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Functional Yoghurt Beverages Fortified with Different Sorts of Carrot Products

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ABSTRACT

In this study, functional yoghurt beverages were fortified with different sorts of carrot products including of 5% fresh carrot pulp (FCP), carrot treated with instant controlled pressure drop (CDIC), and carrot treated with conventional hot air drying (CHAD). The different treatments were analyzed for physicochemical, rheological, microbiological, and organoleptic properties when fresh and after 10 and 20 days of storage at 4±1 °C. Total solids, protein, fat, and ash contents were found to be higher in carrot-yoghurt beverages as compared to the control. In addition, there was a gradual decrease in total phenolic contents and antioxidant activities during storage period. Furthermore, the treatments supplemented with CDIC and CHAD exhibited higher water holding capacity. The addition of carrot products had a positive impact on the starter culture bacteria. The viable probiotic cell count throughout the product shelf-life was above the minimum count required in a probiotic product (more than log 6 CFU/g) for treatments containing CDIC and CHAD. However, CDIC and FCP gained the highest scores for the overall sensory attributes.

***Keywords*:** Yoghurt beverage, Carrot, Instant controlled pressure drop (CDIC), Physicochemical, Rheological, Microbiological, Sensory properties.

INTRODUCTION

Throughout the last few years, the request for "healthy" beverages and foods has dramatically increased on a worldwide scale (Corbo *et al.*, 2014). The recent developments in the scientific research supported the impression that diet may accomplish the nutritional requirements and exert a valuable role in certain diseases (Otles and Cagindi, 2012). Numerous diverse categories of functional beverages are nowadays commercially presented, among them the dairy-based beverages including minerals/ω-3 and probiotics-enriched drinks, energy and sports beverages, with an increasing substantial demand and interest for non-dairy beverages prepared by using fruits, vegetables, and cereals (Corbo *et al.*, 2014; Granato *et al.*, 2010b; Kandylis *et al.*, 2016). Yoghurt is considered one of the most prevalent fermented dairy products produced through the fermentation of milk using bacterial strains. There are several categories of yoghurt, among them set-type, stirred-type, and yoghurt drinks. The regular intake of such immune-linked functional food has an effective role in decreasing various diseases and disorders-related risks (Gharibzahedi and Chronakis, 2018). The health-promoting belongings accompanied by satisfactory textural and organoleptic aspects of yoghurt types have caused a substantial improvement in their consumption (Park *et al.*, 2005). The consumption of yoghurt has considerably increased since countless consumers linked yoghurt with enhanced health consequences (Hekmat and Reid, 2006). The food industry sector has developed novel probiotic products with the aim of deliver growing demand. The major science-based profits related to probiotic strains are anticarcinogenic, antimutagenic, antimicrobial, antihypertension, beneficial impacts on the absorption of minerals, particularly regarding bone constancy, decrease food allergies symptoms, decrease the indicators of Crohn's syndrome and intestines disease, and decrease the levels of low-density-lipoprotein cholesterol. Also, some of lactobacilli strains have shown inhibition of the pathogenic microorganisms, for instance *Salmonella enteritidis*, *Shigella sonnei*, *Serratia marcescens*, and *Escherichia coli* (Granato *et al.*, 2010a). Consequently, probiotics have been comprehensively incorporated in several dairy products during the last decades, and the yoghurt fortified with *Lactobacillus acidophilus* and/or *Bifidobacterium* species was extensively marketed. To attain the demanded health benefits, it is required that the probiotic strains count in a product during its shelf-life should be more than 10^6-10^7 colony forming unit per gram (Ranadheera *et al.*, 2012).

Fruit and vegetable juices and their derivative products, for instance drinks and nectars have a knowledgeable growing reputation. Biochemically, carrot is considered a plentiful source of fibers, β-carotene, several functional components and vital micronutrients. Because of their higher content of the carotenoid compounds, carrot roots have been recognized as cancer inhibiters, free radicals scavenger, immune and anti-mutagenic enhancers. It is hard to voluntarily make carrot obtainable during the year due to the seasonal production and being perishable. One of the main substitutes of preservation in order to extra develop value-added products is the desiccation of carrot during the season of growing. To take advantage of the higher dietary fibers content and

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antioxidant properties of carrot, it is required to produce novel products with ideal phytochemicals content without influencing the taste. Consequently, it appears that the successful production of products from fresh, semi-finished, or dehydrated carrots may perhaps encounter the recent trend of consumers. Simultaneously, this will not only deliver nutritious products with a sensible price to the consumers, but support the effective application of carrot as well (Sharma *et al.,* 2012).

In some countries, the most common approach for the manufacture of yoghurt beverages is to mix the regular yoghurt with water, cheese whey or the whey obtained during the manufacture of concentrated/strained yoghurt (de Almeida *et al.,* 2000; Oliveira *et al.,* 2002; Penna *et al.,* 2003). In such context, the objective of the present research aimed to investigate the physicochemical characteristics, rheological attributes, microbiological evaluation, and organoleptic properties of novel functional yoghurt beverages supplemented with different sorts of carrot including fresh carrot pulp (FCP), carrot treated with instant controlled pressure drop (CDIC), and carrot treated with conventional hot air drying (CHAD).

MATERIALS AND METHODS

Materials

Fresh bulk buffalo's milk (6% fat) was acquired from the dairy processing unit, Department of Food Science, Faculty of Agriculture, Zagazig University (Egypt). Bacterial strains; *Bifidobcterium lactis* (BB-12), *L. acidophilus* (LA-5), *Streptococcus thermophiles*, and *L. delbrueckii* subsp. *bulgaricus* (FD-DVS ABY-3 Probio-Tec®) were purchased from Chr. Hansen Inc. Laboratories, Milwaukee, WI, by Misr Food Additives (MIFAD), Egypt. Commercial stabilizer (1:1:1); guar gum (E412), fatty acid mono- and diglycerides (E471), and sodium carboxymethyl cellulose (E466) were obtained from EGY-DAIRY company, 10th of Ramadan city, Egypt. Pure cane sugar was purchased from the local market to prepare a sucrose syrup (8%), which was heated at 85 °C for 15 min, cooled and kept in a refrigerator (4±1 °C). The sucrose syrup was prepared and used within 24 h of preparation.

Carrot tubers; good quality fresh carrot (*Daucus carota* L.) tubers were manually selected and procured from a local vegetable market (Zagazig, Egypt). Carrot tubers were cautiously washed in potable water in order to get rid of the impurities. Then, they were trimmed by using a stainless-steel knife and washed again carefully with potable water. After the processes of washing and peeling, carrot tubers were sliced at 1 cm thickness and blanched in hot water at 95 °C for 5 min.

Preparation of carrot products

Fresh carrot pulp (FCP): The blanched carrot tubers were put in a blender and mixed to form a homogeneous pulp paste which was stored frozen in plastic containers at -20 °C until used. This pulp was prepared fresh and used within 24 h of preparation.

Carrot treated with instant controlled pressure drop (CDIC): The obtained samples of carrot were treated by using the controlled sudden decompression (Instant Controlled Pressure Drop, DIC®) in the Laboratory of Engineering Sciences for the Environment (LaSIE-UMR-CNRS 7356), University La Rochelle, Avenue Michel Crépeau, 17000 La Rochelle, France. The DIC® technology was applied according to Louka *et al.* (2004). Carrot pieces were returned to the hot air dryer and dried to less than 5% moisture content. The dried carrot slices were grinded in order to form a powder which was then sieved and stored in air-tight food grade plastic containers until being used.

Carrot treated with conventional hot air drying (CHAD): Drying process was systematically accomplished by using an electric convective hot air dryer (Memmert D06064UNB 800 Model, Germany). The samples were exposed to a constant drying temperature of 60 °C (Cui *et al.,* 2004) and an air velocity of 1.2 m/sec, and continuously dried to an equilibrium moisture content of 5% moisture.

Preparation of yoghurt beverage treatments

Fresh buffalos' milk was distributed to four groups. The first batch was treated as a control treatment (C). To the other three groups, 5% (w/w) of carrot sorts (FCP, CDIC, and CHAD, respectively) were added. To all treatments, stabilizers were added at the ratio of 0.5%, homogenized at 60 °C and 600 Kpa, pasteurized at 72 °C for 15 sec, and rapidly cooled to 42 °C. After that, starter culture (FD-DVS ABY-3 Probio-Tec®) 0.05% (w/v) was added, and 100 mL of milk was distributed in sterile glass bottles (200 mL). All the treatments were incubated at 42 °C until a pH value of 4.4-4.6 was reached, and the resultant yoghurt was kept in the refrigerator (4±1 °C) overnight, and then the yoghurt was well mixed with the previously prepared sucrose syrup at 1:1 ratio. Yoghurt beverages of different treatments were mixed in the bottles and stored at 4±1 °C for 20 days. Samples were taken when fresh and after 10 and 20 days for the examinations.

Chemical composition

Moisture, fat, protein, and ash contents of yoghurt beverage treatments were estimated according to the methods reported by Cunniff (1996) and James (2013). The total carotenoids (β-carotene) and fiber contents were determined according to the AOAC (2000), ascorbic acid content as described by Howard, *et al.* (1999), total flavonoid and anthocyanin contents determination was carried out according to Ordonez, *et al.* (2006) and Du and Francis (1973). Flavour compounds as acetaldehyde in yoghurt beverages were determined as described by Lees and Jago (1969).

The content of carbohydrates was calculated by the difference between total solids content and (fat + protein + ash) according to Guzmán-González *et al.* (1999). The caloric value was calculated by using the equation given by Chandan (2011) as follow; calories factors = (protein × 4.27) + (fat × 8.79) + (carbohydrate × 3.87), and expressed as Kcal 100/mL product.

Total phenolic content and antioxidant activity of yoghurt beverages:

Water extract of yoghurt beverages

Yoghurt beverage samples (10 g) were mixed with 2.5 mL distilled water, and 1 M of HCl was used to adjust the pH at 4.0. The beverages were transported to a water bath and kept at 45 °C for 10 min, and then centrifuged for 10 min at 10,000 rpm and 4 °C to remove the precipitated proteins. Then, the supernatant was gathered, and NaOH (0.5 M) was used to adjust the pH at 7.0 followed by centrifugation (Jouan C3i MultiFunction Centrifuge with AUTO-LOCK, Thermo Fisher Scientific, USA) in order to

eliminate the residual precipitated proteins and salts. Finally, the supernatant was collected, kept refrigerated and taken for the next analysis within 24 h.

Total phenolic content assay and minerals determination

The content of total phenolic compounds in yoghurt beverages was estimated using the method reported by Shetty *et al.* (1995) with minor modifications. Briefly, 1 mL ethanol (95%) and 5 mL distilled water were mixed with 1 mL of the water extract of yoghurt beverages in a test tube. To each sample, 0.5 mL of Folin-Ciocalteu reagent 50% (v/v) was added and well-mixed. After 5 min, 1 mL of sodium carbonate (5%) was added, and the reaction mixture was left to stand for 1 h. The absorbance was calculated at 725 nm, and the total phenolic compounds in yoghurt beverages were determined as micrograms of gallic acid equivalents for each gram (µg GAE/g) sample. Various concentrations of CH_3OH-gallic acid (5-60 µg/mL) were used to design the standard curves.

The atomic absorption spectrophotometry (ParkinElmer, Spectr. AA 220, Varian-USA) was used to determine the contents of Ca, Mg, K, Na, Cu, Mn, Zn, and Fe in yoghurt beverages. Minerals were determined in ash solution (Srivastava, 2010)

Antioxidant activity

1,1-diphenyl-2-picrylhydrazyl (DPPH) inhibition in yoghurt beverages was estimated as stated in the method reported by Shetty *et al.* (1995). The water extract of yoghurt beverages (250 µL) was mixed with 3 mL of 60 µM DPPH in ethanol. The mixture was kept at the room temperature for few minutes after strong shaking, and the absorbance (JENWAY 6705 UV / VIS Spectrophotometer, UK) was measured at 517 nm. A blank containing distilled water (250 µL) was used instead of the water extract of yoghurt beverages to compare the obtained reading. The % inhibition was calculated as follow;

$$\% \text{ inhibition} = [A^{control} - A^{extrac}] / [A^{control}] \times 100$$

Protein proteolysis

The O-pthaldialdehyde (OPA) reagent was firstly prepared following the procedure reported by Church *et al.* (1983). The solution was made by mixing the following reagents and diluting to a final volume of 50 mL by using distilled water; [5 mL of 100 mM sodium tetraborate, 2.5 mL of 20% (w/w) sodium-dodecyl sulfate (SDS), 40 mg of OPA (dissolved in 1 mL methanol), and 100 µL of β-mercaptoethanol]. The prepared reagent was used within 2 h of preparation. OPA reagent (1.0 mL) was mixed with a small portion of the water extract of yoghurt beverages. Then, the solution was briefly mixed via inversion and left for 2 min at room temperature. Finally, the absorbance was measured (JENWAY 6705 UV / VIS Spectrophotometer, UK) at 340 nm, and the peptides concentration was compared with tryptone standards (0.125-1.50 mg/mL).

Rheological analysis:

The viscosity (centipoises, cP) of yoghurt beverage samples was measured according to the procedure described by Ranadheera *et al*. (2012). In addition, the procedure reported by Isanga and Zhang (2009) was used to determine the water holding capacity (WHC) of yoghurt beverages and their susceptibility to syneresis (STS).

Color measurement:

The color attributes of yoghurt beverages (L*, a* and b*) were determined according to Rao *et al.* (2011) using the HunterLab color analyzer (Hunter Lab Color Flex EZ, USA). The L* value (lightness index) varies between 0 (black) and 100 (white), while a* value refers to the greenness (−a*) or redness (+a), and b* value indicates the blueness (−b*) or yellowness (+b). Firstly, petri dishes were filled with the samples of different yoghurt beverage treatments, and the dishes were directly placed on the colorimeter sensor. The color intensity (C), total color difference (ΔE), and the hue angle (h_{ab}) in comparison to an untreated control were calculated, where $h_{ab} = 0^o$ for red hue and $h_{ab} = 90^o$ for a yellow hue, and the results were determined using the following formulas;

$$C = (a^{*2} + b^{*2})^{0.5}$$

$$h_{ab} = \arctan (b^*/a^*)$$

$$\Delta E = [(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2]^{0.5}$$

where L_0, a_0 and b_0 are the values of L, a, and b for the control reference sample.

The color of yoghurt beverages was also expressed as whiteness index (WI) according to the formula reported by Al-Hooti *et al.* (2000);

$$WI = 100 - [(100 - L^*)^2 + a^{*2} + b^{*2}]^{0.5}$$

Microbiological examinations:

Yoghurt beverage samples were subjected to the microbiological analysis when fresh, and after 10 and 20 days of storage. All microorganisms incorporated in yoghurt beverages were counted by using differential media and the approaches are mentioned below. After the period of incubation, the colonies number was enumerated on two serial plates with 25 to 250 colonies. *S. thermophilus* was enumerated on M17 agar (Difco Laboratories) at 37 °C for 48 h. *L. delbrueckii* ssp. *bulgaricus* was counted on MRS agar with pH adjusted to 5.2 at 42 °C/48 h (Dave and Shah, 1997b). MRS-sorbitol agar (1.0% D-sorbitol) was used for enumerated of *L. acidophilus* at 37 °C/48 h, while, MRS agar (Difco Laboratories) media supplemented with neomycin-paromomycin-nalidixic acid-lithium chloride broth with 1% L-cysteine (NPNL) solution was used to enumerate *Bifidobacterium* BB12 (Karagül-Yüceer *et al.*, 2001). The plates were incubated under anaerobic conditions (BBL anaerobic jar containing gas generating kit, BR038B Oxoid) for 72 h at 37 °C. The results were determined as log colony-forming units per gram (log cfu/g) of sample, and the viability of each culture in different samples was calculated according to Paseephol and Sherkat (2009), as follows;

$$\% \text{ Viability} = (\text{cfu/g after 20 days of storage/initial cfu/g}) \times 100.$$

Coliforms, moulds and yeasts were enumerated according to Feng *et al.* (2002) and ISO (2004), respectively, and the results were determined as log cfu/g.

Sensory evaluation:

The organoleptic properties of yoghurt beverages were performed by a tasting panel consisted of students and staff recruited from the Faculty of Agriculture, Zagazig University according to the method reported by Ranadheera *et al.* (2012). Each panelist was given 4 samples of yoghurt beverages to taste, evaluate and comment on the sensory attributes at each serving. The panelists were requested to assess yoghurt beverage samples regarding the color & appearance, aroma, body & texture, taste, and the overall acceptability by using a 9-point hedonic scale as follow; (9, extremely like; 8, like very much; 7, moderately like; 6, slightly like; 5, neither

like nor dislike; 4, slightly dislike; 3, moderately dislike; 2, dislike very much; and 1, extremely dislike).

Statistical analysis:

The analysis of data was performed by using SPSS/PASW statistical software (version 20, SPSS Inc., Chicago, IL, USA). One way ANOVA was used to analyze data of the physicochemical properties. Microbial viability data were analyzed by using repeated measure ANOVA. In both cases the Bonferroni post hoc test was performed for means comparison. Nonparametric tests were performed to determine the statistical differences of the sensory data, and where appropriate, T-tests were performed for comparison of two means. A P value ≤ 0.05 was considered statistically significant for all analyses.

RESULTS AND DISCUSSION

Physicochemical characteristics of carrot-yoghurt beverages

Table 1 displays the chemical composition and the bioactive compounds in milk and the different sorts of carrot products (FCP, CDIC, and CHAD) used in the preparation of yoghurt beverages. The content of fat was significantly higher in milk (6.00%) as compared to carrot products (0.31, 2.85, and 3.06%, respectively). Milk contained a significantly higher ($P \leq 0.05$) content of protein (3.71%) than FCP (1.11%), while CDIC and CHAD contain a substantial higher amount than milk (6.16 and 6.67%, respectively). Conversely, it was noted that fibers and anthocyanin were not detected in milk, while carrot products possessed higher contents of these components. In addition, carrot products comprised significantly higher ($P \leq 0.05$) contents of the phenolic compounds as compared to milk. The content of calcium was higher in milk (186 mg/100 g) than the other sorts of carrot products (61, 143, and 128 mg/100 g, respectively).

Regarding the chemical composition of yoghurt beverage treatments, it was shown that the total solids, protein, fat, and ash contents were higher in carrot-yoghurt beverages than the control beverage (Table 2). The variations in total solids and fat contents may influence some other physicochemical properties, for instance syneresis, WHC, and viscosity.

Table 1. Chemical composition and bioactive compounds of milk and carrot products used for the preparation of yoghurt beverages.

Components	Milk	FCP	CDIC	CHAD
Total solids%	16.77±1.09^{b}	11.46±1.23^{c}	94.98±2.40^{a}	94.89±1.64^{a}
Ash%	0.72±0.16^{b}	0.81±0.02^{b}	5.75±0.40^{a}	5.31±1.28^{a}
Fat%	6.00±0.20^{a}	0.31±0.20^{c}	2.85±0.40^{b}	3.06±0.50^{b}
Protein%	3.71±0.54^{b}	1.11±0.41^{c}	6.16±1.09^{a}	6.67±0.91^{a}
Crude fiber%	0.00	3.21±1.07^{b}	51.08±5.50^{a}	55.76±5.49^{a}
Carbohydrates%	4.84±0.43^{b}	2.93±0.65^{b}	28.88±3.37^{a}	24.13±7.12^{a}
Calories (Kcal/100g)	87.31±2.73^{c}	18.80±2.95^{d}	163.12±9.46^{a}	148.76±4.49^{b}
Antioxidant activity %	19.50±6.08^{d}	51.50±5.28^{c}	87.75±9.50^{a}	72.13±7.88^{b}
Total phenolic (mg/00g)	6.45±2.20^{c}	70.23±6.98^{b}	192.25±7.90^{a}	184.87±12.83^{a}
Total flavonoids (mg/100g)	0.16±0.05^{b}	0.05±0.03^{b}	0.78±0.11^{a}	0.66±0.05^{a}
Ascorbic acid (mg/100g)	12.30±4.95^{b}	34.30±6.90^{a}	25.96±7.29^{ab}	23.15±5.10^{ab}
Anthocyanin (mg/100g)	0.00	2.10±1.15^{a}	2.20±2.05^{a}	2.50±2.08^{a}
Carotenoids (β-carotene) (mg/100g)	0.00	15.46±2.79^{a}	19.96±5.29^{a}	16.15±3.10^{a}
Iron, Fe (mg/100g)	0.09±0.03^{b}	1.81±0.17^{b}	13.16±2.09^{a}	12.70±2.22^{a}
Copper, Cu (mg/100g)	0.06±0.02^{b}	0.32±0.19^{b}	2.30±1.24^{a}	2.22±0.81^{a}
Zinc, Zn (mg/100g)	0.61±0.20^{b}	2.91±0.68^{b}	21.18±2.07^{a}	20.45±1.18^{a}
Manganese, Mn (mg/100g)	0.004±0.003^{b}	0.532±0.09^{b}	3.87±1.15^{a}	3.73±0.32^{a}
Sodium, Na (mg/100g)	45.00±7.00^{c}	62.25±9.00^{b}	152.45±10.80^{a}	136.89±8.36^{a}
Potassium, K (mg/100g)	110.00±23.00^{b}	321.25±93.75^{b}	788.55±136.45^{a}	658.27±186.87^{a}
Phosphorus, P (mg/100g)	85.00±12.00^{b}	71.51±20.98^{b}	190.68±24.32^{a}	173.80±21.45^{a}
Calcium, Ca (mg/100g)	186.00±38.00^{a}	61.00±20.25^{c}	143.36±12.89^{ab}	128.11±14.15^{b}
Magnesium, Mg (mg/100g)	19.00±9.25^{b}	21.00±5.27^{b}	76.00±5.13^{a}	81.00±9.54^{a}

FCP, fresh carrot pulp; CDIC, carrot treated with instant controlled pressure drop DIC®; CHAD, carrot treated with conventional hot air drying.

Mean (±SE). Values with small letters in the same row having different superscripts differ significantly ($P \leq 0.05$).

Table 2. Gross chemical composition of fresh yoghurt beverages supplemented with carrot products.

Components	Treatments			
	Control	YB-FCP	YB-CDIC	YB-CHAD
Total solids%	13.12±1.13^{b}	13.41±1.61^{b}	15.47±0.78^{a}	15.80±2.55^{a}
Ash%	0.40±0.07^{b}	0.42±0.13^{b}	0.54±0.14^{a}	0.53±0.39^{a}
Fat%	3.30±0.2^{a}	3.31±0.21^{a}	3.37±0.27^{a}	3.38±0.18^{a}
Protein%	2.04±0.48^{a}	2.07±0.19^{a}	2.19±0.46^{a}	2.21±0.29^{a}
Crude Fiber%	0.00	0.16±0.14^{b}	1.28±0.72^{a}	1.39±0.65^{a}
Carbohydrates%	7.39±0.86^{c}	7.62±0.48b^{c}	9.36±1.21^{ab}	9.68±1.20^{a}
Calories (Kcal/100 g)	57.40±4.85^{a}	57.87±2.22^{a}	61.48±4.77^{a}	61.12±3.42^{a}
Iron, Fe (mg/100 g)	0.09±0.01^{b}	0.19±0.02^{b}	0.76±0.20^{a}	0.73±0.10^{a}
Copper, Cu (mg/100 g)	0.07±0.03^{b}	0.08±0.03^{b}	0.18±0.05^{a}	0.18±0.04^{a}
Zinc, Zn (mg/100 g)	0.67±0.08^{b}	0.82±0.11^{b}	1.73±0.38^{a}	1.69±0.28^{a}
Manganese, Mn (mg/100 g)	0.005±0.002^{b}	0.03±0.02^{b}	0.20±0.11^{a}	0.19±0.03^{a}
Sodium, Na (mg/100 g)	49.50±2.60^{b}	52.61±8.59^{b}	72.12±5.44^{a}	71.34±7.06^{a}
Potassium, K (mg/100 g)	121.00±14.00^{b}	147.06±13.94^{b}	310.43±101.07^{a}	303.91±104.34^{a}
Phosphorus, P (mg/100 g)	93.50±6.75^{a}	97.08±22.17^{a}	118.03±10.22^{a}	117.19±13.83^{a}
Calcium, Ca (mg/100 g)	204.60±21.65^{a}	207.65±25.91^{a}	226.77±41.48^{a}	226.01±15.64^{a}
Magnesium, Mg (mg/100 g)	20.90±2.35^{a}	21.95±1.70^{a}	24.70±1.84^{a}	24.95±3.17^{a}

YB-FCB, yoghurt beverage prepared by using fresh carrot pulp; YB-CDIC, yoghurt beverage prepared by using carrot treated with instant controlled pressure drop DIC®; YB-CHAD, yoghurt beverage prepared by using carrot treated with conventional hot air drying (BCHAD).

Mean (±SE). Values with small letters in the same row having different superscripts differ significantly ($P \leq 0.05$).

Table 3 shows that there were slight significant variances in the mean levels of acidity among the control and yoghurt beverages after 10 days of manufacture. The acidity of yoghurt might have an additional contributing factor, since higher acidity is correlated with the stimulation of syneresis (Tamime and Robinson, 1999), while titratable acidity, pH, and syneresis patterns among various yoghurt beverages after one week of storage would suggest that acidity was not the driving force (McCann *et al.,* 2011). In this study, the pH of yoghurt beverages demonstrated slight variations during the subsequent storage. The preliminary pH of milk was decreased during processing and storage period consistent with the evolution of the starter cultures and the probiotic bacteria. It is well known that microorganisms' growth in milk decreases the pH value. Among the different microorganisms, *L. bulgaricus* is assumed to be mainly responsible for the detected changes in pH during a short time, since the starter cultures only contain *L. acidophilus* LA-5, *S. thermophilus,* and *Bifidobacterium* BB-12. Furthermore, the overall decline in the pH values in the different types of yoghurt beverages was also observed during storage period. Comparable results were described in other studies on cow's milk yoghurt (Dave and Shah, 1997a; Dave and Shah, 1997b). There was a substantial ($P \leq 0.05$) variation in the pH values between control yoghurt beverage and the other beverages at the end of storage period. This pH decline may be attributed to the continuous fermentation by lactic acid bacteria and the contribution of acidity from the added carrot products.

The obtained OPA values of control yoghurt beverage were significantly lower ($P \leq 0.05$) than the rest types of carrot-yoghurt beverages when fresh and during storage (Table 3). The spectrophotometric absorbance that forms the basis of OPA values is associated with the released α-amino groups produced through milk proteins proteolysis. The obtained values can be used as a parameter for the proteolytic activity in probiotics and yoghurt (Shihata and Shah, 2000). Milk proteins are immunologically diverse (El-Agamy *et al.,* 2009), and this could contribute to the variances in the ease and extent of proteolysis. Enzymes with proteolytic activity in carrot-yoghurt beverages with different activities for milk proteins may contribute to some extent in increasing the OPA values.

Acetaldehyde is considered to be one of the major volatile constituents in charge of yoghurt aroma. The existence of *Lactobacilli* spp. in the starter culture can affect the final product content of acetaldehyde (Ekinci and Gurel, 2008; Güler-Akın and Akın, 2007). During the fermentation process and cold storage, the content of acetaldehyde markedly increased, while the other volatile compounds exhibited a reasonable increase (Tamime and Deeth, 1980). The volatile compounds level regularly increased after the end of fermentation process up to 10 days of cold storage possibly because of the starter residual activity, and slowly declined after that (Gueimonde *et al*., 2003). Conversely, the formation of numerous volatile compounds was higher ($P \leq 0.05$) in the fresh YB-FCP than the fresh control. These results indicated the enhanced production of acetaldehyde in yoghurt, and agreed with the results previously reported by Ruas-Madiedo *et al.* (1998).

Total phenolic content and antioxidant activity

The variations in the total phenolic contents and antioxidant activities (%) of yoghurt beverage treatments when fresh and throughout storage are also shown in Table 3. The results cleared that the utilization of carrot products increased the contents of total phenolic and antioxidant activities as compared to the control sample. The results also indicated a gradual decline in the contents of total phenolic and antioxidant activities during storage period. Probiotic bacteria e.g. *Bifidobacterium* spp. have the ability to hydrolyze polyphenols to aromatic acids, for instance phenyl propionic, phenyl valeric, phenyl acetic, and benzoic acids (Manach *et al*., 2004). It was reported that the use of carrot products had improved the content of total phenolic compounds and enhanced the antioxidant activities (Karaaslan *et al.,* 2011; Scarano *et al.,* 2018). These bioactive components are regularly subjected to disease-preventing and health-benefiting privileges (Kris-Etherton *et al.*, 2004). In the recent years, phenolic compounds have attracted the attention of food and health specialists owing to their antioxidant power and free radical scavenging capacity (Macheix *et al*., 1990).

Rheological properties:

Water holding capacity (WHC)

The data in Table 3 show that the WHC of YB-CDIC and YB-CHAD was significantly ($P \leq 0.05$) higher than that of the control and YB-FCP. The variations in the WHC of the carrot-yoghurt beverages may be attributed to the properties of the different total solids presented. The interactions between water and proteins are very important in food systems because of their influences on the texture and flavor of foods. Among the major factors that affect the WHC of food protein conformations, amino acids composition and the surface hydrophobicity/polarity (Barbut, 1999). In addition, Wu *et al*. (2000) revealed that WHC is related to the capability of proteins to hold water within yoghurt structure. Also, milk fat globules could play a significant ($P \leq 0.05$) role in holding water. The WHC of YB-CDIC is associated with the porous matrix structure produced by the polysaccharide chains that are able to hold large amounts of water through the hydrogen bonds (McCann *et al*., 2011; Thebaudin *et al.,* 1997).

Susceptibility to syneresis (STS)

Syneresis, an undesirable characteristic in yoghurt products, is the impact of liquid separation from the curd of yoghurt (Wu *et al*., 2000). Serum separation happens in fermented dairy products owing to the accumulation and sedimentation of casein micelles throughout storage. The STS% of YB-CDIC and YB-CHAD was significantly ($P \leq 0.05$) lower than that of the control and YB-FCP. The lower STS might be attributed to the higher total solids content in the samples. It was reported by Staff (1998) that low-fat yoghurt is susceptible to have a higher syneresis degree in comparison with high-fat yoghurt. As yoghurt is frequently manufactured by using homogenized milk to enhance its stability, this procedure covering the increased fat globules surface with casein, allowing milk fat globules to contribute as a copolymer together with casein to reinforce the gel network and decrease syneresis (Keogh

and O'kennedy, 1998). The incorporation of carrot products (CDIC and CHAD) was found to be necessary to decrease serum separation in fermented milk. The unprompted separation of whey is associated with the weak network that may be attributed to the increase in the reorganization of gel matrix, and moreover negatively influences consumer perception and acceptability of yoghurt. McCann *et al.* (2011) reported that the utilization of carrot cell wall particles hastened the rate of pH reduction, decreased the loss of whey, and increased firmness of the final set gels.

Viscosity

The viscosity of yoghurt beverages was significantly ($P \leq 0.05$) increased with the incorporation of CDIC and CHAD (Table 3). The interactions between carrot products and casein particles contribute in serum separation reduction, along with the impact of increased viscosity. The viscosity of control yoghurt beverage was higher than that of yoghurt containing FCP, consistent with the higher total solids content in yoghurt as described by Isanga and Zhang (2009); Martın-Diana *et al.* (2003) and Tamime and Robinson (1999).

Table 3. Physicochemical properties and bioactive compounds of yoghurt beverages supplemented with carrot products.

Parameter	Storage period (days)	Treatments				Means
		Control	YB-FCP	YB-CDIC	YB-CHAD	
Titratable acidity (% lactic acid)	Fresh	0.66±0.06^{a}	0.71±0.10^{a}	0.63±0.14^{a}	0.60±0.05^{a}	0.65±0.09^{B}
	10	0.71±0.13^{a}	0.74±0.07^{a}	0.76±0.08^{a}	0.73±0.10^{a}	0.74±0.08^{A}
	20	0.76±0.09^{b}	0.78±0.03^{b}	0.85±0.08^{a}	0.81±0.07^{a}	0.80±0.07^{A}
	Means	0.71±0.09^{a}	0.74±0.07^{a}	0.75±0.13^{a}	0.71±0.11^{a}	
pH values	Fresh	4.76±0.21^{a}	4.73±0.05^{a}	4.81±0.01^{a}	4.84±0.12^{a}	4.79±0.11^{A}
	10	4.69±0.07^{a}	4.68±0.09^{a}	4.64±0.10^{a}	4.67±0.11^{a}	4.67±0.08^{B}
	20	4.63±0.11^{a}	4.59±0.25^{a}	4.52±0.11^{b}	4.56±0.18^{b}	4.58±0.15^{B}
	Means	4.69±0.14^{a}	4.67±0.15^{a}	4.65±0.14^{a}	4.70±0.17^{a}	
protein proteolysis (mg/g)	Fresh	96.00±14.00^{c}	470.00±41.00^{a}	390.00±61.00^{a}	270.00±42.00^{b}	306.50±151.58^{A}
	10	110.00±42.00^{d}	500.00±62.00^{a}	400.00±55.00^{b}	286.00±39.00^{c}	324.00±157.33^{A}
	20	152.00±13.00^{c}	521.00±131.00^{a}	410.00±62.00^{ab}	300.00±36.00^{b}	345.75±156.19^{A}
	Means	119.33±34.00^{d}	497.00±78.51^{a}	400.00±52.18^{b}	285.33±36.25^{c}	
Acetaldehyde (µg/100g)	Fresh	185.21±56.93^{a}	191.23±24.02^{a}	163.01±18.24^{a}	159.68±11.57^{a}	174.78±34.40^{B}
	10	225.58±31.42^{a}	219.85±15.15^{a}	244.08±13.92^{a}	236.54±24.46^{a}	231.51±21.49^{A}
	20	182.63±27.37^{a}	178.23±11.77^{a}	191.85±9.60^{a}	185.13±6.87^{a}	184.46±14.60^{B}
	Means	197.81±44.22^{a}	196.43±24.01^{a}	199.78±36.66^{a}	193.78±36.66^{a}	
Water holding capacity (WHC)%	Fresh	35.58±4.67^{bc}	30.18±10.07^{c}	53.13±8.37^{a}	47.87±7.38^{ab}	41.69±11.72^{A}
	10	30.77±6.48^{b}	28.37±6.85^{b}	52.66±3.59^{a}	47.42±6.83^{a}	39.80±12.07^{A}
	20	36.71±3.54^{bc}	27.31±1.94^{c}	51.82±10.43^{a}	46.27±7.96^{ab}	40.52±11.38^{A}
	Means	34.35±5.15^{b}	28.62±6.29^{b}	52.53±6.94^{a}	47.18±6.45^{a}	
Susceptibility to syneresis (STS)%	Fresh	39.29±4.96^{a}	40.29±8.96^{a}	9.54±3.71^{b}	14.49±4.76^{b}	25.90±15.48^{A}
	10	37.21±7.04^{a}	42.21±10.04^{a}	11.18±1.93^{b}	15.38±4.74^{b}	26.49±15.11^{A}
	20	41.47±4.78^{a}	46.46±8.82^{a}	14.33±4.92^{b}	18.18±7.07^{b}	30.11±15.70^{A}
	Means	39.32±5.25^{a}	42.98±3.85^{a}	11.68±3.85^{b}	16.02±5.15^{b}	
Viscosity (cp) or mPa.s	Fresh	61000±2000^{a}	60000±28000^{a}	76000±5000^{a}	74000±2000^{a}	67750±14372^{A}
	10	52000±8000^{b}	56000±1000^{b}	77000±5000^{a}	75000±3000^{a}	65000±12358^{A}
	20	54000±7000^{b}	52000±3000^{b}	75000±5000^{a}	71000±2000^{a}	63000±11297^{A}
	Means	55666±6782^{b}	56000±14508^{b}	76000±4415^{a}	73333±2738^{a}	
Antioxidant activity %	Fresh	27.00±8.00^{b}	71.00±12.00^{a}	84.00±12.00^{a}	76.00±12.00^{a}	64.50±25.00^{A}
	10	22.00±5.00^{b}	63.00±12.00^{a}	78.00±15.00^{a}	75.00±6.00^{a}	59.50±24.97^{AB}
	20	19.00±12.00^{b}	52.00±15.00^{a}	65.00±12.00^{a}	63.00±16.00^{a}	49.75±22.59^{B}
	Means	22.66±8.39^{c}	62.00±14.01^{b}	75.66±14.16^{a}	71.33±12.17^{ab}	
Total phenolic (mg/100g)	Fresh	11.00±2.00^{b}	56.00±11.00^{a}	62.00±15.00^{a}	60.00±18.00^{a}	47.25±24.60^{A}
	10	15.00±4.00^{c}	51.00±11.00^{b}	68.00±6.00^{a}	56.00±9.00a^{b}	47.50±21.72^{A}
	20	9.00±4.00^{c}	45.00±13.00^{b}	72.00±9.00^{a}	51.00±13.00^{b}	44.25±25.30^{A}
	Means	11.66±4.00^{c}	50.67±11.20^{b}	67.33±10.22^{a}	55.62±12.59^{b}	

Treatments abbreviation, see Table 2.

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly ($P \leq 0.05$).

Color attributes

Color is considered as the main quality issue that entices the consumer to the product, possessing a significant impact on its acceptance. The color of carrot products is mainly attributed to its carotenoids content (Scarano *et al.,* 2018). In carrot-yoghurt beverages, the values of a* which indicate the redness (+a*) and greenness (-a*) increased with the use of carrot products. The values of b* (yellowness) increased in yoghurt beverages (YB-CDIC and YB-CHAD) in comparison with the control (Table 4). Hue angle and chroma are the parameters associated with a* and b* values. Chroma values (C*) which refer to the intensity of color had increased in YB-CDIC, YB-CHAD and YB-FCP as compared to the control. Hue (hab°) values were higher in YB-CDIC, YB-FCP and YB-CHAD than control samples. Total color difference values (ΔE), which signpost the scale of color change between control yoghurt beverages at initial time and after the addition of carrot products. It was seen that ΔE values increased with the use of carrot products (CHAD, CDIC and FCP, respectively).

Color intensities of carrot-yoghurt beverages varied, and could be defined as yellow-orange pale, and white. The yellow-orange color of yoghurt beverages may be attributed to the carrot products used. Carrot-yoghurt beverages had the most yellow-orange color as shown by having the highest a* value ($P \leq 0.05$) and more yellow in appearance (i.e., highest b* value). In contrast, control yoghurt beverage exhibited the lowest yellow color intensity (b*) with a similar degree of redness (a*). As

expected, L* values were the highest ($P \leq 0.05$) for control yoghurt beverages. Hue angle values for control and other yoghurt beverages were significantly different, which was within the predictable values of 40 to 90° transition from orange to yellow. Control yoghurt beverages had a lower ($P \leq 0.05$) hue angle. Although, when colors are close to neutral, slight variances can cause a wide difference in the determined hue angle (Wadhwani and McMahon, 2012). The whiteness index, which accounted for the lightness of yoghurt beverages was determined based on L*, a* and b* values. The whiteness index was affected by the interactions between yoghurt and carrot products. For yoghurt beverages containing carrot products, a significant decline in the whiteness parameter was obtained in comparison with the control.

Table 4. Color properties of yoghurt beverages supplemented with different sorts of carrot products during storage at 4±1°C.

Color values	Storage period (months)	Treatments				Means
		Control	YB-FCP	YB-CDIC	YB-CHAD	
L*	Fresh	81.78±1.47^{a}	67.53±3.72^{b}	57.6±2.65^{c}	53.25±2.60^{c}	65.04±11.68^{B}
	10	83.51±1.74^{a}	70.25±3.86^{b}	61.52±4.83^{c}	55.23±3.03^{c}	67.62±11.48^{AB}
	20	84.23±3.03^{a}	71.23±5.28^{b}	62.21±4.04^{b}	56.24±6.01^{b}	68.48±11.48^{A}
	Means	83.17 ±2.18^{A}	69.67±4.11^{B}	60.44±4.04^{C}	54.90±3.83^{D}	
a*	Fresh	-2.55±0.70^{c}	3.51±0.36^{b}	8.26±0.99^{a}	8.35±0.76^{a}	4.39±4.70^{C}
	10	-2.27±0.06^{c}	4.65±0.46^{b}	8.75±0.10^{a}	9.02±0.67^{a}	5.04±4.78^{B}
	20	-1.86±0.24^{c}	5.25±0.60^{b}	9.29±0.96^{a}	9.67±0.44^{a}	5.59±4.89^{A}
	Means	-2.22±0.48^{c}	4.47±0.87^{b}	8.76±0.82^{a}	9.01±0.79^{a}	
b*	Fresh	8.37±0.31^{c}	15.37±0.88^{b}	50.53±2.73^{a}	52.93±2.34^{a}	31.80±21.05^{A}
	10	9.15±0.96^{c}	16.15±1.20^{b}	50.85±2.76^{a}	53.42±2.23^{a}	32.39±20.86^{A}
	20	11.33±0.92^{c}	17.33±2.32^{b}	51.37±2.10^{a}	53.75±1.93^{a}	33.44±20.17^{A}
	Means	9.61±1.49^{d}	16.28±1.62^{c}	50.91±2.23^{b}	53.36±1.92^{a}	
C*	Fresh	8.75±0.39^{c}	15.77±0.48^{b}	51.20±5.25^{a}	53.58±2.33^{a}	32.32±21.27^{A}
	10	9.43±0.82^{c}	16.81±0.45^{b}	51.60±1.66^{a}	54.18±2.07^{a}	33.01±21.00^{A}
	20	11.48±1.77^{c}	18.11±1.15^{b}	52.20±1.05^{a}	54.61±1.64^{a}	34.10±20.36^{A}
	Means	9.88±1.58^{d}	16.89±1.21^{c}	51.66±2.84^{b}	54.12±1.81^{a}	
h_{ab}°	Fresh	-73.04±2.21^{b}	77.13±1.43^{a}	80.71±2.54^{a}	81.03±2.08^{a}	41.45±69.08^{A}
	10	-76.06±3.19^{c}	73.92±1.33^{b}	80.23±3.02^{a}	80.41±1.95^{a}	39.62±69.85A^{B}
	20	-80.67±1.69^{c}	73.14±2.07^{b}	79.74±1.52^{a}	79.80±2.55^{a}	38.00±71.63^{B}
	Means	-76.59±3.94^{c}	74.73±2.31^{b}	80.22±2.15^{a}	80.41±1.98^{a}	
WI*	Fresh	79.79±2.46^{a}	63.90±1.21^{b}	33.52±7.73^{c}	28.89±3.36^{c}	51.52±22.41^{A}
	10	81.01±1.35^{a}	65.83±3.53^{b}	35.63±2.66^{c}	29.72±2.55^{d}	53.04±22.23^{A}
	20	80.49±1.87^{a}	66.01±5.64^{b}	35.55±5.86^{c}	30.02±3.63^{c}	53.02±22.23^{A}
	Means	80.43±1.76^{a}	65.24±3.52^{b}	34.90±5.13^{c}	29.54±2.82^{d}	
ΔE	Fresh	0.00	16.99±3.16^{b}	49.79±2.57^{a}	54.02±5.23^{a}	30.20±23.74^{A}
	10	1.92±0.19^{d}	16.51±2.83^{c}	48.41±3.85^{b}	53.73±2.16^{a}	30.14±22.71^{A}
	20	3.90±1.11^{c}	15.99±3.26^{b}	47.04±6.21^{a}	52.11±4.25^{a}	29.76±21.54^{A}
	Means	1.94±1.78^{d}	16.49±2.70^{c}	48.41±4.05^{b}	53.28±3.65^{a}	

Treatments abbreviation, see Table 2.

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly ($P \leq 0.05$).

Microbiological examination:

A slight decrease in the viability of *S. thermophilus* was obvious in the different types of yoghurt beverages at the end of storage period (Table 5). Several studies have reported a minor growth of *S. thermophilus* numbers throughout 10 days of storage, and then decreased by approximately one log cycle (Birollo *et al*., 2000; Dave and Shah, 1997a; Dave and Shah, 1997b). In the current study, higher viable counts for *L. bulgaricus* than *S. thermophilus* in all types of yoghurt treatments after incubation were observed. *S. thermophilus* viability stayed beyond that of lactobacilli at the end of storage period. The supplementation with carrot products had a positive influence on starter culture bacteria, probably owing to their content of sugars and crude fibers. It seems likely that the pH drop in carrot-yoghurt beverages contributed to the higher viability of starter culture bacteria. The counts of *L. bulgaricus* tend to significantly decrease ($P \leq 0.05$) at the end of storage period. *L. bulgaricus* was able to maintain a high viability after 10 days of storage in yoghurt supplemented with CDIC and CHAD, respectively. Comparable results were established by Güler-Akın and Akın (2007), who observed a significantly higher number of *L. bulgaricus* in yoghurt incubated at 42 °C. This is different from the results of Vinderola *et al*. (2000), who found non-significant variations in *L. bulgaricus* numbers in yoghurt after roughly one month of storage at 5 °C.

During storage, the probiotic bacteria counts were found to decline in all samples (Table 5). In general, the viability of *B. lactis* BB-12 was reasonable in the different types of yoghurt beverages, and the least therapeutic content was preserved at the end of storage period suggesting that yoghurt delivered appropriate conditions for these organisms. However, the use of carrot products appeared to produce a significant positive influence on the survival of *L. acidophilus* LA-5. Kailasapathy *et al.* (2008) observed a high viability for *L. acidophilus* in stirred fruit yoghurt prepared by using commercial fruit mixes up to 5 weeks of storage. It was reported that *L. bulgaricus* could be detrimental to *L. acidophilus* because of its ability to produce hydrogen peroxide in yoghurt, which might sequentially result in a partial injury to the active *L. acidophilus* cells (Dave and Shah, 1997a; Dave and Shah, 1997b). Since the starter cultures used in the current research mainly consisted of both *L. bulgaricus* and *S. thermophilus*, *L. bulgaricus* may demonstrate an antagonistic impact on *L. acidophilus* LA-5, causing the lower viability. However, *L. acidophilus* LA-5 was able to

maintain at the least therapeutic content (>6 log cfu/g) up to 20 days of storage. This improved viability of *L. acidophilus* LA-5 in carrot yoghurt beverages may be attributed to the availability of nutrients in carrot products. *L. acidophilus* LA-5 viability was affected by the different carrot products used in the manufacture of yoghurt beverages, which is in consistent with the findings of Kailasapathy *et al.* (2008).

Table 5. Viable bacterial counts (log CFU/g) in yoghurt beverages supplemented with carrot products during storage at 4±1°C.

Microorganisms	Storage period (days)	Treatments				Means
		Control	YB-FCP	YB-CDIC	YB-CHAD	
Streptococcus thermophilus	Fresh	6.91±0.33^{a}	7.01±0.38^{a}	6.88±0.13^{a}	6.79±0.56^{a}	6.89±0.34^{A}
	10	6.64±0.61^{a}	7.25±0.52^{a}	7.41±0.28^{a}	7.32±0.69^{a}	7.16±0.56^{A}
	20	6.11±0.67^{a}	6.36±0.53^{a}	6.54±0.67^{a}	6.42±0.84^{a}	6.36±0.61^{B}
	Means	6.55±0.59^{a}	6.86±0.58^{a}	6.94±0.53^{a}	6.84±0.73^{a}	6.80±0.60
	% Viability	88.42±1.83^{c}	90.73±2.54^{bc}	95.06±2.48^{a}	94.55±0.97^{ab}	
Lactobacillus delbrueckii spp. *bulgaricus*	Fresh	7.15±0.53^{a}	7.56±0.45^{a}	7.16±0.52^{a}	7.03±0.95^{a}	7.22±0.58^{A}
	10	7.02±0.86^{a}	7.14±0.84^{a}	7.31±0.20^{a}	7.19±0.79^{a}	7.17±0.63^{A}
	20	6.31±0.67^{a}	6.66±0.36^{a}	6.86±0.45^{a}	6.71±0.97^{a}	6.64±0.59^{A}
	Means	6.83±0.72^{a}	7.12±0.64^{a}	7.11±0.41^{a}	6.98±0.81^{a}	7.01±0.65
	% Viability	88.25±1.87^{b}	88.10±4.15^{b}	95.81±0.77^{a}	95.45±0.47^{a}	
Lactobacillus acidophilus	Fresh	6.96±0.69^{a}	7.06±0.51^{a}	6.93±0.32^{a}	6.61±0.74^{a}	6.89±0.53^{A}
	10	6.76±0.89^{a}	7.24±0.71^{a}	7.59±0.42^{a}	7.33±0.65^{a}	7.23±0.66^{A}
	20	6.05±0.79^{a}	6.23±0.68^{a}	6.58±0.45^{a}	6.21±0.68^{a}	6.27±0.60^{B}
	Means	6.59±0.80^{a}	6.84±0.72^{a}	7.03±0.56^{a}	6.72±0.77^{a}	6.80±0.71
	% Viability	86.93±1.67^{b}	88.24±4.88^{b}	94.95±3.70^{a}	93.95±4.97^{a}	
Bifidobacterium lactis	Fresh	6.66±0.57^{a}	6.71±0.81^{a}	6.45±1.20^{a}	6.41±0.64^{a}	6.56±0.73^{AB}
	10	6.34±0.24^{a}	6.87±0.45^{a}	6.97±0.57^{a}	6.91±0.20^{a}	6.77±0.43^{A}
	20	6.02±0.13^{a}	6.13±0.41^{a}	6.25±0.86^{a}	6.15±0.26^{a}	6.14±0.43^{B}
	Means	6.34±0.42^{a}	6.57±0.60^{a}	6.55±0.85^{a}	6.49±0.49^{a}	6.48±0.59
	% Viability	90.39±1.86^{c}	91.36±1.90^{bc}	96.90±2.32^{a}	95.94±3.36^{ab}	

Treatments abbreviation, see Table 2.

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly ($P \leq 0.05$).

In accordance to other studies, synbiotic potential of carrot juice complemented with *Lactobacillus* spp. exposed that both bacterial strains namely *L. rhamnosus* and *L. bulgaricus* were able to grow in carrot juice, reaching approximately 5×10^{9} cfu/g after 48 hrs of fermentation, and the pH was declined to 3.5-3.7 or below (Nazzaro *et al*., 2008). In the meantime, some biochemical features of the fermented juice, for instance β-carotene content and antioxidant activity were also maintained, showing that *Lactobacillus* spp. metabolism did not destroy these constituents after storage at 4 °C for 4 weeks. The obtained results showed also that coliform, moulds and yeasts were not detected in different treatments due to the good sanitary conditions throughout processing.

Sensory evaluation:

As shown in Table 6, the yoghurt beverage scores recorded for color, body & texture, taste, and overall acceptability demonstrated that the supplementation with carrot products positively influenced the sensory attributes. Yoghurt beverages recorded higher scores for aroma and taste, probably reflecting a joined contribution from flavor compounds in carrot products and the higher viability of *L. acidophilus* LA-5, which may produce flavor compounds as well. Acetaldehyde for instance is recognized as a main flavor component in yoghurt, and the existence of Lactobacilli in the starter cultures can impact the final product content of acetaldehyde (Ekinci and Gurel, 2008; Güler-Akın and Akın, 2007). The integration of natural sugars into the yoghurt base through the use of carrot products was another key reason in the higher consumer acceptability of functional probiotic carrot-yoghurt beverages (El-Abasy *et al.,* 2012). Color and appearance of carrot-yoghurt beverages were recorded most highly for the four treatments. While among the various preparations, CDIC and FCP resulted in the highest ($P\leq0.05$) scores for overall sensory attributes. Lactic acid produced by *L. bulgaricus* may also be responsible for higher acidity taste of YB-CDIC and YB-FCP. Although carrot-yoghurt beverages demonstrated higher acidity levels compared to control yoghurt beverages, they were able to maintain higher consumer acceptability than control yoghurt beverage, possibly due to the sugar content in the added carrot products. The overall sensory scores for these products decreased with the progress in storage period. The YB-CDIC and YB-FCP treatments gained the highest scores for overall sensory attributes. However, these findings suggested that through the improvement of sensory properties with carrot (YB-CDIC and YB-FCP), functional yoghurt beverages could become more acceptable and appealing.

Table 6. Sensory evaluation of yoghurt beverages supplemented with different sorts of carrot products during storage at 4±1°C.

Parameter	Storage period (days)	Treatments				Means
		Control	YB-FCP	YB-CDIC	YB-CHAD	
Colour and appearance (9)	Fresh	8.23±0.27^{a}	8.47±0.53^{a}	8.75±0.25^{a}	7.12±0.88^{b}	8.14±0.79^{A}
	10	7.22±1.28^{ab}	7.53±0.47^{ab}	8.50±0.50^{a}	6.58±0.42^{b}	7.46±0.97^{B}
	20	6.15±0.85^{b}	7.24±0.26^{ab}	8.11±0.39^{a}	6.33±1.17^{b}	6.96±1.04^{B}
	Means	7.20±1.19^{bc}	7.75±0.67^{b}	8.45±0.44^{a}	6.68±0.84^{c}	
Aroma (9)	Fresh	8.56±0.31^{a}	8.75±0.25^{a}	8.75±0.36^{a}	7.34±0.66^{b}	8.35±0.70^{A}
	10	8.25±0.75^{ab}	8.50±0.50^{ab}	9.00±0.00^{a}	7.75±0.25^{b}	8.38±0.62^{A}
	20	7.58±0.92^{a}	8.11±0.11^{a}	8.57±0.43^{a}	7.25±1.33^{a}	7.88±0.89^{A}
	Means	8.13±0.75^{b}	8.45±0.40^{ab}	8.77±0.31^{a}	7.45±0.78^{c}	
Body and texture (9)	Fresh	8.53±0.43^{a}	8.06±0.44^{a}	8.75±0.25^{a}	8.44±0.56^{a}	8.44±0.45^{A}
	10	7.25±0.75^{a}	7.50±0.50^{ab}	8.57±0.43^{a}	7.11±0.89^{a}	7.61±0.82^{B}
	20	6.45±0.45^{b}	6.58±0.92^{b}	8.29±0.71^{a}	6.48±0.52^{b}	6.95±0.99^{C}
	Means	7.41±1.03^{b}	7.38±0.86^{b}	8.54±0.48^{a}	7.34±1.05^{b}	
Taste (9)	Fresh	8.53±0.43^{a}	8.58±0.33^{a}	8.75±0.26^{a}	8.18±0.32^{a}	8.52±0.37^{A}
	10	9.00±.00^{a}	9.00±.00^{a}	8.75±0.25^{ab}	7.50±1.00^{b}	8.50±0.79^{A}
	20	8.14±0.14^{a}	8.27±0.23^{a}	8.58±0.42^{a}	7.16±0.84^{b}	8.04±0.69^{B}
	Means	8.56±0.44^{a}	8.62±0.38^{a}	8.61±0.35^{a}	7.60±0.81^{b}	
Overall acceptability (9)	Fresh	8.24±0.26^{ab}	8.57±0.43^{ab}	8.75±0.25^{a}	7.13±1.37^{b}	8.17±0.91^{A}
	10	7.80±0.80^{ab}	8.00±0.50^{a}	8.50±0.50^{a}	6.58±0.92^{b}	7.72±0.95^{A}
	20	6.38±0.38^{c}	7.28±0.28^{b}	8.25±0.25^{a}	6.27±0.73^{c}	7.05±0.92^{B}
	Means	7.47±0.96^{b}	7.95±0.66^{ab}	8.50±0.37^{a}	6.66±0.98^{c}	
Total scores (45)	Fresh	42.09±0.62^{ab}	42.43±0.82^{a}	43.75±1.25^{a}	38.21±3.79^{b}	41.62±2.78^{A}
	10	39.52±1.98^{ab}	40.53±1.97^{a}	43.57±0.43^{a}	35.52±3.48^{b}	39.79±3.56^{A}
	20	34.70±0.80^{b}	37.48±1.02^{ab}	41.80±1.70^{a}	33.49±4.59^{b}	36.87±3.97^{B}
	Means	38.77±3.43^{b}	40.14±2.46^{b}	43.04±1.42^{a}	35.74±4.01^{c}	

Treatments abbreviations, see Table 2.

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly ($P \leq 0.05$).

CONCLUSION

The present study introduced a novel functional probiotic yoghurt beverage. The physicochemical, rheological, microbiological, and organoleptic properties of yoghurt beverages supplemented with different sorts of carrot (including 5% of FCP, CDIC, and CHAD) were evaluated. The obtained results showed that total solids, protein, fat, and ash contents were higher in carrot-yoghurt beverages compared to the control sample. In addition, there was a gradual reduction in total phenolic compounds and antioxidant activities after 10 and 20 days of storage. The WHC of YB-CDIC and YB-CHAD treatments was significantly higher than that of control and YB-FCP. Furthermore, the STS% of YB-CDIC and YB-CHAD treatments was significantly lower than that of control and YB-FCP. The viscosity of yoghurt beverages had significantly increased with the use of CDIC and CHAD, respectively. The use of carrot products had a positive influence on the viability of starter culture bacteria. The overall sensory scores for these products decreased with the progress in storage period, while YB-CDIC and YB-FCP treatments gained the highest scores for sensory attributes. The obtained results would open the way for the incorporation of carrot products in other dairy products for enhanced functional products.

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مشروبات اليوغورت الوظيفية المدعمة بأنواع مختلفة من منتجات الجزر

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تم تدعيم مشروبات اليوغورت بأنواع مختلفة من منتجات الجزر: 5٪ من لب الجزر الطازج (FCP) ، الجزر المجفف بتكنولوجيا الإنتفاش DIC (CDIC)، الجزر المعالج بالتجفيف بالهواء الساخن (CHAD). تم تحليل المعاملات المختلفة للخصائص الفيزيائية والكيميائية واللون والخصائص الريولوجية والتقييم الميكروبيولوجي والخصائص الحسية وهي طازجة وبعد 10 و 20 يوماً من التخزين عند 4 ± 1 درجة مئوية. أظهرت النتائج أن محتوى المواد الصلبة الكلية والبروتين والدهون والرماد كان أعلى في مشروبات اليوغورت المدعمة مقارنة بعينات المقارنة. بالإضافة إلى ذلك، كان هناك انخفاض تدريجي في محتوى الفينول الكلي ومضادات الأكسدة بعد 10 و20 يوماً من التخزين، على التوالي. علاوة على ذلك، أظهرت المعاملات المدعمة بـ CDIC و CHAD قدرة أعلى على الاحتفاظ بالماء. كان لإضافة منتجات الجزر تأثير إيجابي على بكتيريا البادئ، أصبح عدد الخلايا الحيوية الحية طوال فترة صلاحية المنتج أعلى من الحد الأدنى المطلوب في المنتج الحيوي البروبيوتيك (أكثر من 6 لوغاريتمات وحدة مكونة للمستعمرة/جرام) في كل المعاملات بصفة عامة وكانت أعلى في المعاملات المحتوية على CDIC و CHAD، وحصلت المعاملات المدعمة بـ CDIC و FCP على أعلى الدرجات في تقييم الحسى.