that the body consumes copper frequently. So it is necessary to rely on eating foods rich in copper, this is available in many foods. It is found in meat, seafood, nuts, and seeds such as sesame seeds and chia seeds, whole grains, chickpeas, cocoa, avocados, and raisins.

Zinc is an essential trace element that plays a role in growth, tissue repair and wound healing, intestinal mucosal integrity, synthesis of testicular hormones, and the immune response. Zinc intake is closely related to protein intake; as a result, zinc deficiency is an important component of nutritionally related morbidity worldwide. Symptoms attributable to severe zinc depletion include primary hypogonadism, diarrhea, growth failure, skin disease, impaired taste and smell, and impaired immunity and resistance to infection. Zinc supplementation or food fortification in populations at risk for zinc deficiency appears to have beneficial effects on the incidence and outcome of serious childhood infectious diseases. The recommended dietary allowance (RDA) for zinc ranges from 2 mg/day in young infants to 9 mg/day in adolescent females and 11 mg/day in adolescent males (Abrams, 2020).

The (RDA) is Recommended Dietary Allowance, Average daily level of intake sufficient to meet the requirements of nearly all (97 – 98 %) healthy individuals often used to plan nutritionally adequate diets for individuals. As the RDA of iron % is (10 mg per day), intake of 100g of fortified yogurt with oilseeds as a source of iron necessary to have a bout meet as quarter of RDA. This was pronounced in all treatments especially in T8 and T4.

Data presented determination of (Fe, Zn and Cu) in Table (7) reveled that there were significant differences between control and other treatments in iron % and

RDA. By increasing the percentage of seeds, the Fe, Cu and Zn% increased in all treatments. This trend was much pronounced for iron in T8 (1.49), and T4 (1.62) and the lowest value was (0.03) for control. This is due to the iron content of both flaxseeds and sesame seeds, which contain (7.3 – 9.7) % of iron respectively (Khalaf *et al*., 2019).

Antioxidant activity by DPPH%

It is clear from these data in Fig. (4) that functional yogurt fortified with flaxseeds had highest of antioxidant activity ranged from (7.07 to 9.87) according to added percentage, followed by functional yogurts fortified with sesame seeds which ranged from (6.21 to 8.52) according to added percentage (Abd El-Hak *et al.*, 2016). While, control yogurt recorded lowest value of antioxidant activity (2.55). These results are according with Bialasová *et al*. (2018) and Marand *et al.* (2020) who reported that antioxidant activity of flaxseed-enriched yogurts was significantly higher than that of the control sample.

Thiobarbituric Acid (TBA) values

Data presented in Table (8) Showed the effect of plant seeds fortification on oxidant fat in yogurt treatments at the end of storage period (14 days). The differences in TBA value of yogurt treatments are not clear. The TBA value of fortified yogurt treatments T4 and T7 were closed to control, while fortified yogurt with 15% flaxseed (T8) recorded a slight increase in TBA value.

On the other hand, yogurt fortified with 10% sesame (T3) recorded a slight decrease compared with control and other treatments. These are agreement with Kaur and Saini (2000) who reported that sesame seeds increases cell resistance to lipid peroxidation (LPO) and it has been suggested that sesame found in Sesame Oil (SO) enhances hepatic detoxification of chemicals and reduces the incidence of chemically induced mammary tumors.

Sensory evaluation

Appearance During the storage period the fortification of yogurt with SS and FS in treatments (T1, T2) for sesame seeds and (T6, T7) for flaxseeds which improved the appearance of the yogurt since the product became homogeneous without wheying off.

Table 7. Mineral content of yogurt fortified by sesame seeds and flaxseed.

Treatment	Iron		Cu%	Zn %
	%	RDA%		
C	0.03±0.05 ^{A}	0.300	0.159±0.01 ^{A}	0.165±0.10 ^{A}
T1	0.39±0.10 ^{B}	3.9	0.19±0.0 ^{AB}	0.258±0.0 ^{B}
T2	0.58±0.12 ^{C}	5.8	0.20±0.0 ^{B}	0.294±0.0 ^{BC}
T3	1.09±0.16 ^{DE}	10.9	0.22±0.0 ^{BC}	0.494±0.1^{D}
T4	1.62±0.13 ^{EF}	16.2	0.28±0.01 ^{C}	0.652±0.2 ^{E}
T5	0.342±0.40 ^{B}	3.42	0.187±0.0 ^{AB}	0.241±0.01 ^{B}
T6	0.442±0.07 ^{BC}	4.42	0.194±0.0 ^{AB}	0.308±0.01 ^{C}
T7	0.876±0.31 ^{D}	8.76	0.292±0.0 ^{C}	0.346±0.02 ^{C}
T8	1.49±0.01 ^{E}	13.81	0.311±0.0 ^{D}	0.39±0.02^{CD}

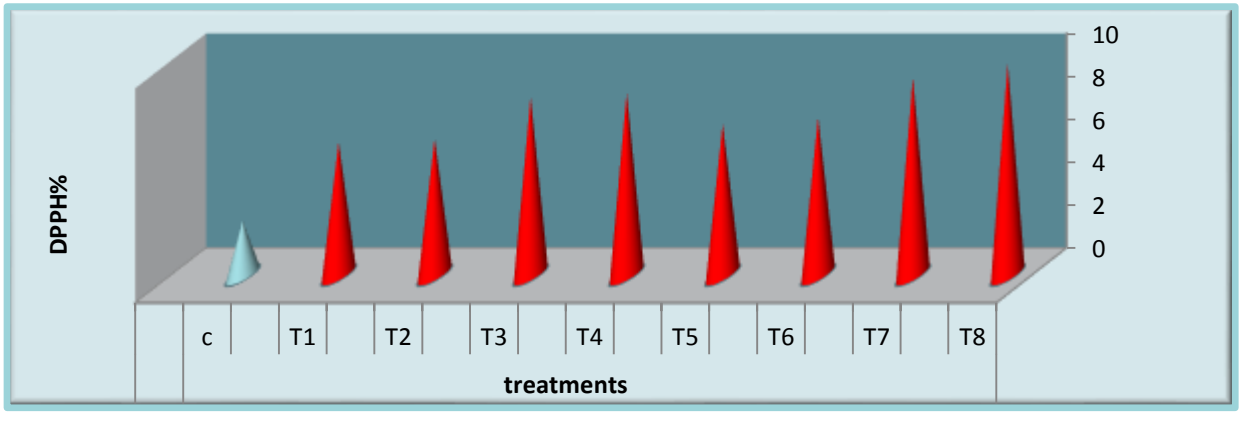

Fig. 4. Antioxidant activity by DPPH% of yogurt fortified by sesame seeds and flaxseed.

Table 8. TBA % of yogurt fortified by sesame seeds and flaxseed at the end of storage.

Treatments	TBA %
C	0.47
T3	0.43
T4	0.47
T7	0.49
T8	0.52

Table 9. Sensory evaluation of yogurt fortified by sesame seeds and flaxseed at fresh and during storage period.

Treatments	Storage period	Appearance (10)	Flavor (10)	Texture (10)	Consistency (10)	Overall acceptable (10)
C	F.	8.67±0.50	9.00±0.0	8.00±1.00	7.33±0.57	8.00±0.0
	7	8.33±0.57	8.33±0.57	7.33±0.57	6.6667±0.57	7.00±0.57
	14	7.33±0.57	7.00±0.57	6.66±0.57	6.00±1.0	6.33±0.57
	total	8.11±0.871 E	8.11±0.92 F	7.33±0.86 BCDE	6.67±0.866 A	7.10±0.86 CD
T1	F.	8.67±0.57	7.6±0.57	8.33 ±0.57	7.33±0.57	8.33±0.57
	7	7.66±0.57	7.0±0.00	8.00±0.00	6.67±0.57	8.00±1.00
	14	6.66±0.57	6.67±0.57	8.00±0.00	6.00±1.0	8.00±1.00
	total	7.67±1.0 CDE	7.1±0.60 BCD	8.11±0.33 F	6.67±0.86 A	8.11±0.781 E
T2	F.	8.67±0.57	8.33±0.57	9.00±0.0	7.67±0.57	9.00±0.00
	7	7.33±1.1	8.00±.0.00	8.00±.00	6.67±0.57	8.67±0.57
	14	7.67±0.57	7.33±1.15	7.00±1.0	6.67±0.00	7.33±0.57
	total	7.89±0.92 CDE	7.88±0.78 EF	8.00±1.00 EF	7.00±0.707 BC	8.33±0.86 E
T3	F.	7.67±0.57	7.67±0.57	9.00±0.0	8.33±0.577	7.33±0.57
	7	7.67±0.57	6.67±0.57	8.000±0.0	7.67±0.57	6.67±0.57
	14	6.67±0.57	6.00±1.00	7.00±1.00	6.33±0.57	5.67±0.57
	total	7.33±.70 BCD	6.78±.91 AB	8.00±1.00 EF	7.44±1.0 CD	6.55±.88 ABC
T4	F.	7.67±0.57	7.00±0.00	8.33±0.57	9.00.±0.0	6.67±1.15
	7	7.33±0.577	6.33±0.57	7.33±0.57	7.67±0.57	6.67±0.57
	14	6.00±0.00	5.33±0.57	7.00±1.00	6.67±0.577	5.67±0.57
	total	7.00±0.86 AB	6.22±0.83 A	7.56±0.8 CDE	7.78±1.0 D	6.33±0.86 AB
T5	Fr	8.33±0.577	8.33±0.57	8.00 ±1.0	7.00±1.0	8.33±0.57
	7	8.00±1.00	7.00±.0.0	8.33±0.57	6.66±0.57	8.00±1.0
	14	8.00±1.00	7.33±1.1	7.667±0.57	6.33±0.57	8.00±1.0
	total	8.11±0.78 E	7.56±0.78 DEF	8.00±0.70 EF	6.67±0.70 A	8.11±0.78 E
T6	Fresh	8.33±0.57	7.67±0.57	7.67±0.5	8.66±0.57	8.00±0.00
	7	8.00±0.0	6.67±1.1	7.33±1.1	6.667±0.57	7.67±0.57
	14	7.67±0.57	6.33±0.57	7.00±0.0	6.33±1.1	7.33±0.57
	total	8.00±0.50 E	6.88±0.92 BC	7.33±0.86 BCDE	7.22±1.3 BCD	7.66±0.86 CD
T7	Fresh	7.67±0.57	7.33±0.57	7.33±1.15	7.67±0.577	8.00±0.00
	7	7.33±0.57	7.00±0.00	7.67±0.57	7.33±0.57	6.67±0.57
	14	7.00±0.00	6.33±0.57	7.00±0.00	6.67±0.57	6.33±0.57
	total	7.33±0.50 BCD	6.89±0.60 BC	7.33±0.707 BCDE	7.22±0.66 BCD	7.00±0.86 CD
T8	Fresh	7.67±.1.15	7.67±0.57	6.67±0.57	7.67.±1.5	7.33±0.57
	7	6.33±0.57	7.0±1.0	6.33±0.57	7.67±0.57	6.3±0.57
	14	5.67±0.57	5.33±0.57	5.33±0.57	7.0±1.0	6.0±1.0
	total	6.56±1.1 A	6.67±1.2 A	6.11±0.78 A	7.44±1.0 CD	6.55±1.2 BC
Total	Fresh	7.67±0.57 c	7.00±0.00 c	8.33±0.57 c	8.33±0.57 c	7.33±0.57 c
	7	7.33±0.57 bc	6.33±0.57 b	7.33±0.57 ab	7.67±0.57 b	6.67±0.57 b
	14	6.0±0.00 a	5.33±0.57 a	7.00±1.0 a	6.33±0.57 a	5.67±0.57 a
	total	7.00±0.86	6.22±0.83	7.56±0.88	7.44±1.0 AB	6.56±0.81 AB

Flavor Results revealed that there was significant difference between control and other treatments, which (T1 &T2) had the highest value. For control and all treatments during the storage period there were significant difference. Texture Significant differences were observed in texture value in yogurt fortified with sesame or flaxseed when compared to control. Texture values were increased in T2 followed by T1 and T7, these results are in line with Basiri *et al*. (2022). Consistency For all treatments there were significant differences, as the percent of oil seeds increased, the value of consistency increased, which T4, T8 had the highest value (9.00, 8.33) followed by T3, T7 (8.333, 7.6667). Overall acceptable Results revealed that there were significant differences between control and other treatments, which the high score for sesame seeds was (8.333, 8.111) for T2 &T1, these result are according with Aly *et al*. (2020) and Marand *et al.* (2020) who reported that the additives improved Labneh microstructure quality and developed the organoleptic properties especially the appearance, flavor and texture. Generally, it could be recommended that adding 4 % sesame seeds powder in making Labneh had the greatest overall acceptability, but higher levels of sesame powder applied resulted in reduced product acceptability (Table 9).

Microbiological analysis

From Table (10) it is clear that the growth of yeasts and molds was not observed in the different fresh yoghurt control and the other treatments, but they appeared and increased until the end of storage, these findings are in approval with those of Shan (2000). The results obtained for the total number of bacteria (TBC) in all the yoghurt treatments increased gradually until 14, days. However, yoghurt fortified with 3% of sesame seeds had the highest count while, yoghurt fortified made with 5% of sesame seeds had the lowest count. The obtained results suggest that the bacterial populations were inhibited by sesame seeds. These results are in line with Fitrotin *et al.* (2015).

CONCLUSION

From this study, the best results were obtained with yogurt fortified with 10% sesame seeds, 15% flaxseeds, (10 and 15%) pumpkin seeds, and 15% watermelon seeds. These treatments are characterized by high ratio of iron needed to fill approximately (13.5 to 16.5%) of the body's daily needs from iron as well as fortifying elements and minerals such as (zinc and copper), and it also improved the nutritional value of the control yogurt by increasing the proportion of protein, fats, and carbohydrates, due to the high effect of these seeds as antioxidants, and it also works to reduce the values of fat oxidation, and improve the texture and cohesion values of yogurt.

Table 10. Microbiological analysis of yogurt fortified by (sesame seeds &flaxseeds) at fresh and the end of storage.

Treatments	Storage period	Yeasts&Molds (log_{10} CFU/ml)	(TBC) (log cfu/ml Mean±SD	
C	F	0.0±0.0	9.49±0.12	9.5±0.11^{b}
	14.days	2.0±0.12^{a}	9.51±0.10	
T1	F	0.0±0.0	7.39±0.12	7.40±0.06^{a}
	14.days	1.47±0.01^{a}	7.44±0.20	
T2	F	0.0±0.0	7.32±0.0	7.36±0.06^{a}
	14.days	1.60±0.10^{a}	7.41±0.12	
T3	F	0.0±0.0	7.30±0.11	7.34±0.16^{a}
	14.days	2.30±0.12^{ab}	7.39±0.21	
T4	F	0.0±0.0	7.17±1.1	7.22±0.60^{a}
	14.days	2.30±0.03^{ab}	7.27±0.20	
T5	F	0.0±0.0	7.60±0.12	7.62±0.11^{ab}
	14.days	2.30±0.12^{ab}	7.65±0.10	
T6	F	0.0±0.0	7.54±1.0	7.57±0.60^{ab}
	14.days	2.47±0.21^{b}	7.61±0.20	
T7	F	0.0±0.0	7.47±0.0	7.51±0.15^{ab}
	14.days	2.47±0.24^{b}	7.56±0.31	
T8	F	0.0±0.0	7.47±0.20	7.45±0.16^{a}
	14.days	2.69±0.20^{b}	7.44±0.12	

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الملخص العربي

تعزيز القيمة الغذائية لزبادي من خلال التدعيم ببعض بذور السمسم وبذور الكتان

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تم صنع الزبادي بالتحصين ببعض البذور الزيتية (بذور السمسم ss والكتان fx) بنسب مختلفة (٣، ٥، ١٠ و١٥%) للجميع. تعزيز ss و fx كان له تأثير كبير على قيمة pH ونسبة الحموضة وقيمة اللزوجة وحسن خصائص القوام، مما قلل من انفصال مصل اللبن عن الزبادي. إنه يعزز القيمة الغذائية، مما زاد من TS عبر البروتين، الدهون، ومحتوى المعادن. الخصائص الحسية لجميع المعالجات الطازجة كانت الأعلى قبولاً بعد ٣ و٩ أيام من التخزين. أشارت النتائج إلى أن بذور السمسم وبذور الكتان تُعتبران مصدراً جيداً للعناصر الغذائية في النظام الغذائي وقد يكون لهما فوائد صحية واقتصادية بسبب محتواهما من الألياف والمعادن وتأثيرهما الكبير في النشاط المضاد للأكسدة.

الكلمات المفتاحية: الزبادي، بذور السمسم، بذور الكتان، القيمة الغذائية، التدعيم، نسبة الحديد.