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Physicochemical, microbiological and sensory properties of carrot juice fortified set-style yoghurt

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Abstract

An attempt has been made to develop carrot juice-based set-style yoghurt for enriched nutritional and therapeutic properties. Yoghurts were fortified with carrot juice at a ratio of 10%, 20%, 30%, 40% and 50% and were analyzed for physicochemical properties, bioactive compound (total phenolic content, total flavonoid content, vitamin C, antioxidants and β-carotene content) and organoleptic properties. Fortification of carrot juice significantly ($p<0.01$) increased the percentage of carbohydrates (35.47 to 42.92%), ash (0.57 to 0.87%), total solid (50.5 to 52.61%), solids non-fat (45.77 to 49.37%) and fibre (0.36 to 0.46%), and significantly ($p<0.01$) decreased the percentage of fat (4.73 to 3.24%). Similar increase in bioactive compounds also found with the fortification of carrot juice e.g., β-carotene (0.00 to 4.43 mg/100 g), antioxidant activity (18.29 to 48.42 %), TPC (0.00 to 15.44 mg/100 g), TFC (0.00 to 5.18 mg/100 g) and vitamin C (0.76 to 1.28 mg/100 g). No yeast, mould and coliform were observed in any yoghurt samples. The sensory analysis suggested that yoghurt fortified with 30% carrot juice was the best with the highest overall acceptability (8.4) along with the lowest syneresis (10.81%). The addition of carrot juice above this concentration started decreasing the scores of good qualities of the fortified yoghurts. Taking into account all findings, we concluded that carrot juice could be added up to 30% for large-scale production of fortified yoghurt.

1. Introduction

The development of diversified dairy products such as fruits and vegetables fortified yoghurts will significantly contribute to the food manufacturer and will also add a new dimension to the dairy food varieties in Bangladesh. Yoghurt is a fermented milk product, which has gained great popularity around the world owing to its therapeutic, nutritional and sensory properties (Cakmakci *et al.,* 2014). It is considered a healthy food because of its probiotic effects such as assimilation of protein and calcium, protection against gastrointestinal complications, lowering blood cholesterol, decreasing the risk of cancer, enhancing digestion of lactose and production of short-chain fatty acids (Gahruie *et al.,* 2015). Owing to these nutritional and healthy properties, worldwide consumption of yoghurt has been increasing day by day (Aryana and Olson, 2017). If regular yoghurt is fortified with fruits and vegetables then it contributes as prebiotics (fibres) (Allgeyer *et al.,* 2010). Fortification enhances colour and flavours (Smith and Hui, 2008) and also enriches the yoghurt with a bulk of natural photochemical antioxidants (carotenoids, flavonoids and phenols) (Dimitrios, 2006). Carrot (*Daucus carota L.)* is rich in carbohydrates, dietary fibre, calcium, phosphorus, iron, potassium, magnesium, copper, manganese, sulfur, vitamin C and phenolic compounds (Hashimoto and Nagayama, 2004) but deficient in protein and fat (Kiros *et al.,* 2016). On the other hand, regular yoghurt is rich in protein, fat, calcium, potassium, B vitamins (B1, B2, B6, nicotinic and pantothenic acids) but deficient in iron, vitamin C, carotenes and dietary fibres (Gahruie *et al.,* 2015). Fruit and milk are one such mixture in which the antioxidant capacity of fruit constituents can be delivered in combination with the health benefits of milk (Wegrzyn *et al.,* 2008). Expectedly, a combination of carrot juice and yoghurt will produce a nutritionally balanced food by improving the functional properties of yoghurt (Kiros *et al.,* 2016). These products may be particularly useful in places where there is inadequate nutrition as milk-based beverages have been proved to be ideal vehicles for newly discovered bioactive food ingredients (Shukla *et al.,* 2003). Considering the fact that the incorporation of carrot juice in yoghurt

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formulation could increase nutritional value and improve physicochemical properties, this work aimed to study the various physicochemical, microbiological and sensory characteristics of set-style yoghurt and also to find out the optimized level of carrot juice fortification to prepare nutritionally enriched yoghurt with the best sensory attributes along with the lowest syneresis.

2. Materials and methods

2.1 Milk samples and ingredients

Cow's fresh whole milk and carrots (*Daucus carota L.*) were collected from the local market of Tangail, Bangladesh. Cane sugar (sweetener) was also purchased from the local market. Refrigerated yoghurt used as a starter culture was also purchased from the local supermarket.

2.2 Preparation of carrot juice

Collected carrot (*Daucus carota L.*) roots were washed and peeled thoroughly. Both ends of the roots were removed. Then the roots were cut longitudinally into halves with a sharp knife. These halves were steam-blanched for 2 mins to inactivate pectinase and peroxidase and to tenderize the carrot tissues (Salwa *et al.,* 2004). The prepared halves were homogenized in a mechanical blender (Panasonic MX-AC 300) and the mixture was filtered with a clean muslin cloth to extract carrot juice.

2.3 Yoghurt formulation

Before starting the yoghurt processing, the necessary apparatuses were washed, cleaned and sterilized. Collected cow milk was divided into equal six parts. Carrot juice was added to each part of the milk sample at 10%, 20%, 30%, 40% and 50%. One part of milk was kept as a control sample and no carrot juice was added. All samples were pre-heated at 60-65°C for 5 mins. Thereafter sugar was added to the samples. Then, the mixer was heated at 90°C for 10-12 mins to reduce the volume to 1/3 of the total volume. Next, the mixer was cooled to 40°C using running tap water. Commercial yoghurt as starter culture (0.2 g/L) was inoculated in the mixture. Prepared mixtures were incubated at 42°C for 6 hrs. After incubation, the yoghurt samples were immediately cooled by transferring them from the incubator to a refrigerator (4°C). The final samples were coded according to the percentage of fortification of cow's milk with carrot juice. Control, 10%, 20%, 30%, 40% and 50% carrot juice fortified yoghurts were coded as CJ 0, CJ 10, CJ 20, CJ 30, CJ 40 and CJ 50 respectively.

2.4 Proximate composition of carrot juice and yoghurt

Carrot juice and yoghurt samples were analyzed for moisture, fat, protein, ash and fibre content according to AOAC (1980). The total soluble solids (TSS) (°Bx) of the fresh carrot juice was determined by hand refractometer (AOAC, 2000). However, the total solids content of yoghurt (IDF, 1991) and solids-not-fat (Kiros *et al.,* 2016) were determined by using equation 1 and 2 respectively.

$$\text{Total solids (TS) \%} = 100 - \text{Moisture \%} \quad (1)$$

$$\text{Solids-non-fat} = \text{Total solids (TS) \%} - \text{Fat \%} \quad (2)$$

2.5 Bioactive compound of carrot juice and yoghurt

Vitamin C content was determined according to the 2, 6-dichloroindophenol titrimetric method (AOAC, 1990) and β-carotene was estimated according to AOAC (1980).

2.6 Antioxidant activity of carrot juice and yoghurt

The DPPH radical scavenging capacity of each sample was determined according to Miliauskas *et al.* (2004). The colour of the mixture containing the DPPH (2,2-diphenyl–picrylhydrazyl) turned from deep violet to yellow. The higher the antioxidant activity the faster the discolouration rate. The absorption was measured using a spectrophotometer (MODEL: T60 U, S/N: 18-1650-01-1010 AC230V) (50-60Hz 150W) at 515 nm. The following formula was used for calculating radical scavenging activity.

$$\text{DPPH Scavenged(\%)} = \frac{\text{(Absorbance of DPPH solution} - \text{Absorbance in the presence of sample extract)}}{\text{Absorbance of DPPH solution}} \times 100 \quad (3)$$

2.7 Total phenolic compound and total flavonoid compound of carrot juice and yoghurt

The total phenolic compound (TPC) was determined by the method of Song *et al.* (2010) using Folin-Ciocalteo reagent. The absorbance of samples was measured at 765 nm against blank solution and expressed as gallic acid equivalent (mg GAE/g dry weight). The total flavonoid compound (TFC) was determined by the aluminium chloride colourimetric method (Miliauskas *et al.,* 2004). Quercetin was used as standard and flavonoid content was determined as quercetin equivalent. Quercetin (1 g) was dissolved in 100 mL methanol to make a 1% solution. A standard quercetin curve was constructed by preparing the dilutions of (0.1, 0.5, 1.0, 2.5 and 5 mg/mL) concentration prepared in methanol. Quercetin dilution (100 µL of each) was added to 500 µL of distilled water and then sodium nitrate (100 µL of 5% sodium nitrate) was mixed. The mixer was allowed to stand for 6 mins. Then 150 µL of 10% aluminium chloride solution was added and allowed to stand for 5 mins after which 200 μL solution of 1M sodium hydroxide was added sequentially. The absorbance of this reaction mixture was recorded at 510 nm on a UV spectrophotometer. The same procedure was repeated with a stock solution.

2.8 Physicochemical analysis of carrot juice and yoghurt

The pH was determined by a glass electrode attached to the pH meter (STARTER 3100) with a temperature probe. The pH meter was calibrated with three different standard solutions such as pH: 4.1 (acid), 7 (neutral) and 10 (buffer) before final measurements (Kumar *et al.,* 2018). Titratable acidity (TA) of the mixture was determined by titrating against 0.1N NaOH (Caric *et al.,* 2000) and TA was expressed as a percentage of lactic acid. The viscosity of yoghurt was determined by Laboratory Viscometer (DVS-80S, Occulab) machine at 60 rpm rotor speed for 2 mins. Syneresis of yoghurt samples was done according to Hassan *et al.* (2015). Set yoghurt (25 mL) was slowly transferred to 50 mL capacity centrifuge tubes causing minimum disturbance to the coagulum. The mixer was centrifuged at 3394 rpm in a centrifuge (Make-Remi, India) for 20 mins. The quantity of whey separated at the top of the coagulum inside centrifuge tubes was recorded as mL. The weight fraction of the supernatant liquid was used as an index of whey syneresis (%).

2.9 Microbiological analysis of yoghurt

Approximately 1 g of yoghurt sample was taken into a culture tube and dissolved with 9 mL of peptone water. Plate count agar was used as the culture media for the determination of the total plate count. The culture media was incubated at 36°C for 48 hrs. A colony counter (Stuart: SC6 PLUS) was used for the enumeration of the total plate count. Yeast and mould counts were determined by inoculating the sample on potato dextrose agar and incubated at 25°C for 5 days (Harringan and Mccance, 1976). The coliform count was determined using Violet Red Bile Agar (VRBA) by the pour plate technique (Richardson, 1985). Plates were incubated at 30°C for 24 hrs. Typical dark red colonies (>0.5 mm diameter) were considered coliforms and the results were reported as counts per gram of yoghurt.

2.10 Sensory analysis of yoghurt

Ten semi-trained panellists from the faculties and students of the Food Technology and Nutritional Science Department, Mawlana Bhashani Science and Technology University, Tangail, Bangladesh assessed the sensory quality of yoghurts. Sensory evaluation of control and carrot yoghurts was carried out to determine their organoleptic characteristics such as colour, flavour, taste, texture and overall acceptability. A nine-point hedonic scale varying from dislike extremely (score 1) to like extremely (score 9) was used (Wichchukita and O'Mahonyc, 2014). The sample presentation order was randomized among and within assessors (Hashim *et al.,* 2009). The panellists were chosen based on their willingness, availability and motivation.

2.11 Statistical analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS version 20.0 SPSS Inc. Chicago, Illinois, USA). One-way ANOVA (Tukey's test) was used for determining the significance/non-significance of results at a 95% confidence interval. Microsoft Excel version 10.0 was used for graphic illustration. The correlation was established using the Pearson chi-square test at 0.01 and 0.05 levels of significance.

3. Results and discussion

3.1 Composition of milk and carrot juice

Total solids, water, solids-not-fat, protein, fat and ash contents of cow milk were 12.4, 87.6, 9.1, 3.0, 3.3 and 0.7 (%w/w, fresh basis), respectively and are typical values reported for cow milk (Claeys *et al.,* 2014).

It was observed that fresh carrot juice contained 8.17% carbohydrate, 0.57% fat and 0.77% protein (Table 1). The ash content was found to be 0.89%; the reason for the lesser value of ash might be because of some processes involved when making the carrot juice i.e. the juice was extracted and the chaff was discarded. The moisture content was found to be 89.16% which implies that carrot has a shorter life span because the higher the moisture in a sample, the higher the growth of microorganisms on it to disrupt its constituents. It was also revealed that fresh carrot juice contained 8.15% total soluble solids, which is in agreement with the previous findings of Moza (2010). Furthermore, the value of the crude fibre was recorded at 1.176%. The mean values of titrable acidity and pH were found to be 0.06% and 6.13, respectively which are in accordance with the findings of Zadernowski *et al.* (2010). Among the bioactive compounds, carrot juice contained 9.75 mg/100 g β-carotene and 4.97 mg/100 g vitamin C; indicating a good source of bioactive compounds which are in agreement with the previous findings of Leahu *et al.* (2013). The antioxidant activity of raw carrot juice was found to be 24.39%. The total phenolic content and flavonoid content was found to be 59.2 and 19.13 mg/100 g respectively.

3.2 Proximate composition of the yoghurt

The proximate composition of set-style yoghurt

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Table 1. Composition of fresh carrot juice

Proximate Composition								
Carbohydrate (%)	Fat (%)	Ash (%)	Moisture (%)	TSS (%)	Fibre (%)	Protein (%)	Acidity (%)	pH
8.17±0.35	0.57±0.11	0.89±0.12	89.16±0.6	8.15±0.17	1.176±0.15	0.77±0.86	0.06±0.03	6.13±0.05

Bioactive composition				
β-carotene (mg/100 g)	Antioxidant activity (%)	Total Phenolic Content (mg/100 g)	Total Flavonoid Content (mg/100 g)	Vitamin C (mg/100 g)
9.75±0.09	24.39±0.93	59.2±1.01	19.13±0.97	4.97±1.23

Values are presented as mean±SD of three replicates.

Table 2. Proximate composition of set-style yoghurts fortified with various levels of carrot juice

Parameters	Carrot juice fortification (%, w/w)						p-value
	CJ 0	CJ 10	CJ 20	CJ 30	CJ 40	CJ 50	(χ^2)
Carbohydrate (%)	35.47±0.35^a	36.80±0.51^a	38.51±0.52^b	40.34±0.32^c	41.98±0.41^c	42.92±0.24^c	0.000** (0.997)
Fat (%)	4.73±0.21^a	4.32±0.11^a	4.01±0.23^a	3.89±0.14^b	3.67±0.16^b	3.24±0.26^c	0.000** (-0.986)
Ash (%)	0.57±0.04^a	0.64±0.03^b	0.68±0.03^b	0.72±0.02^c	0.78±0.02^c	0.87±0.04^c	0.000** (0.99)
Moisture (%)	49.50±0.26^a	48.90±0.46^{ab}	48.36±0.29^{ab}	47.74±0.51^b	47.62±0.55^b	47.39±0.29^b	0.001** (-0.980)
Total solid (%)	50.5±0.26^a	51.1±0.46^{ab}	51.64±0.29^{ab}	52.26±0.51^b	52.38±0.55^b	52.61±0.29^b	0.001** (0.974)
Solids-non-fat (%)	45.77±0.21^a	46.78±0.11^a	47.63±0.23^a	48.37±0.14^b	48.71±0.16^b	49.37±0.26^c	0.000** (0.988)
Fiber (%)	0.36±0.01^a	0.38±0.02^a	0.41±0.01^b	0.42±0.01^b	0.44±0.01^b	0.46±0.02^c	0.000** (0.994)
Protein (%)	9.37±0.11^a	8.96±0.19^b	8.03±0.21^b	6.89±0.08^c	5.51±0.28^{ab}	5.12±0.32^{ab}	0.000** (-0.988)

Values are presented as mean±SD of three replicates. Values with different superscript within the same row are significantly different ($p<0.05$). **$p<0.01$ level. CJ 0: No carrot juice added, CJ 10: 10% carrot juice, CJ 20: 20% carrot juice, CJ 30: 30% carrot juice, CJ 40: 40% carrot juice and CJ 50: 50% carrot juice.

fortified with carrot juice varied widely (Table 2).

Carrot juice fortification affected the proximate composition of yoghurt significantly ($p<0.01$). Increasing carrot juice fortification to set-style yoghurts significantly ($p<0.01$) increased carbohydrate, total solid, solids-non-fat, fibre and ash content whereas significantly ($p<0.01$) decreased fat, moisture and protein content (Table 2). A significantly higher amount of carbohydrate, ash, total solid, solids-non-fat and fibre was found in CJ50 yoghurt whereas the lowest value was observed in control yoghurt (CJ 0). The higher sugar and crude fibre content of carrots may contribute to this increment. A similar observation was also reported by Salwa *et al.* (2004) and Cliff *et al.* (2013). The protein content of fortified yoghurt decreased with the increasing incorporation of carrot juice. Similarly, a decreasing trend in fat content was observed with the increasing incorporation of carrot juice in yoghurt. Similar results were also reported by Kucukoner and Tarakci (2003) and Bakirci and Kavaz (2008). This expected variation in the proximate composition was due to differences in the formulation of the yoghurts.

3.3 Bioactive compounds of the yoghurt

Fortification of carrot juice significantly ($p<0.01$) affected the entire bioactive compound content (Table 3). All the bioactive compounds in yoghurt significantly increased with the increase in carrot juice fortification. Therefore, it would be useful for the human diet with the fortification of carrot juice (Cakmakci *et al.,* 2014). The control sample (CJ 0), which was prepared solely with milk, had no β-carotene (0.00 mg/100 g) whereas the highest β-carotene content was determined in CJ 50 (4.43 mg/100 g). Carrot juice fortified yoghurts contained β-carotene ranging from 0.94 to 4.43 mg/100 g. A significant increase in the β-carotene content of the yoghurts was found with a gradual increase in carrot juice fortification. The antioxidant activity of the yoghurts was expressed as radical scavenging acidity (RSA%). The antioxidant activity was found highest in CJ 50 sample (48.42 mg/100 g) whereas the lowest was in CJ 0 (18.29 mg/100 g) (Table 3). The antioxidant activity also significantly ($p<0.01$) increased with the gradual increase of fortification of carrot juice. A similar increasing trend was also reported for TPC, TFC and vitamin C (Table 3).

CJ 50 yoghurt sample contained a significantly

Table 3. Bioactive compounds of set-style yoghurt fortified with various levels of carrot juice

Carrot juice (%)	β-Carotene (mg/100 g)	Antioxidant activity (%)	TPC (mg/100 g)	TFC (mg/100 g)	Vitamin C (mg/100 g)
CJ 0	0.00^{e}	18.29 ± 0.75^{a}	0.00^{a}	0.00^{a}	0.76 ± 0.02^{a}
CJ 10	0.94 ± 0.19^{ab}	41.11 ± 0.43^{b}	2.54 ± 0.19^{b}	0.75 ± 0.24^{b}	0.79 ± 0.01^{a}
CJ 20	1.74 ± 0.51^{b}	42.51 ± 0.41^{b}	5.51 ± 0.33^{c}	1.38 ± 0.38^{c}	0.85 ± 0.05^{b}
CJ 30	2.26 ± 0.36^{c}	44.49 ± 0.52^{c}	9.09 ± 0.51^{d}	2.05 ± 0.13^{ab}	0.92 ± 0.02^{b}
CJ 40	3.59 ± 0.71^{ca}	45.89 ± 0.61^{c}	13.19 ± 0.35^{ab}	2.44 ± 0.25^{ab}	1.23 ± 0.06^{c}
CJ 50	4.43 ± 0.16^{d}	48.42 ± 0.95^{ab}	15.44 ± 0.46^{bc}	5.18 ± 0.23^{ca}	1.28 ± 0.04^{c}
p-value (χ^2)	0.000** (0.995)	0.050^{*} (0.812)	0.000** (0.997)	0.006* (0.938)	0.005** (0.941)

Values are presented as mean±SD of three replicates. Values with different superscript within the same row are significantly different ($p<0.05$). ** $p<0.01$. * $p<0.05$. TPC: Total Phenolic Content. TFC: Total Flavonoid Content. CJ 0: No carrot juice added, CJ 10: 10% carrot juice, CJ 20: 20% carrot juice, CJ 30: 30% carrot juice, CJ 40: 40% carrot juice and CJ 50: 50% carrot juice.

higher ($p<0.05$) amount of all forms of bioactive compounds than other samples. El-Abasy *et al*. (2012) revealed that mixes of carrot juice and some fermented dairy products' potentiality increase the bioactive compounds of the product.

3.4 Physicochemical properties of yoghurt

The different levels of carrot juice fortification in set -style yoghurt significantly affected various physicochemical properties such as pH, acidity, viscosity and syneresis (Table 4). Fortification of carrot juice significantly ($p<0.01$) affected the pH and acidity of the formulated yoghurt samples. A negative correlation (χ^2 = -0.970) was observed between the carrot juice fortification and the pH of the yoghurt samples. It indicates that increasing carrot juice percentage in yoghurt formulation results in decreasing pH value that contributes to increasing acidity. This decrease in pH values in all yoghurts might be due to competition among various organisms present in the fermented yoghurts such that they are inhibited by the fermentation process until one organism became dominant and out-competed the others by a process of natural selection and succession (Ramaite, 2004). This could be a result of the ability of these organisms to produce a high quantity of organic acids and live within an acidic environment (Fowoyo and Ogunbanwo, 2010). The lowest pH value (4.28) was exhibited by CJ 50 sample with the highest acidity (1.13%) due to lactic acid development. Roy *et al.* (2015) observed a similar effect of fruit juice in the activity of yoghurt cultures. The lactic acid bacteria growing in milk respond to a variety of plant and animal extracts showing increased acid production.

The fortification of carrot juice did not influence the viscosity of the yoghurts. The highest viscosity was determined in CJ 30 (4776.67 mPa.s) whereas the lowest was in CJ 50 (2260.00 mPa.s), which indicates that the higher percentage of carrot juice fortification lowers the viscosity values. The addition of fruit or fruit juice decreases the water-holding capacity of protein in yoghurts which may cause a decrease in the viscosity (Cakmakci *et al.,* 2014). Syneresis or whey separation is one of the important quality parameters of yoghurts. It is a major defect in yoghurt production that could limit the shelf life and acceptability because of imparting undesirable appearances (Kiros *et al.,* 2016). A higher value of syneresis shows that yoghurt is of low quality (Mahmood *et al.,* 2008). The highest value of syneresis (21.21%) was observed in CJ 50 yoghurts which indicate its low quality, and the lowest value (10.81%) was found in CJ 30 yoghurts (Table 4). Similar syneresis results were reported by Kucukcetin *et al.* (2011).

Table 4. Physicochemical analysis of set-style yoghurt fortified with various levels of carrot juice

Carrot Juice (%)	pH	Acidity (%)	Viscosity (mPa.s)	Syneresis (%)
CJ 0	4.62 ± 0.01^{a}	0.72 ± 0.02^{a}	4050.00 ± 30.00^{a}	13.63 ± 0.21^{a}
CJ 10	4.54 ± 0.01^{a}	0.77 ± 0.02^{a}	4193.33 ± 40.41^{b}	12.50 ± 0.18^{a}
CJ 20	4.41 ± 0.01^{b}	0.85 ± 0.01^{b}	4506.00 ± 30.55^{c}	11.24 ± 0.14^{b}
CJ 30	4.35 ± 0.00^{ca}	0.97 ± 0.01^{ab}	4776.67 ± 32.14^{ab}	10.81 ± 0.13^{b}
CJ 40	4.32 ± 0.01^{ca}	0.98 ± 0.01^{ab}	3743.33 ± 30.55^{ca}	15.55 ± 0.28^{c}
CJ 50	4.28 ± 0.02^{c}	1.13 ± 0.03^{c}	2260.00 ± 20.00^{bc}	21.21 ± 0.33^{ab}
p-value	0.001**	0.000**	0.205^{NS}	0.166^{NS}
(χ^2)	(-0.970)	(0.983)	(-0.603)	(0.646)

Values are presented as mean±SD of three replicates. Values with different superscript within the same row are significantly different ($p<0.05$). ** $p<0.01$. NS: Not significant. CJ 0: No carrot juice added, CJ 10: 10% carrot juice, CJ 20: 20% carrot juice, CJ 30: 30% carrot juice, CJ 40: 40% carrot juice and CJ 50: 50% carrot juice.

3.5 Microbiological analysis of yoghurt

Microbiological analysis revealed that the fortification of carrot juice in yoghurts significantly ($p<0.01$) influenced the bacterial count. A negative correlation was observed between bacterial count and juice fortification percentage (Table 5).

The level of acidity of yoghurts increased with the increase in the carrot juice fortification (Table 4). The highest acidity was observed in CJ 50 (Table 4) and expectedly the lowest bacterial count was found in this yoghurt (Table 5). Besides higher acidity, the inhibitory effect of lactic acid produced and the lower carbon source occurring during fermentation eventually leads to low viable counts (Shima *et al.,* 2009). No significant ($p>0.05$) difference in the bacterial count was observed between CJ 10 and CJ 20; and between CJ 30 and CJ 40 yoghurts. The control sample (CJ 0) had a significantly ($p<0.05$) higher bacterial count (1.3×10^4 CFU/mL) compared to any experimental samples. There was no growth of yeast and mould observed in any yoghurts. Moreover, no coliform viable cells were detected in any of the yoghurts. Our results are in agreement with the previous findings which reported that carrot has an inhibitory effect on the growth of microorganisms, especially on mould, yeast and coliform (Salwa *et al.,* 2004; Fowoyo and Ogunbanwo 2010).

3.6 Sensory attributes of yoghurt

All the sensory attributes of formulated yoghurts (except CJ 40) were found significantly different ($p<0.05$) from that of control yoghurt. According to the evaluation of the panellists, the flavour and the taste of samples were satisfactory and sweet, while the colour and appearance of samples were classified as normal [Figure 1(b)]. Increasing the carrot juice fortification by up to 30% increased the sensory scores. Fortification above this concentration started decreasing the scores.

The sensory attributes of fortified yoghurt with different carrot juice percentages were better, particularly yoghurt fortified with 30% (CJ 30) carrot juice. CJ 30 gave significantly ($p<0.05$) the highest sensory scores for all the sensory attributes *viz.* colour, flavour, texture, taste and overall acceptability. Considering all of these, the panellists appreciated and chose yoghurt CJ 30 as the most favourable. Significantly ($p<0.05$) the lowest sensory scores were recorded for CJ 50 yoghurt regarding all the sensory parameters viz. colour, flavour, texture and overall acceptability. The sensory scores of this study are similar to the findings of El-Abasy *et al*. (2012) who reported that the addition of carrot juice at 4:1 level to the yoghurt gives better sensory qualities.

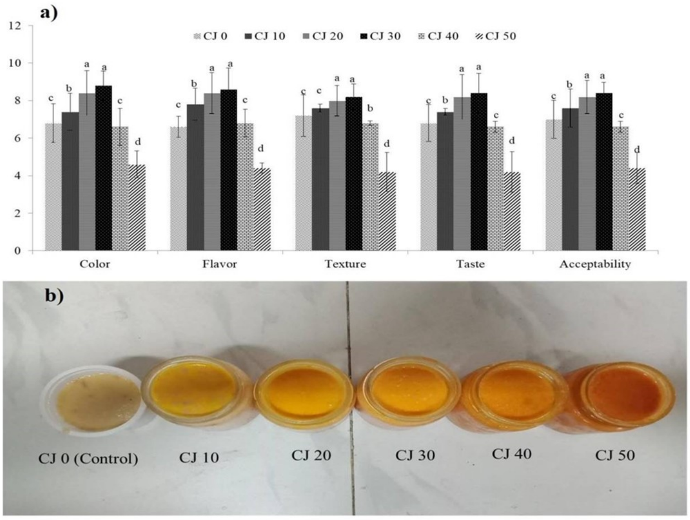

Figure 1. a) Average score of sensory parameters perceived by panelist. Bars with different notations are statistically different ($p<0.05$) among sensory scores; b) Macroscopic appearance of control and carrot juice fortified yoghurt after manufacture. CJ 0: No carrot juice added, CJ 10: 10% carrot juice, CJ 20: 20% carrot juice, CJ 30: 30% carrot juice, CJ 40: 40% carrot juice and CJ 50: 50% carrot juice.

4. Conclusion

Value addition in set-style yoghurt by incorporation of carrot juice is a new concept in Bangladesh. It is strongly evident from this study that the fortification of carrot juice significantly affects the proximate composition, bioactive composition, microbial growth

Table 5. Microbiological analysis of set-style yoghurt fortified with various levels of carrot juice

Carrot juice (%)	Total Plate Count (CFU/mL)	Yeast and Mold (CFU/mL)	Coliform Count (CFU/mL)
CJ 0	1.3×10^{4a}	Nil	ND
CJ 10	1.2×10^{4bc}	Nil	ND
CJ 20	1.2×10^{4bc}	Nil	ND
CJ 30	1×10^{4c}	Nil	ND
CJ 40	1×10^{4c}	Nil	ND
CJ 50	0.8×10^{4d}	Nil	ND
p-value	0.002**		
(χ^2)	(-0.961)		

Values are presented as mean±SD of three replicates. Values with different superscript within the same row are significantly different ($p<0.05$). **$p< 0.01$. NS: Not significant. CJ 0: No carrot juice added, CJ 10: 10% carrot juice, CJ 20: 20% carrot juice, CJ 30: 30% carrot juice, CJ 40: 40% carrot juice and CJ 50: 50% carrot juice.

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and organoleptic properties of yoghurt. The bioactive compounds mainly β-carotene, total phenolic content, total flavonoid component, antioxidant activity and vitamin C content increased significantly after the addition of carrot juice and leads to enhancing the functional properties of yoghurt. Carrot juice addition to yoghurt also reduced the total viable bacteria count in yoghurt. The findings of this study highlighted the possibility of processing yoghurt with up to 30% carrot juice fortification resulted in maintaining good characteristics of organoleptic examination with the lowest syneresis. Hence the study concluded that carrot juice could be used in the manufacturing of set-type yoghurt. However, yoghurt with a 30% level of carrot juice incorporation could be selected for further trials and commercial processing before large-scale production.

Conflict of interest

The authors declare no conflict of interest.

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