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QUALITY ASSESSMENT OF YOGURT ENRICHED WITH OAT AND CHICKPEA POWDERS AS SOURCE OF DIETARY FIBERS

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ABSTRACT: The aim of this study was to evaluate the effect of addition of oat and chickpea powders on the rheological, physicochemical and sensory characteristics of yogurt. Yogurt was fortified with oat and chickpea powders at ratios of 1, 2 and 3% of each. Yogurt was stored at 5 ±2˚C and analyzed when fresh and after 5, 10 and 15 days of storage. Results showed that: Control yogurt had the lowest total solids (TS), fat, protein, ash and fibers contents compared with fortified yogurt treatments. The TS, fat ,protein, ash and fibers contents of yogurt containing oat and chickpea powders at different concentrations increased gradually by increasing the percentage added, Addition of oat and chickpea powders at different concentrations increased the pH in yogurt. Whereas, titratable acidity decreased with increased fortification ratio. Fortification of yogurt with oat and chickpea powders at different concentrations significantly decreased whey syneresis and increased viscosity compared with control yogurt and this increasing was proportional to the fortification ratio. Addition of oat and chickpea powders at different concentrations significantly increased phenolic contents and antioxidant activity of yogurt treatments and these increments were proportional to the fortification ratio. Yogurt treatments fortified with oat and chickpea powders at different concentrations had the lowest counts of total bacteria, yeast and moulds,*Streptococcus salivarius subsp. thermophilus* and *Lactobacillus delbruekii subsp. bulgaricus*counts. Total bacteria, yeast and moulds,*Streptococcus salivarius subsp. thermophilus* and *Lactobacillus delbruekii subsp. bulgaricus*counts decreased with increasing the fortification ratio. Control yogurt had the lowest sensory evaluations values. Addition of oat and chickpea powders improved the organoleptic properties of fortified yogurt; the highest mean value was related to sample containing 3% oat powder.

Key words: Yogurt, oat, chickpea powders, dietary fibers.

INTRODUCTION

Yogurt is one of the most consumed healthy and nutritious foodstuff worldwide (**Shi *et al*., 2017; Zhi*et al*., 2018)**. Yogurt has a better digestibility of proteins than milk and many latent positive effects on health by providing the human body prebiotic and probiotic bacteria. Additionally, by incorporating fibers in yogurt, researchers have achieved a mean of increased fibers consumption in all sectors of the populace and they have developed a functional food with an extensive array of beneficial effects. Several studies reported prebiotic fortification by adding dietary fibers in yogurt. Consumption of high fiber yogurt may prevent or reduce obesity, diabetes, cancer, hypercholesterolemia, gastrointestinal disorders, colonic diverticulosis and constipation, ulcerative colitis, hyperlipidemia, hypertension, coronary artery disease, but also promote intestinal microflora and gastrointestinal immunity (**Dello*et al*, 2017; Tomic*et al*., 2017**).

Since it is known that a lack of fibers in the diet can be the cause of many nutrition-associated illnesses, the European Food Safety Authority (EFSA) has been forced to recommend

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an average daily fibers intake of 25 g (**EFSA, 2010**). Fibers are found in the cell wall of vegetables, fruits or cereals. They include polysaccharides (pectins, cellulose and hemicelluloses) and lignin. Although both soluble and insoluble fibers are available, usually the insoluble fibers are used with food fortifying intents (**Tejada-Ortigoza*et al*, 2016: Dönmez*et al.*, 2017**).

Many researchers reported that the rheological properties of yogurt are affected differently depending on the type of fiber source (**Luana *et al*., 2014; Raju and Pal, 2014).** The role in increasing the water holding capacity, in stabilization of high fat yogurt, in enhancing viscosity characteristics the gel forming ability are properties of fibers that allow the development of fiber-enriched yogurt with improved texture and reduced syneresis (**DelloStaffolo *et al*., 2017; Balthazar *et al*., 2016)**.

Oat (*Avena sativa* L.) and oat products are a good sources of vitamin E, polyunsaturated fatty acids, soluble dietary fiber, β-glucan, and their consumption in the human diet is beneficial to human well-being (**Tiwari and Cummins, 2011; Singh *et al*., 2013).**Oat fibers (containing β-glucan, an indigestible polysaccharide) were proven to increase immunity, to improve anticancer activity and lower blood cholesterol, lipids and blood glucose. Adding oat fibers in yogurt fostered the creation of a good fermented product, with insignificant drop in flavour quality and only a minor decline in texture quality **(Khanna and Mohan, 2016)**.

Chickpea (*Cicerarietinum* L) is one of the most consumed legumes worldwide. Among their benefits are the high protein concentrations that reflect not only at the nutritional level but also on the supply of active peptides; besides, it represents different metabolites with pharmacological activities (**Chang *et al*., 2009).** Some biological activities identified in the different compounds of chickpea are antioxidant, antihypertensive, hypocholesterolemic, and anticancer (**Ghribi *et al*, 2015**). Although most reports are based on the effect of proteins and their hydrolysates, alcoholic extracts have also been proven that contain phenolic compounds, saponins, phytates, among others; therefore, their consumption has been dubbed as an alternative for the prevention of chronic degenerative diseases (**Faridy*et al*., 2020**).

The aim of this study was to evaluate the effect of the addition of two types of fibers sources (oat and chickpea powders) on the rheological, physicochemical and sensory characteristics of yogurt.

MATERIALS AND METHODS

Materials

Milk

Fresh buffalo's standardized milk (3% fat) was obtained from Dairy Technology Unit, Food Science Department, Faculty of Agriculture, Zagazig University, Egypt.

Preparation of oat and chickpea powders

Oat and chickpea were purchased from local market at Zagazig; the seeds were cleaned and rendered free of dust, dirt, foreign materials and broken seed.Ground seeds were converted to the powder form, and sieved with 40, 60 mesh sizes sieves.

Starter cultures

Streptococcus salivarius subsp. thermophilus EMCC104 and *Lactobacillus delbruekii subsp. bulgaricus*EMCC1102were obtained from the Microbiological Resources Center (MIRCEN), Faculty of Agric. Aim Shams Univ., Egypt.

Methods

Manufacture of yogurt

Fresh bulk buffalo's milk containing 3% fat was used in the preparation of yogurt and served as a control (C). Buffalo's milk (3% fat) was divided into 6 equal portions. Oat powder was added to three portions at the rate of 1, 2 and 3% (T1, T2 and T3). Chickpea powder was added to the other three portions at rate of 1, 2 and 3% (T4, T5 and T6). Each milk treatments were homogenized and heated to 90˚C for 15 min., then, cooled to 42 ± 1˚C, inoculated with 2% of yogurt starter cultures, filled in plastic cups and incubated at 42˚C until a uniform coagulation was obtained. The yogurt samples of all treatments were stored at 5± 2˚C and analyzed when fresh and after 5, 10 and 15 days of storage. All treatments were carried out intriplicates.

Chemical analysis

Total solids, fat, ash, crude fiber total protein (TN) contents, titratable acidity and dietary fiber of yogurt samples were determined according to **AOAC (2007)**. The changes in pH values of yogurt samples during storage were measured using a laboratory pH meter with glass electrode (HANNA, Instrument, Portugal).

Rheological measurements

The viscosity and released whey of yogurt samples were measured according to the method of **Aryana (2003).** The quantity of whey collected from every sample in graduated cylinder after 2 h of drainage at 20˚C was used as an index of syneresis. Viscosity of yogurt samples was determined using Rotational Viscometer Type Lab. Line Model 5437.

Sensory evaluation

The sensory properties of yogurt samples were assessed by 10 panel members of the Dairy Sci., Dep., Fac. Agric., Zagazig, Univ. for flavour (60) body and texture (30) and appearance (10) as reported by**Nelson and Trout (1981)**.

Determination of total phenolic content

Total phenolic content (TPC) of different extracts was measured by using UV spectrophotometer (Jenway-UV–VIS Spectrophotometer), based on a colorimetric oxidation/reduction reaction, as described by **Skerget *et al*. (2005)**. Total phenolic content expressed as gallic acid equivalent (GAE) was calculated, and the results were expressed as an mg GAE g^{-1} extract **(AOAC, 2007).**

Determination of total flavonoid content in oat and chickpea

The total flavonoid content was determined by the aluminum chloride colorimetric method according to **Lin and Tang (2007).** Quercetin was used as the reference standard and the results were milligram quercetin equivalents (mg EQ)/g.

Radical scavenging activity (Scavenging DPPH)

The electron donation ability of the obtained extracts was measured by bleaching of the purple colored solution of DPPH according to the method of **Hanato*et al*. (1988)**. The absorbance was determined against a control at 517 nm (**Gulcin*et al*., 2004).** Percentage of antioxidant activity of DPPH was calculated as follows:

DPPH scavenging effect %=((A0-A1)/A0) ×100

Where, A0 is the absorbance of the control reaction and A1 is the absorbance in the extract. Samples were analyzed in triplicate.

Microbiological analysis

Microbiological analyses were performedfor freshtreatments and after 5, 10, and 15 days of storage at 5± 2 ˚C. Total bacterial count (T.B.C) was determined using plate count agar method according to **Houghtby *et al.* (1992).** Coliform bacteria and yeast and mould counts were determined according to **Marshall (1992).** The enumeration of *Streptococcus salivarius subsp. thermophilus* was performed at 37ºC for 48hr. under anaerobic condition using M17agar (Oxoid Ltd). Counting of *Lactobacillus delbrueckii* subsp. *bulgaricus* was carried out on MRS agar (Oxoid Ltd) the plates were incubated in anaerobic condition at 42ºC for 48hr. **Rybka and Kailasaphaty (1996)**.

Statistical Analysis

Data were statistically analyzed using the general linear models procedure of the statistical analysis system **SAS (1998)**. Significances of differences were defined at $p < 0.05$.All experiments were repeated three times and all obtained data are expressed as an average.

RESULTS AND DISCUSSION

Chemical Composition of Oat and Chickpea Powders

The proximate chemicalcomposition of oatand chickpea powdersare illustrated in Table 1. The results showed that there is a difference between for each macro nutrients contents. Moisture, protein, fat, ash and fiber contents of oat powder were (8.14, 10.94, 7.80, 0.09 and 9.36 g/100g respectively. These results are in agreement with the data obtained by **Fistes *et al*. (2014).** Moisture, protein, fat, ash and fiber contents of chickpea powder were (6.34, 26.40, 6.20, 3.14 and 3.96 g/100g), respectively. These results are in agreement with the data obtained by **Wani and Kumar (2014).**

Table 1. Chemical composition, Total phenolic, flavonoid contents and radical scavenging activity of oatand chickpea powders

Chemical composition	Oat powder	Chickpea powder
Moisture (%)	8.14±0.06[a]	6.34±0.08[b]
Total protein (%)	10.94±0.11[b]	26.40±0.04[a]
Fat (%)	7.80±0.04[a]	6.20±0.06[b]
Ash (%)	4.50±0.12[a]	3.14±0.16[b]
Fiber (%)	9.36 ±0.06[a]	3.96±0.09[b]
Total phenolic content(mg/100g)	130.70±8.60[b]	270.40±12.14[a]
Total flavonoid content (mg/100g)	72.80±4.20[b]	104.26±8.32[a]
Radical scavenging activity (%)	68.86±2.22[b]	72.50±2.34[a]

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

Table 1 revealed that, the TPC of ethanolic oat and chickpea extracts were 130.70 and 270.40 mg/100g, respectively. While the TFC of ethanolic oat and chickpea extracts were 72.80 and 104.26 mg/100g, respectively. RSA (%) of ethanolic oat and chickpea extracts were 68.86 and 72.50%, respectively. These results agree with those previously reported by **Ibrahim *et al*. (2020)** for oat, **Segev*et al*. (2011)** for chickpea.

Chemical Compositionof Different Types of Fortified Yogurt

Chemical compositions of fortified yogurt samples are shown in Tables 2 and 3. Control yogurt samples had the lowest total solids (TS) and it was significantly ($P \leq 0.05$) compared with fortified yogurt treatments. The TS content of yogurt containing oatand chickpea powders at different concentrations increased gradually by increasing the percentage added, butchickpea yogurt treatments had the highest TS contents compared with others fortified yogurt treatments. The TS content of all yogurt treatments slightly increased as storage period progressed.

Control yogurt (C) had the lowest protein content. The total protein of yogurt containing oat and chickpea powders at different concentrations increased gradually by increasing the percentage added, chickpea yogurt treatments had the highest protein contents compared with others fortified yogurt treatments. The total protein of all yogurt treatments slightly increased as storage period progressed.

Supplementation of yogurt with oat and chickpea powders at different concentrations slightly increased fat contents by increasing the percentage added, oat yogurt treatments had the highest fat contents compared with others fortified yogurt treatments. The fat of all yogurt treatments slightly increased as storage period progressed.

Supplementation of yogurt with oat and chickpea powders at different concentrations slightly increased ash contents by increasing the percentage added, oat yogurt treatments had the highest fat contents compared with others fortified yogurt treatments. The of all yogurt treatments slightly increased as storage period progressed

Total fiber content of yogurt treatments increased by adding oat and chickpea powders at different concentrations and these increments were proportional to the fortification ratio, oat yogurt treatments had the highest fiber contents compared with others fortified yogurt treatments. The fiber content of all yogurt treatments slightly increased as storage period progressed. These results are in agreement with the data obtained by **Karaca *et al.* (2019) and Pérez-chabela*et al*. (2021)**.

Table 2. Total solids, fat and protein contents of different fortified yogurt types during storage period

Samples	T.S (%)				Fat (%)				Protein (%)			
	Storage period (days)				Storage period (days)				Storage period (days)			
	fresh	5	10	15	fresh	5	10	15	fresh	5	10	15
C	14.34±0.04^{f}	15.12±0.03^{f}	16.04±0.04^{f}	16.70±0.21^{f}	3.1±0.15^{c}	3.25±0.15^{c}	3.35±0.15^{c}	3.40±0.15^{c}	3.70±0.02^{e}	4.20±0.02^{e}	5.00±0.09^{e}	5.26±0.06^{e}
T1	15.20±0.02^{e}	16.03±0.03^{e}	16.92±0.12^{e}	17.65±0.14^{e}	3.20±0.10^{b}	3.34±0.10^{b}	3.40±0.10^{b}	3.48±0.10^{b}	3.80±0.03^{d}	4.36±0.02^{d}	5.14±0.05^{d}	5.38±0.08^{d}
T2	16.02±0.02^{d}	16.80±0.03^{d}	17.72±0.07^{d}	18.54±0.09^{d}	3.28±0.10^{ab}	3.42±0.10^{ab}	3.48±0.10^{ab}	3.70±0.10^{ab}	3.92±0.02^{d}	4.48±0.02^{d}	5.26±0.05^{d}	5.66±0.06^{d}
T3	16.84±0.02^{b}	17.62±0.02^{b}	18.55±0.09^{b}	19.23±0.07^{b}	3.36±0.10^{a}	3.50±0.10^{a}	3.60±0.10^{a}	3.82±0.10^{a}	4.04±0.02^{c}	4.60±0.03^{c}	5.34±1.13^{c}	5.78±0.08^{c}
T4	15.30±0.02^{e}	16.02±0.02^{e}	16.93±0.07^{e}	17.60±0.08^{e}	3.16±0.10^{cd}	3.30±0.10^{cd}	3.42±0.10^{cd}	3.50±0.10^{cd}	4.00±0.02^{c}	4.50±0.02^{c}	5.24±0.04^{c}	5.55±0.07^{c}
T5	16.22±0.02^{c}	16.92±0.02^{c}	17.85±0.06^{c}	18.54±0.06^{c}	3.22±0.10^{b}	3.36±0.10^{b}	3.48±0.10^{b}	3.55±0.10^{b}	4.26±0.02^{b}	4.78±0.03^{b}	5.50±0.57^{b}	5.82±0.08^{b}
T6	17.14±0.02^{a}	17.83±0.02^{a}	18.70±0.04^{a}	19.35±0.10^{a}	3.30±0.10^{ab}	3.42±0.15^{ab}	3.56±0.15^{ab}	3.62±0.21^{ab}	4.50±0.02^{a}	5.03±0.03^{a}	5.79±0.50^{a}	6.08±0.08^{a}

Table 3. Ash and fiber contents of different fortified yogurt types during storage period

Samples	Ash (%)				Fiber %			
	Storage period (days)				Storage period (days)			
	fresh	5	10	15	fresh	5	10	15
C	0.74±0.02^{d}	0.78±0.04^{d}	0.82±0.04^{d}	0.90±0.05^{d}	0.00±0.02^{d}	0.00±0.002^{d}	0.00±0.002^{d}	0.00±0.002^{d}
T1	0.80±0.02^{c}	0.82±0.02^{c}	0.87±0.05^{c}	0.95±0.06^{c}	0.09±0.02^{bc}	0.14±0.01^{bc}	0.20±0.02^{bc}	0.32±0.02^{bc}
T2	0.85±0.02^{b}	0.86±0.03^{b}	0.93±0.06^{b}	1.00±0.06^{b}	0.20±0.02^{a}	0.26±0.01^{a}	0.34±0.01^{a}	0.40±0.02^{a}
T3	0.90±0.02^{a}	0.90±0.03^{a}	0.98±0.05^{a}	1.06±0.06^{a}	0.28±0.01^{b}	0.35±0.01^{b}	0.42±0.02^{b}	0.50±0.01^{b}
T4	0.78±0.01^{c}	0.81±0.05^{c}	0.85±0.05^{c}	0.94±0.04^{c}	0.03±0.02^{c}	0.09±0.02^{c}	0.15±0.02^{c}	0.22±0.02^{c}
T5	0.82±0.02^{c}	0.84±0.04^{c}	0.88±0.04^{c}	0.98±0.07^{c}	0.08±0.01^{bc}	0.14±0.01^{bc}	0.22±0.02^{bc}	0.30±0.02^{bc}
T6	0.85±0.02^{b}	0.87±0.04^{b}	0.92±0.06^{b}	1.02±0.05^{b}	0.12±0.02^{b}	0.20±0.01^{b}	0.29±0.01^{b}	0.36±0.01^{b}

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

C: Control yogurt (3 % fat). , T1 : yogurt with 1% oat powder ,T2: : yogurt with 2% oat powder ,T3: yogurt with 3% oat powder,T4: yogurt with 1% chickpea powder ,T5: yogurt with 2% chickpea powder,T6: yogurt with 3% chickpea powder.

pH and Titratableacidity Values of Different Types of Fortified Yogurt

Table 4 shows the effect of adding oatand chickpea powders at different concentrations on pH and titratable acidity of resultant yogurt. Addition of oat and chickpea powders at different concentrations increased the pH values in yogurt. Whereas, titratable acidity decreased with increasing fortification ratio. Acidity of all yogurt treatments increased as storage period progressed, while pH of all yogurt treatments decreased as storage period progressed .Similar observation was reported by **Atwaa*et al*, (2020) and Pérez-chabela*et al*. (2021)**.

Rheological Properties

Fortification of yogurt with oat and chickpea powders at different concentrations significantly decreased whey syneresis and increasedviscosity compared with control yogurt and this increasing was proportional to the fortification ratio (Table 5). These results might be due to increasing the water holding capacity ofoat and chickpea powders. Viscosity of all yogurt treatments increased as storage period progressed up to 10 days and then decreased up to the end of storage period. While whey syneresis of all yogurt treatments decreased as storage period progressed up to 10 days and then increased at the end of storage period. These results are in agreement with those reported by **Karaca*et al*. (2019) and Pérez-chabela*et al*. (2021)**.

Total Phenolic Content (TFCmg/100 g) and Radical Scavenging Activity (RSA) of Different Types of Fortified Yogurt

Phenolic contents and antioxidant activity of yogurt samples are presented in Table 6 There were significant differences in the phenolic contents and antioxidant activity of the samples ($P < 0.05$). Addition ofoat and chickpea powders at different concentrations significantly increased phenolic contents and antioxidant activity of yogurt treatmentsand these increments were proportional to the fortification ratio. The highest value of phenolic contents and antioxidant activity at the end of storage period was for yogurt fortified with 3% oat powders. Similar observation was reported by **Atwaa*et al*. (2020) and Pérez-chabela*et al*. (2021)**. Phenolic contents and antioxidant activity of all yogurt treatments decreased as storage period progressed.

Microbiological Evaluation of Different Types of Fortified Yogurt

Table 7 shows the differences in total bacterial counts of plain and fortified yogurt during storage period. The results indicated that total bacterial count decreased gradually as storage period progressed until the end of storage period. Yogurt treatments fortified with oat and chickpea powders at different concentrations had the lowest counts of total bacterial count. Total bacterial count decreased with increasing the fortification ratio.

Yeast and mould counts increased in all treatments up to the end of storage period yogurt treatments fortified with oat and chickpea powders at different concentrations had the lowest yeast and moulds counts. Yeast and moulds counts decreased with increasing the fortification ratio.

Coliform bacteria not detected in all treatments up to the end of storage period. These results may be due to high antibacterial or antifungal properties of oat and chickpea powders (**Arena *et al*, 2016; Kan*et al*, 2010).**

Streptococcus salivarius subsp. thermophilus and *Lactobacillus delbruekii subsp. bulgaricus*counts increased gradually in all treatments up to 5 days form storage and then decreased at the end of storage period. Yogurt treatments fortified with oat and chickpea powders at different concentrations had the lowest *Streptococcus salivarius subsp. thermophilus* and *Lactobacillus delbruekii subsp. bulgaricus* counts (Table 8). Fortification of yogurt with oat and chickpea powders decreased the countsof *Streptococcus salivarius subsp. thermophilus* and *Lactobacillus delbruekii subsp. bulgaricus*compared to control yogurt and this may be due to high antibacterial or antifungal properties of oat and chickpea. The general trend of these results agreed with those reported **Elsanhoty and Ramadan (2018) and Habib*et al*. (2018)**.

Sensory Evaluations of Different Types of Fortified Yogurt

Results in Table 9 showed that there was different between control and fortified yogurt for sensory attributes; control yogurt had the lowest values. Addition of oat and chickpea

Table 4. pH and acidity values of different fortified yogurt types during storage period

Samples	Titratable (lactic acid %)				pH			
	Storage period (days)				Storage period (days)			
	fresh	5	10	15	fresh	5	10	15
C	0.88±0.03^{b}	0.95±0.03^{b}	1.02±0.02^{b}	1.12±0.03^{b}	4.30±0.03^{bc}	4.16±0.02^{bc}	4.05±0.03^{bc}	3.95±0.02^{bc}
T1	0.92±0.04^{a}	1.00±0.03^{a}	1.07±0.03^{a}	1.22±0.03^{a}	4.28±0.03^{c}	4.14±0.02^{c}	4.02±0.02^{c}	4.00±0.02^{c}
T2	0.88±0.04^{b}	0.92±0.03^{b}	0.98±0.03^{b}	1.06±0.03^{b}	4.36±0.04^{b}	4.25±0.31^{b}	4. 18±0.02^{b}	4.09±0.02^{b}
T3	0.86±0.03^{bc}	0.90±0.02^{bc}	0.94±0.03^{bc}	1.02±0.03^{bc}	4.40±0.07^{ab}	4.31±0.03^{ab}	4.22±0.02^{ab}	4.15±0.02^{ab}
T4	0. 90±0.03^{ab}	0.98±0.02^{ab}	1.04±0.03^{ab}	1.16±0.03^{ab}	4.30±0.03^{bc}	4.12±0.02^{bc}	4.00±0.02^{bc}	3.92±0.02^{bc}
T5	0.86±0.04^{bc}	0.90±0.03^{bc}	0.95±0.03^{bc}	1.02±0.02^{bc}	4.38±0.04^{ab}	4.28±0.02^{ab}	4.22±0.02^{ab}	4.14±0.02^{ab}
T6	0.86±0.03^{bc}	0.89±0.02^{bc}	0.92±0.03^{bc}	0.98±0.03^{bc}	4.44±0.04^{a}	4.35±0.02^{a}	4.26±0.02^{a}	4.22±0.02^{a}

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

C: Control yogurt (3 % fat). , T1 : yogurt with 1% oat powder ,T2: : yogurt with 2% oat powder ,T3: yogurt with 3% oat powder,T4: yogurt with 1% chickpea powder ,T5: yogurt with 2% chickpea powder,T6: yogurt with 3% chickpea powder .

Table 5. Viscosity and Synersses of different fortified yogurt types during storage period

Samples	Viscosity (mPa)				Syneresses (ml/100ml)			
	Storage period (days)				Storage period (days)			
	fresh	5	10	15	fresh	5	10	15
C	5200±25.17^{e}	5600±30.00^{e}	6000±20^{e}	5900±26.44^{e}	28.67±1.53^{a}	25.00±2.00^{a}	22.33±1.53^{a}	24.00±2.00^{a}
T1	5280±30.55^{e}	5760±20.00^{e}	6140±20.28^{e}	5970±597.75^{e}	27.0±1.53^{b}	24.0±1.15^{b}	20.00±2.00^{b}	22.00±2.00^{c}
T2	5350±35.12^{c}	5820±20.00^{c}	6250±20.00^{c}	6070±20.00^{c}	26.00±2.00^{bc}	23.00±2.00^{bc}	18.00±2.00^{bc}	22.00±2.00^{c}
T3	5500±20.00^{a}	5900±106.93^{a}	6350±20.82^{a}	6180±26.46^{a}	25.00±2.00^{c}	23.00±2.00^{c}	17.00±2.00^{c}	20.00±2.00^{d}
T4	5220±35.12^{e}	5730±268.51^{e}	5900±20.00^{e}	5840±30.55^{e}	28.00±2.52^{a}	25.00±2.00^{a}	21.00±2.00^{a}	24.00±2.00^{a}
T5	5280±30.00^{d}	5790±30.00^{d}	6180±20.82^{d}	6000±20.82^{d}	28.00±1.53^{a}	24.00±2.00^{b}	20.00±2.00^{b}	23.00±2.00^{bc}
T6	5420±595.01^{b}	5840±30.00^{b}	6210±20.00^{b}	6140±20.82^{b}	26.00±2.08^{bc}	24.00±2.00^{b}	20.00±2.00^{b}	23.00±2.00^{bc}

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

C: Control yogurt (3 % fat). , T1 : yogurt with 1% oat powder ,T2: : yogurt with 2% oat powder ,T3: yogurt with 3% oat powder,T4: yogurt with 1% chickpea powder ,T5: yogurt with 2% chickpea powder,T6: yogurt with 3% chickpea powder .

Table 6. Total phenolic content and radical scavenging activity of different fortified yogurt types during storage period

Treatment	TFC mg / 100g				RSA%			
	Storage period(days)				Storage period (days)			
	fresh	5	10	15	fresh	5	10	15
C	42.40±2.98^{g}	30.80±2.80^{f}	22.60±2.88^{g}	14.50±2.90^{g}	22.50±1.12^{g}	16.40±1.08^{g}	12.20±1.11^{g}	9.80±1.22^{g}
T1	83.6±2.00^{f}	72.7±2.40^{e}	40.7±2.66^{f}	36.07±2.86^{f}	35.4±1.00^{f}	28.1±1.10^{f}	22. 9±1.330^{f}	15.2±1.20^{f}
T2	94.2±1.80^{e}	78.5±2.12^{d}	47.4±2.30^{e}	40.6±2.50^{e}	40.2±1.10^{e}	34.8±1.16^{e}	30.5±1.24^{e}	22.8±1.35^{e}
T3	154.6±1.78^{c}	92.3±2.00^{c}	62.8±2.14^{c}	56.4±2.20^{c}	43.6±1.14^{c}	36.4±1.32^{c}	33.2±1.50^{c}	26.5±1.66^{c}
T4	108.4±2.04^{d}	82.5±2.50^{d}	58.4±2.70^{d}	46.6±2.88^{d}	40.2±1.08^{d}	33.5±1.14^{d}	28.2±1.31^{d}	22.1±1.20^{d}
T5	190.7±1.60^{b}	147.4±1.90^{b}	104.2±2.10^{b}	94.3±2.30^{b}	47.3±1.22^{b}	40.7±1.30^{b}	33.5±1.24^{b}	30.6±1.55^{b}
T6	257.4±1.80^{a}	214.2±1.99^{a}	192.5±2.20^{a}	154.7±2.55^{a}	50.7±1.00^{a}	46.2±1.08^{a}	43.4±1.31^{a}	39.4±1.40^{a}

* Values (means ±SD) with different superscript letters are statistically significantly different ($P \leq 0.05$).

C: Control yogurt (3 % fat)., T1 : yogurt with 1% oat powder ,T2: : yogurt with 2% oat powder ,T3: yogurt with 3% oat powder,T4: yogurt with 1% chickpea powder ,T5: yogurt with 2% chickpea powder,T6: yogurt with 3% chickpea powder .

Table 7: Total bacteria (TBC), coliform and yeast and mould counts of different fortified yogurt types during storage period

Treatment	TBC cfu 10^{7}				Total coliforms				Yeast and Mould cfu 10^{1}			
	Storage period (days)				Storage period (days)				Storage period (days)			
	fresh	5	10	15	fresh	5	10	15	fresh	5	10	15
C	100	73	56	30	ND	ND	ND	ND	ND	ND	ND	6
T1	104	78	64	36	ND	ND	ND	ND	ND	ND	ND	4
T2	96	67	48	26	ND	ND	ND	ND	ND	ND	ND	2
T3	88	60	45	20	ND	ND	ND	ND	ND	ND	ND	4
T4	98	65	58	28	ND	ND	ND	ND	ND	ND	ND	3
T5	90	61	52	22	ND	ND	ND	ND	ND	ND	ND	4
T6	84	55	47	16	ND	ND	ND	ND	ND	ND	ND	5

Table 8. ***Streptococcus salivarius subsp. thermophilus*** **and** ***Lactobacillus delbruekii subsp. Bulgaricus*** **counts of different fortified yogurt types during storage period**

Treatment	*Streptococcus salivarius subsp. thermophilus cfu 10^7*				*Lactobacillus delbruekii subsp. bulgaricuscfu 10^7*			
	Storage period (days)				Storage period (days)			
	fresh	5	10	15	fresh	5	10	15
C	52	70	68	59	26	44	63	82
T1	56	74	65	47	28	45	72	85
T2	43	67	62	39	23	37	66	75
T3	34	56	53	28	17	29	53	63
T4	45	66	60	34	25	43	55	61
T5	33	58	50	25	19	31	47	56
T6	29	42	36	22	14	25	38	45

C: Control yogurt (3 % fat). , T1 : yogurt with 1% oat powder ,T2: : yogurt with 2% oat powder ,T3: yogurt with 3% oat powder,T4: yogurt with 1% chickpea powder ,T5: yogurt with 2% chickpea powder,T6: yogurt with 3% chickpea powder .

Table 9: Sensory evaluations of different fortified yogurt types during storage period

Samples	Appearance (10)				Body and Texture (30)				Flavour (60)				Total(100)			
	Storage period (days)				Storage period (days)				Storage period (days)				Storage period (days)			
	fresh	5	10	15	fresh	5	10	15	fresh	5	10	15	fresh	5	10	15
C	8	8	7	7	28	28	27	26	56	55	55	54	92±0.30 g	91±0.32 g	89±0.36 g	85±0.42 g
T1	8	7	7	7	28	28	27	26	58	57	56	55	94±0.22 e	91±0.30 e	89±3.02 e	86±0.34 e
T2	9	9	8	8	29	29	28	27	58	58	57	56	96±0.25 c	96±0.33 c	93±0.30 c	90±0.33c
T3	9	9	8	8	30	30	29	28	59	59	58	57	98±0.23 a	98±0.30 a	95±0.33 a	92±0.32 a
T4	8	7	7	7	28	28	27	26	57	56	55	54	93±0.20 f	90±0.32f	88±0.36 f	85±0.35 f
T5	9	9	8	8	29	29	28	27	57	57	56	55	95±0.22 d	95±0.36d	92±0.34d	89±0.33 d
T6	9	9	8	8	30	30	29	28	58	58	57	57	97±0.24 b	97±0.28 b	94±0.30 b	91±0.32 b

powder improved the organoleptic properties of fortified yogurt. The highest mean value was related to sample containing 3% oat powder .The organoleptic properties of all yogurt treatments decreased as storage period progressed. A similar observation was found by **Al-Hamdani *et al*. (2015) and Atwaa *et al*. (2020).**

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تقييم جـــــودة الزبـــادي المـدعـــم بمســـاحيق الشـــوفـان والحمـص كمصـدر للأليـاف الغذائيـــة

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الهدف من هذه الدراسة هو تقييم تأثير إضافة كل من مسحوق الشوفان والحمص على الخصائص الريولوجية والفيزيائية والكيميائية والحسية للزبادي. تم تدعيم الزبادي بمسحوق الشوفان والحمص بنسب 1، 2 و 3% لكل منهما. تم حفظ الزبادي عند درجة حرارة 5 ± 2 درجة مئوية وتم تحليله بعد تخزينه طازجًا وبعد مرور 5 ، 10 و 15 يومًا. أظهرت النتائج أن: عينة زبادي المقارنة احتوت على أقل محتوى من المواد الصلبة الكلية، الدهن، البروتين ، الرماد والألياف مقارنة مع معاملات الزبادي المدعم. زادت نسبة المواد الصلبة الكلية والدهن والبروتينات والرماد والألياف في الزبادي المحتوي على مساحيق الشوفان والحمص بتركيزات مختلفة تدريجياً بزيادة النسبة المضافة، كما أدت إضافة مسحوق الشوفان والحمص بتركيزات مختلفة إلى ارتفاع قيم ال pH في الزبادى بينما انخفضت الحموضة بزيادة نسبة التدعيم. كما أدى تدعيم اللبن الزبادي بمسحوق الشوفان والحمص بتركيزات مختلفة إلى انخفاض معنوي في انفصال الشرش وزيادة اللزوجة مقارنة بعينة المقارنة وكانت هذه الزيادة متناسبة مع نسبة التدعيم. أدت إضافة مسحوق الشوفان والحمص بتركيزات مختلفة إلى زيادة معنوية في المحتوى الفينولي والنشاط المضاد للأكسدة في معاملات الزبادي وكانت هذه الزيادات متناسبة مع نسبة التدعيم. كانت معاملات الزبادي المدعمة بمسحوق الشوفان والحمص بتركيزات مختلفة أقل عدداً من الخمائر والفطريات وعدد البكتيريا الكلية، وعدد , *Streptococcus salivarius subsp. thermophilus* واجمالى الخمائر والفطريات البكتيرياالكلية ، *Lactobacillus delbruekii subsp. bulgaricus* *Streptococcus salivarius subsp. thermophilus* , *Lactobacillus delbruekii subsp. bulgaricus* والتي انخفضت مع زيادة نسبة التدعيم. واظهرت عينة المقارنة أقل قيم في التقييم الحسي وأدت إضافة مسحوق الشوفان والحمص إلى تحسين الخصائص الحسية للزبادي المدعم ؛ وأعلى قيمة كانت للمعاملة المحتوية على 3% مسحوق الشوفان..

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