Turkish Journal of Agriculture - Food Science and Technology, 11(12): 2300-2307, 2023
DOI: https://doi.org/10.24925/turjaf.v11i12.2300-2307.6187

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Fortification of Yogurt with Red Dragon Fruit's (*Hylocereus Polyrhizus*) Peel Powder: Effects on Comprehensive Quality Attributes and Sensory Properties

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ARTICLE INFO

Research Article

Received : 15-06-2023
Accepted : 16-10-2023

Keywords:
Red dragon fruit peel
Fortified yogurt
Quality attributes
Antioxidant activity
Sensory evaluation

ABSTRACT

This study was conducted to evaluate the quality features, antioxidant capabilities, microbiological and sensory aspects of yogurt fortified with 2%, 5%, and 7% red dragon (RD) peel powder. The yogurt was formulated using the classical technology adapted to laboratory conditions. The results of the physicochemical properties showed significant differences in pH (4.73–4.36), acidity (0.18–0.16 g lactic acid/100 g), and ascorbic acid (1.17-1.34 mg/100 g) among different yogurt formulations ($P<0.05$). In addition, RD peel powder fortification showed increasing trends in crude fiber (1.53-3.34 g/100 g), ash (5.19-5.29 g/100 g), and moisture (76.70-80.19 g/100 g) content, respectively; while the reversed trend was observed for fat (3.48-2.36 g/100 g), and crude protein (4.49-4.07 g/100 g) contents, respectively. Furthermore, gradual progression of RD peel powder in fortified yogurt manifested an improvement of the overall antioxidant activity (1.30-1.57 μmol TE/mL). The analyses of the sensory properties demonstrated that yogurt with RD peel powder in proportions of 2% received the highest hedonic score for consumer approval. Moreover, no coliform was reported in any of the control and fortified yogurts. Therefore, it could be concluded that RD peel powder can be employed as a functional food constituent in yogurt with improved quality attributes and sensory properties compared to plain yogurt.

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Introduction

Modern food industries generate millions of tons of waste during processing, which poses serious threat to our ecosystem, the economy, and public health. Agricultural wastes are full of bioactive phytochemicals, such as vitamins, phenolic compounds, carotenoids, essential oils, dietary fibers, polysaccharides, antioxidants, and pigments (Dueñas and García-Estévez, 2020). These potential bioactive compounds have the ability to provide numerous health benefits and can be used in food and pharmaceutical industries (Kumar et al., 2020). However, the use of such food wastes or by-products from different agro-industries in product development seemed to be an excellent way to produce secondary food products. Some of the wastes have already been used by the global food markets to improve the nutritional value of some foods. For example, adding soy flour to spaghetti increases the protein and amino acid content, while addition of king palm flour to cookies and gluten-free cookies enhances the yield of nutritious fiber and some nutrients like calcium, magnesium, or potassium. Furthermore, mango peel flour was also used to formulate extruded foods, baked goods, and dairy products (Hernández and Serna-Saldivar, 2019; Tadesse et al., 2019; Kainat et al., 2022). Thus, proper utilization of agricultural wastes rich in functional ingredients and biomaterials are becoming more and more interesting to food scientists.

Red dragon (RD) fruit's peel is one of the potential sources of phytochemicals and natural functional food ingredients among the fruit wastes. It is also rich in several health-beneficial chemicals like polyphenols, anthocyanins, flavonoids, and betalains; in addition to being a plentiful source of essential oils, vitamins, and minerals. Additionally, it has been reported that the peels of RD fruit contain a significant quantity of dietary fibers (59-90 g/100 g), with the insoluble and soluble fibers (IDF and SDF) accounting for approximately 55-82% and 21-39%, respectively (Jamilah et al., 2011). Furthermore, it has been estimated that peels of RD fruit contain higher nutrients and show greater antioxidant activity compared to its edible portion (Gondim et al., 2005; Le, 2022). However, the peels of RD fruit make up approximately 22–44% of the total fruit weight and are typically thrown away after processing, or used as animal feed on farms, or they are transferred to landfills and incinerators (Liaotrakoon et al., 2013). It is inevitable that dumping these fruit wastes into the environment for an extended period of time causes the emission of greenhouse gases and encourages the growth of certain insects, pests, and microbes (Cheok et al., 2018). Therefore, RD peel can be used in various food product formulations to improve their functional value as well as contributing to a greater reduction in food waste.

Food products with a balanced nutritional composition and additional health benefits have drawn more and more attention in recent years (Klopčič et al., 2020). One of the most popular dairy products, yogurt is far healthier than milk, especially for individuals who are lactose intolerant. This food item is often regarded as a staple by consumers since it provides a significant number of nutrients, including proteins, vitamins, minerals, and numerous health-improving microorganisms (Qiu et al., 2021). Although yogurt has a high nutritional profile, it is not mostly well thought-out as an important source of bioactive phytochemicals. As a result, dairy products that have been supplemented with natural ingredients such as seeds, peels, and plants are considered as a great strategy to increase the overall nutritive value of this food, which can have a significant positive impact on human health (Caleja et al., 2016; O'sullivan et al., 2016). In recent days, growing interest has already been shown in fortifying yogurt with bioactive plant extracts, such as moringa powder, strawberries, chia seeds, and concentrated strawberry pulp, to improve the nutritional benefits of plain yogurt (Jaster et al., 2018; Zhang et al., 2019; Kowaleski et al., 2020). Consequently, this evidence has raised the question to develop a novel dairy product enriched with RD peel powder to offer health benefits as well as to satisfy consumers' sensory appeal.

Thus, considering the health benefits, this study aimed to investigate the feasibility of fortifying red dragon (RD) fruit's peel in yogurt and to analyze its effect on quality attributes, antioxidant properties, microbial, and sensory characteristics of fortified yogurt to increase its popularity among the consumers as well food manufacturers.

Materials and Methods

Materials

Milk and red dragon fruits were procured from local supermarkets, situated in Chattogram, Bangladesh. The raw ingredients were collected in sterile glass bottle and airtight sealed plastic bags, respectively and immediately transferred to the laboratory to avoid contamination and further stored in refrigerated condition. Chemicals such as sodium hydroxide, 2,6-dichlorophenolindophenol, *meta*-phosphoric acid, glacial acetic acid, methanol, agar medium, *n*-hexane, hydrochloric acid, and boric acid were procured from Sigma-Aldrich Co. (St. Louis, Missouri, USA). All chemicals used for the research purposes were of analytical grade.

Preparation of RD peel powder

Fresh fruit was thoroughly washed with distilled water to remove dirt or any extraneous residue. Peels of RD fruit were removed with a hand peeler (OXO Good Grips Prep Y-Peeler) and cut into cube shaped slices. The slices were immediately immersed into potassium *meta*-bisulfite solution (0.02%) for 5 min. Then fruit peels were standardized and blanched at 70 °C for 5 min to avoid enzymatic degradation during storage. Peels were then freeze-dried (Accumax Freeze Dryer, Accumax India, New Delhi, India). Dried peels were ground into fine powders using mixer grinder. Following packing in zipper bags (LDPE Plain Plastic Zipper bags), the finely ground powder was kept in airtight food grade plastic containers with labelling until it was used again.

Preparation of yogurt

The conventional technique of yogurt formulation was used as reported by Dabija et al. (2018). Raw milk was first standardized to contain almost 3.5% fat and 8.5% SNF (solids non-fat) followed by pasteurization (90 °C for 15 min), cooling (41 °C), inoculation with 0.02% (w/v) starter culture obtained from an indigenous yogurt sample containing mixed culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, dosing in yogurt jars with addition of 0%, 2%, 5%, and 7% (w/v) peel powder. All the inoculated milk blends were placed into incubator (43 °C for 6 h) to ease fermentation and further stored in a refrigerator (4 °C) overnight. The whole experimental procedure is presented in Figure 1 and Table 1 shows the formulation of sweetened yogurt with different percentage of dried red dragon peel powder.

Physicochemical characteristics

With a pH meter (model: HI-98107, Hanna Instrument, Italy), the pH of yogurt samples was determined. Titration method from Chouchouli et al. (2013) was used to evaluate titratable acidity of samples with minor changes. Briefly, 20 mL of distilled water was added to 10 g of yogurt before being titrated with standard 0.1 M NaOH in the presence of phenolphthalein indicator. Prior to use NaOH was standardized against potassium hydrogen phthalate. The percentage of lactic acid in the results was then calculated. Vitamin C content was determined using the titrimetric 2, 6-dichlorophenolindophenol method (Ranganna, 1986). Vitamin C in test samples was extracted using a 2% oxalic acid solution followed by titrating it with 2, 6-dichlorophenolindophenol until a light pink color appeared.

Proximate composition

Proximate composition of RD peel powder fortified yogurt samples was determined using the standard methods (AOAC, 2006). Moisture content was determined by hot air oven drying at 105 ºC until a constant mass was produced. The amount of crude protein was estimated by the Kjeldahl procedure. Ash content was measured gravimetrically in a furnace by heating at 550-650 ºC to a constant weight. The soxhlet technique was used to extract fat using n-hexane. The crude fiber content was also determined in this particular effort.

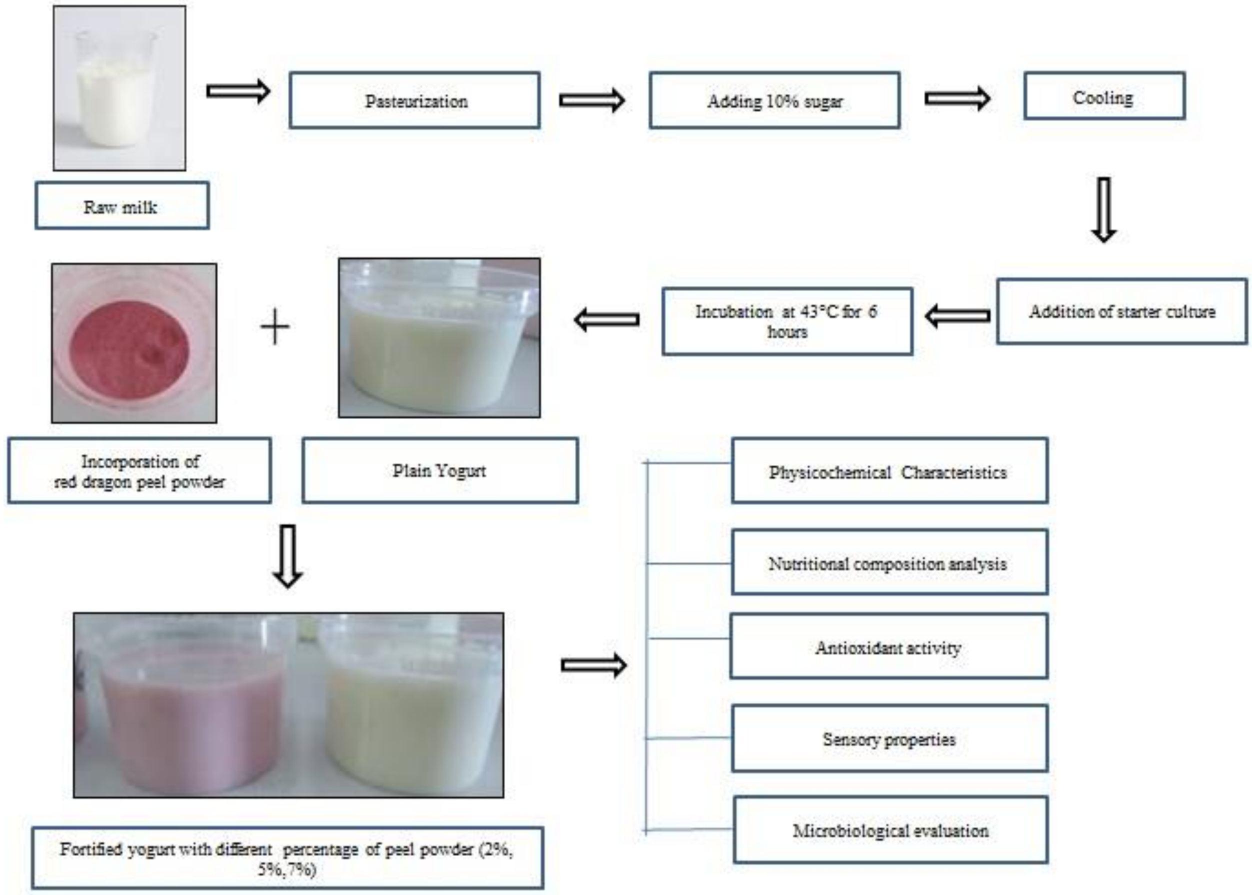

Figure 1. Schematic representation of the experimental procedure

Table 1. Treatments table

Treatments		Levels (%)
T_0	Control	0%
T_1		2%
T_2	RD peel powder (dried)	5%
T_3		7%

Determination of antioxidant activity

Antioxidant activity was calculated through DPPH assay, following the method as stated by Leong and Shui (2002). An aliquot of 1 mL sample extract was added to 2 mL of methanolic DPPH solution and kept in the dark for 30 min. Absorbance was assayed at 517 nm using a UV-visible spectrophotometer (UV-1800 Shimadzu, Japan). The findings were compared with the Trolox standard curve ($y = 0.0894X+0.3145$, $R^2 = 0.997$) and reported in µmol Trolox equivalent per mL sample.

Microbiological Analysis

According to Wang et al., the total viable bacterial count (TVC) in yogurt was determined by serial dilution method using pour plate technique (Wang et al., 2010). Then, one mL of each sample was sequentially added to nine mL of the sterile diluent (peptone water) and shaken vigorously. The serial dilution process was continued up to 10^5 dilutions. On nutrient agar plates, aliquot portions (0.1 mL) of the appropriate dilution were applied. Colony forming units per mL of sample (cfu/mL) were calculated after the plates were incubated at 37 ºC for 48 hours in an incubator.

Using MacConkey agar medium, the total coliforms (TC) number was calculated in accordance with Micanel et al. (1997). The pour plate technique involved transferring 1 mL of each sample into a sterile plate, to which 10–20 mL of agar media were then added. The medium was quickly combined and shaken for the following 5–10 seconds. The plates were put in an incubator and incubated at 37 ºC for 24 hours and visualized pink colonies were counted.

Sensory evaluation

A trained panel of 10 individuals evaluated the sensory acceptability of yogurts using a 5-point hedonic scale (1- Unsatisfactory; 5- Excellent) (Karagul-Yuceer and Drake, 2006). The panelists assessed the yogurt samples that were offered to them at room temperature in terms of their color, taste, consistency, smell, and overall acceptance.

Statistical Analysis

The results were analyzed with one-way ANOVA to identify significant differences between means of samples. SPSS-25 statistical software was used for data analyses and the results were presented as mean ± standard deviation of three replicates. The mean results were compared by the Fisher's LSD test with 95% confidence interval.

Results and Discussion

Physicochemical properties of fortified yogurt

Table 2 shows that, pH decreased and the TA of RD peel powder fortified yogurts at different inclusion level increased. The pH and TA of different treatments (T_0, T_1, T_2, and T_3) ranged between 4.36-4.73, and 0.16-0.18 (g lactic acid/100 g), respectively. Similar results were reported for yogurts enriched with *Spirulina platensis* powder, *Pleurotus ostreatus* extract, and yogurts containing orange fiber (Vital et al., 2015; Agustini et al., 2017; Erkaya-Kotan, 2020). The decrease in pH; conversely increase in TA might be attributed to the acidic nature of dragon fruit peel material as well as improved culture growth attributable to the pre-biotic potential of fruit's peel (Nyamete and Mongi, 2017). The production of lactic acid from the fermentation of lactose by lactic acid bacteria might have an additional effect on this. Resulting lactic acid caused substantial decrease in the pH of yogurt. The production of organic acids increases as additional sources of sugar are digested; hence, the pH will naturally decrease (Jannah et al., 2014). Furthermore, pH level of the fortified yogurts is in accordance with Benedetti et al. (2016) who stated that consumers prefer fermented products with pH on the range of 4.2 to 4.4. Accordingly, vitamin C amount of the yogurts ranged from 1.17 to 1.34 (mg/100 g) with RD fruit's peel powder fortified yogurt having considerably higher ($P<0.05$) vitamin C than control (Table 2). The higher vitamin C content in fortified yogurt might be attributed to the fact that peels of dragon fruit is an excellent source of vitamin C (Nur et al., 2023). Ścibisz et al. (2019) also reported higher vitamin C content for yogurt enriched with straw berry and blue berry fruit extracts as compared to plain yogurt.

Proximate composition of fortified yogurts

Table 3 depicts the proximate composition of control and red dragon peel fortified yogurts. The moisture content, crude protein, fat, ash content, and crude fiber of different treatments (T_0, T_1, T_2, and T_3) varied from 76.70-80.18, 4.49-4.07, 3.48-2.36, 5.19-5.29, and 1.53-3.34 (g/100 g), respectively. The study findings stated that addition of RD peel powder has a profound consequence on the moisture content ($p<0.05$). The moisture content of the control was 78.06 g/100 g, while the lowest and the highest moisture contents were 76.70 and 80.18 (g/100 g) reported in T_1 and T_3 treatments, respectively. This result is in accordance with Iwalokun and Shittu (2007) who reported higher moisture percentage in yogurt samples blended with vegetable extracts. In addition, increased moisture content in yogurt sample with 15% persimmon pulp was also observed by Khatoon et al. (2021). However, presence of complex carbohydrates and fibers in yogurt, which hold the water, might have incremented the moisture content in peel fortified yogurts.

Casein and whey are two of the high-quality proteins found in yogurt (Nyamete and Mongi, 2017). The crude protein content of control used in this study was 4.49 (g/100 g). Addition of RD peel powder up to 7% showed a non-significant declining trend in protein content. Related study findings were also reported by Roy et al. (2015) and Desouky et al. (2018); that protein amount was decreased in fruit-flavored yogurt. As fruits typically have lower protein contents compared to milk, increasing the amount of fruits in fortified yogurt considerably reduced protein content (Khatoon et al., 2021). However, the decreasing trend in protein content might be due to the proteolytic activity of microorganisms which degrade the protein as demonstrated by Han et al. (2012). Furthermore, the fat content in the plain yogurt (control) used in this study was 3.48 (g/100 g). T_2 and T_3 treatments substantially decreased the fat content compared to control. In accordance, Palka and Flis-Kaczykowska (2019) stated that yogurt formulated with different fruit and vegetable extracts showed lower fat content. Another study of Kauser et al. (2011) also reported that addition of apricot lowered fat content in yogurt. Yogurt's lactic acid bacteria may have converted fats into volatile fatty acids, causing a reduction in fat content (Khatoon et al., 2021). Another possible reason behind the reduced fat content in fortified yogurt might be presence of low amount of fat in fruit peel.

Table 2. Physicochemical properties of fortified yogurt

Treatments	pH	TA (g lactic acid/100 g)	Vitamin C (mg/100 g)
T_0	4.73 ± 0.06^{a}	0.16 ± 0.01^{b}	0.00^{c}
T_1	4.36 ± 0.04^{b}	0.18 ± 0.01^{a}	1.17 ± 0.01^{b}
T_2	4.38 ± 0.03^{b}	0.18 ± 0.02^{a}	1.34 ± 0.01^{a}
T_3	4.42 ± 0.03^{b}	0.18 ± 0.01^{a}	1.34 ± 0.02^{a}

*Values are means of triplicates ± standard deviation. Different superscripts in the same column differ significantly ($p<0.05$). T_0 = Plain yoghurt (control); T_1 = Fortified yoghurt with 2% RD peel powder, T_2 = Fortified yoghurt with 5% RD peel powder, T_3 = Fortified yoghurt with 7% RD peel powder.

Table 3. Proximate composition of fortified yogurts

Treatments	Moisture (g/100 g)	Crude protein (g/100 g)	Fat (g/100 g)	Ash (g/100 g)	Crude fiber (g/100 g)
T_0	78.06 ± 0.04^{c}	4.49 ± 0.02^{a}	3.48 ± 0.01^{b}	5.19 ± 0.01^{b}	1.53 ± 0.02^{d}
T_1	76.70 ± 0.03^{d}	4.05 ± 0.05^{b}	3.53 ± 0.02^{a}	5.28 ± 0.01^{a}	2.37 ± 0.01^{c}
T_2	79.30 ± 0.02^{b}	4.02 ± 0.04^{b}	2.56 ± 0.01^{c}	5.29 ± 0.01^{a}	2.43 ± 0.01^{b}
T_3	80.18 ± 0.02^{a}	4.07 ± 0.07^{b}	2.36 ± 0.01^{d}	5.29 ± 0.01^{a}	3.34 ± 0.03^{a}

*Values are means of triplicates ± standard deviation. Different superscripts in the same column differ significantly ($p<0.05$). T_0 = Plain yogurt (control); T_1 = Fortified yogurt with 2% RD peel powder, T_2 = Fortified yogurt with 5% RD peel powder, T_3 = Fortified yogurt with 7% RD peel powder.

Table 4. Antioxidant activity of fortified yogurts

Treatments	Antioxidant activity (µmol TE/mL)
T_0	1.30±0.003^{d}
T_1	1.43±0.004^{c}
T_2	1.51±0.003^{b}
T_3	1.57±0.005^{a}

*Values are means of triplicates ± standard deviation. Different superscripts in the same column differ significantly ($p<0.05$). T_0 = Plain yogurt (control); T_1 = Fortified yogurt with 2% RD peel powder, T_2 = Fortified yogurt with 5% RD peel powder, T_3 = Fortified yogurt with 7% RD peel powder.

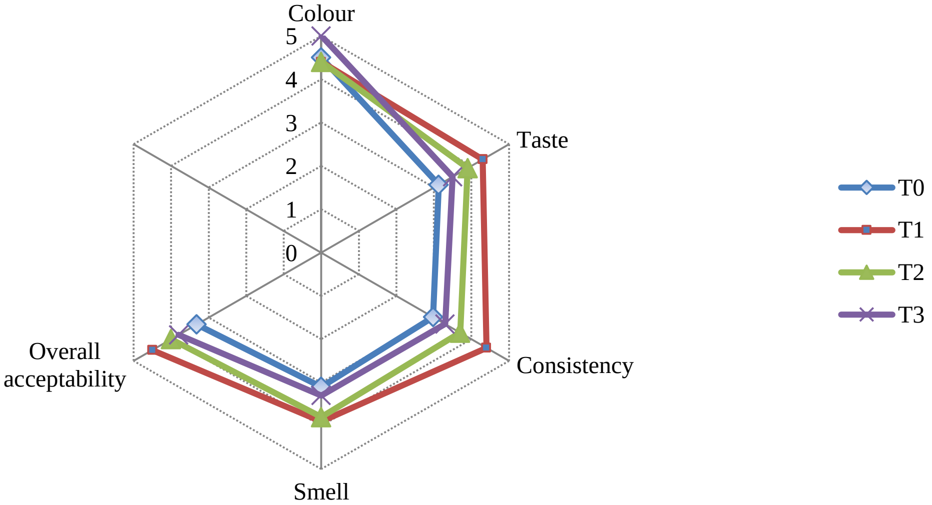

Figure 2. Radar chart of the sensory attributes
*Values are means of ten panelists

The crude fiber content in the plain yogurt (control) used in this study was 1.53 (g/100 g). The findings demonstrated that the amount of fiber increased in fortified yogurt as dragon fruit peel concentration added. This is in accordance with the study of Apriyani (2018); that fiber content of yogurt increases with the addition of dragon fruit skin as dragon fruit peel contain high amount of dietary fiber content (Jamilah et al., 2011). The present study was also found complementary to the report of Mohamed et al. (2014) who reported similar trend in yogurt fortified with dietary fiber and phenolic compounds. The ash content of control used in this study was 5.19 (g/100 g). Addition of RD peel powder up to 7% enhanced the ash contents in fortified yogurts (T_1, T_2, and T_3) compared to control (T_0). In accordance, Ismail et al. (2020) reported that the ash content increased in yogurt developed with the fortification of apricot extract. These reports propose that the ash content is affected by the type of fruits used to fortify the yogurts. The concentration of ash found in red dragon peel extract (16.74 g/100g) is superior to the amount found in orange (1.59 g/100g) and grape (4.24 g/100 g) as reported by Cacatian and Guittap (2018). So, the increasing trend in ash content of fortified yogurt was found owing to the effect of red dragon peel powder associated with higher amount of ash content.

Antioxidant activity of fortified yogurts

The results for antioxidant activity of the fortified yogurts are presented in Table 4 where antioxidant activity of T_1, T_2, and T_3 treatments (1.43-1.57 µmol TE/mL) were significantly higher than that of control (1.30 µmol TE/mL) yogurt ($p<0.05$). This was expected since RD fruit's peel is a rich source of phytochemicals, which might have increased the antioxidant properties in fortified yogurt (Jamilah et al., 2011). The improvement in antioxidant capacity of yogurts enhanced with RD peel is also similar with results previously reported for yogurts enriched with phycocyanin, *Spirulina platensis*, and apple pomace (Mohammadi-Gouraji et al., 2019; Wang et al., 2020). However, the increase might be attributed to the microbial metabolic activity; that may release some of the bounded bioactive materials (Barakat and Hassan, 2017). Rahmawati and Suntornsuk (2016) reported increased antioxidant activity in cow, goat, and buffalo yogurt and attributed this to the release of bioactive (antioxidant) peptides occurring as a result of protein digestion by bacterial fermentation. Milk digestion-produced peptides may function as electron donors, interacting with free radicals to form more stable products (Kullisaar et al., 2002). Hur et al. (2014) also stated that increase in antioxidant activity in fermented plant based foods due to increased release of flavonoids during fermentation. Fermentation induces synthesis of various bioactive compounds as a result of induced structural breakdown of the cell walls (Đorđević et al., 2010). Fermentation is also associated with the modification of bioactive compounds by lactic acid bacteria (Hunaefi et al., 2013; Curiel et al., 2015).

Sensory attributes of fortified yogurts

The scores of sensory evaluation of T_0, T_1, T_2, and T_3, treatments are listed in Figure 2. The degree of likings or acceptance of the sensory attributes such as color, taste, consistency, smell, and overall acceptability varied from 4.40-5.00, 3.13-4.30, 2.98-4.40, 3.10-3.90, and 3.32-4.50, respectively. This result clearly shows RD peel powder fortification considerably affected the sensory scores of formulated yogurts ($p<0.05$). However, T_1 treatment indicated the maximum sensory scores in taste, consistency, smell, and overall acceptability; while T_3 treatment received the highest hedonic score for color attribute. RD fruit's peel contains betacyanin pigment, which contributes to the reddish coloration in yogurt and is thus favored by most of the panelists (Pamungkas et al., 2020). Similarly, addition of RD peel powder to a certain extent seemed to improve consumer expectations regarding taste and smell, since several volatile and non-volatile bacterial metabolites, as well as carbonyl chemicals, contribute to the flavor of yogurt (Cheng, 2010). In addition, inclusion of certain flavor compounds and other minor constituents such as adjuncts of fruits, vegetables, and nuts also affect the overall flavor (Nyamete and Mongi, 2017). In this study, pasteurization induces the release of more volatile compounds and flavor constituents from RD peel, which might have influenced the improved taste and smell in fortified yogurts. However, addition of higher amounts of RD peel powder (7%) might create complexity between the released compounds and other flavor constituents that could be responsible for lower hedonic score in fortified yogurts. Similar findings were also reported for yogurt fortified with fruits and vegetables extracts (Yu et al., 2014; Barakat and Hassan, 2017). Moreover, the apparent consistency perceived on the yogurt samples fortified with RD peel powder yielded greater sensory score compared to control. Most yogurt usually contain considerable amount of fat and protein, which influence their structure, consistency and textural properties (Routray and Mishra, 2011). In this study, the improved consistency in yogurts fortified with RD peel powder might be due to the presence of fiber in RD peel. Fiber acts as prebiotic and influences the growth of starter culture of yogurt. The consistency of yogurt may increase whether these bacteria grow well and produce the desired texture characteristics (Mousavi et al., 2019). The outcomes of this study also exhibited that the addition of RD peel powder has a substantial impact on the overall acceptability of yogurt. The yogurt sample with 2% fruit peel has the best score for overall acceptability, followed by 5% and 7%, while the control scored the lowest. It is clear from the results that the panelists preferred the RD fortified yogurts to plain yogurt. The higher values of taste, smell and consistency of fruit yogurt might be largely responsible for the incremental trend in the overall acceptability of RD peel fortified yogurt. Similar findings were also observed by Bhat et al. (2018) who investigated the impact of psyllium husk on sweetly stirred yogurt. This suggests that product development efforts should focus on delivering the optimal sensory attributes in order to effectively fortify yogurt with RD peel powder.

Microbial evaluation of fortified yogurts

Table 5 demonstrates reduction in TVC (Total viable count) with RD fruit's peel powder fortification. TVC in yogurt sample usually indicates the total number of live cells (microorganisms) present within different formulated yogurts. The highest TVC was reported in T_0 treatment (65.17×10^4 cfu/mL), while TVC in T_1, T_2, and T_3, treatments ranged from 56.64×10^4 to 64.23×10^4 (cfu/mL). However, the bacteriological status of yogurts was within the acceptable standard ($<10^6$ cfu/mL) for fermented milk products (Lourens-Hattingh and Viljoen, 2001; El-Bakri and El-Zubeir, 2009). In line with our results, Fernandes et al. (2019) demonstrated that in comparison to plain yogurt, yogurt supplemented with apple pomace (3.3%) decreased bacterial counts at the end of fermentation. Furthermore, it is also evident that poly- and oligosaccharides derived from fruit's peel might exhibit a prebiotic effect, improving the vitality and adhesion of various lactic acid bacteria, while simultaneously retards the multiplication of various enteric pathogens (Islamova et al., 2017; Wilkowska et al., 2019). When it came to TC, coliform bacteria were not present in any of the yogurt samples indicating that, hygienic procedures were followed in the collection of raw materials and yogurt formulations.

Table 5. Microbial properties of fortified yogurts

Treatments	TVC (cfu/mL)	Coliform
T_0	$65.17\pm1.15\times10^{4a}$	0
T_1	$56.64\pm0.56\times10^{4d}$	0
T_2	$61.45\pm0.48\times10^{4c}$	0
T_3	$64.23\pm0.27\times10^{4b}$	0

*Values are means of triplicates ± standard deviation. Different superscripts in the same column differ significantly ($p<0.05$). T_0 = Plain yogurt (control); T_1 = Fortified yogurt with 2% RD peel powder, T_2 = Fortified yogurt with 5% RD peel powder, T_3 = Fortified yogurt with 7% RD peel powder.

Conclusion

Red dragon peel has been successfully applied for the formulation of nutrient enriched yogurt. The fortified yogurts were found microbiologically safe with improved quality attributes. The present study showed that yogurt with 7% red dragon fruit peel powder presented most prominent antioxidant activity, while yogurt fortified with 2% RD peel powder revealed the maximum sensory scores with best taste profile among all yogurt samples tested. Therefore, further research should emphasis on the characterization of bioactive compounds to evaluate the mechanisms of antioxidant and anti-diabetic activity of yogurts with added red dragon peel powder.

Acknowledgements

The funding for the research was provided by the Ministry of Science and Technology (MOST), Govt. of the People's Republic of Bangladesh and the Advanced Studies and Research (CASR), Chattogram Veterinary and Animal Sciences University (CVASU) of Bangladesh.

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