E-ISSN: 2663-1067
P-ISSN: 2663-1075
www.hortijournal.com
IJHFS 2025; 7(1): 149-151
Received: 17-10-2024
Accepted: 25-11-2024

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Preparation and characterisation of purple dragon fruit (*Hylocereus costaricensis*) yogurt

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DOI: https://doi.org/10.33545/26631067.2025.v7.i1c.256

Abstract
This study aimed to develop and characterize purple dragon fruit (*Hylocereus costaricensis)* yogurt by evaluating its physicochemical, antioxidant, and sensory properties. Yogurt was prepared using standardized milk (3.5% fat, 11.0% solids-not-fat) with varying concentrations of dragon fruit pulp (3%, 5%, and 7%). The results showed that increasing pulp concentration significantly influenced yogurt properties. Lactic acid content increased from 0.46% in the control to 1.10% in the 7% pulp yogurt, while pH decreased from 5.21 to 4.28. Antioxidant activity improved remarkably, with %RSA values rising from 20.06% (control) to 49.63% (7% pulp). Sensory evaluation on a 9-point hedonic scale indicated enhanced color and appearance at higher pulp levels, with the highest rating (9.00) observed in 7% pulp yogurt. However, consistency slightly declined, while flavor and overall acceptability remained favorable. These findings suggest that dragon fruit pulp enhances the functional and nutritional properties of yogurt, making it a promising ingredient for value-added dairy products.

Keywords: Dragon fruit, yogurt, *Hylocereus costaricensis*, Antioxidant activity

1. Introduction
Dragon fruit is a type of vine cactus that is a member of the Cactaceae family (Patwary *et al.*, 2013) [2]. According to Liaotrakoon (2013) [1], the plant's exotic appearance makes it appealing. Dragon fruits are becoming more and more well-liked due to its therapeutic and nutritious qualities (Sonawane, 2017) [4]. The fruit's nutritional qualities make it a significant economic fruit species globally (Rifat *et al*., 2019) [3]. In general, four varieties of dragon fruits are grown in various nations. Their skin is leathery and slightly leafy. Dragon fruit is classified into four species based on the color of its peel and pulp: (i) red peel with white pulp (*Hylocereus undatus*), originating from Vietnam and Thailand; (ii) red peel with red pulp (*Hylocereus polyrhizus*), found in Israel and Malaysia; (iii) red peel with purple pulp (*Hylocereus costaricensis*), native to Guatemala, Nicaragua, Ecuador, and Israel; and (iv) yellow peel with white pulp (*Selenicereus megalanthus*), originating from Colombia and Ecuador (Wakchaure *et al*., 2021) [6]. Dragon fruit is a nutrient-rich fruit containing antioxidants, calcium, fiber, vitamin B, vitamin C, and phosphorus. The edible portion comprises 64.50% of the total fruit weight and has a moisture content of 82.5-83.0%. It contains 0.16-0.23% protein, 0.21-0.61% fat, 6.3-8.8 mg of calcium, 30.2-36.1 mg of phosphorus, 0.5-0.61 mg of iron, and 8-9 mg of vitamin C per 100 g (Tripathi *et al*., 2014) [5]. All parts of the dragon fruit, including the pulp, peel, flowers, and stem, are rich in bioactive compounds such as betalains, flavonoids, tannins, and alkaloids. These compounds contribute to various biological activities in humans, including antioxidant, antimicrobial, and anticancer properties.
Yogurt is a popular fermented milk product known for its numerous health benefits. It aids in improving lactose absorption, making it beneficial for individuals with lactose intolerance, and helps in managing diarrhea. Additionally, yogurt supports digestive health by alleviating constipation, urogenital infections, osteoporosis, anorexia nervosa, and premenstrual syndrome, while also promoting bone health and easing menopausal symptoms. Regular consumption of yogurt has been associated with improved metabolism, weight loss, and reduced cholesterol levels. It also enhances immune function, reduces digestive inflammation, boosts nutrient intake, and improves tolerance to antiretroviral therapy in HIV patients.

Moreover, yogurt helps maintain gut and urogenital flora balance, prevents intestinal disorders, and supports overall well-being (Wulansari *et al.*, 2016) [7].
The incorporation of fruits into yogurt not only enhances its flavor but also enriches its nutritional and therapeutic properties while influencing the fermentation process. This study focuses on the preparation and characterization of yogurt supplemented with *Hylocereus costaricensis* (purple dragon fruit). The impact of this fruit addition on the physicochemical properties and antioxidant activity of yogurt is evaluated.

2. Materials and Methods

2.1 Starter Culture

Yoghurt culture procured from Danisco (YO MIX 883 LYO 50 DCU) was used for the study, which was available in freeze-dried form. It is a blend of defined strains of thermophilic lactic acid bacteria (Streptococcus thermophilus, Lactobacillus delbrueckii subsp. bulgaricus) for direct vat inoculation of milk, milkbase, and other food application.

2.2 Preparation of Yogurt

Raw milk was adjusted to contain 3.5% fat and 11.0% solids-not-fat by incorporating skim milk powder. A 2% starter culture was then introduced. The yogurt mixture underwent pasteurization at 90°C for 10 minutes before being cooled to 45°C. Subsequently, fruit pulp was added at varying concentrations of 3%, 5%, and 7%, and the mixture was incubated at 42 °C for four hours. After incubation, the yogurt was stored at 4 °C under refrigeration to assess the physicochemical properties.

2.3 pH and titratable acidity

The pH was recorded using a digital pH meter at 25ºC. Yogurt sample (10g) was mixed thoroughly with 10 ml of distilled water, Phenolphthalein solution (0.1%, 3 drops) was added and the yogurt suspension was titrated using 0.1 M NaOH. The mixture was stirred continuously and titrated until the indicator changed to a definite pink colour lasting for 30 seconds. The volume of NaOH required to neutralise the yogurt acid was recorded and used to calculate the content of titratable acids

2.4 Antioxidant Activity (DPPH)

The free radical scavenging activity of WSPE (Water Soluble Peptide Extract) was measured by the DPPH method with a slight modification.

2.5 Statistical Analysis

All experiments were carried out in triplicates and the mean values were tabulated. Differences between samples concerning bioactivity were tested using a two-way analysis of variance (GLM procedure), and means of samples were compared using Duncan's Multiple Range test (SPSS 29 static analysis, IBM)

3. Results and discussion

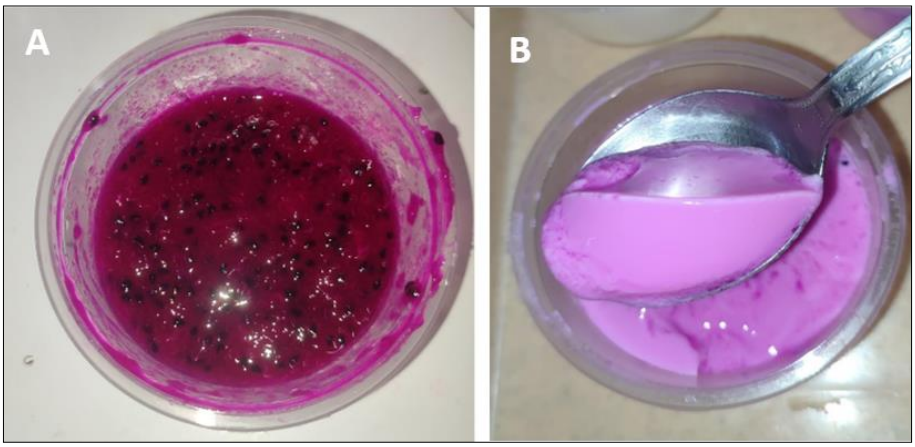

Fig 1: A. Dragon fruit pulp B. Scoop of dragon fruit yogurt

Fig 2: Dragon fruit yogurt in the order control, 3%, 5%, 7%

The incorporation of dragon fruit pulp significantly influenced the physicochemical properties of yogurt as presented in table 1. Lactic acid content increased with the addition of pulp, ranging from 0.65% to 1.10%, compared to 0.46% in the control sample. A corresponding decline in pH was observed, with values decreasing from 5.21 in the control to 4.28 in the sample with the highest pulp concentration. Furthermore, the antioxidant activity (%RSA) exhibited a notable enhancement, rising from 20.06% in the control to 49.63% in the sample with the highest pulp addition. These results indicate that dragon fruit pulp contributes to increased acidity and improved antioxidant properties in yogurt, making it a functional dairy product with enhanced health benefits.

Table 1: Physicochemical Properties of Yogurt

Parameter	Control	3% pulp	3% pulp	3% pulp
Lactic acid %	0.46 ± 0.01	0.65 ± 0.02	0.70 ± 0.01	1.10 ± 0.04
pH	5.21 ± 0.10	4.70 ± 0.21	4.57 ± 0.11	4.28 ± 0.24
Antioxidant activity (%RSA)	20.06 ± 0.65	42.56 ± 0.98	45.37 ± 0.33	49.63 ± 0.55

Figures are mean ± standard deviation of triplicate analysis.

The sensory evaluation of dragon fruit yogurt, assessed using a 9-point hedonic scale, revealed variations in consumer preferences based on pulp concentration as presented in table 2. The color and appearance scores improved with increasing pulp levels, reaching the highest score of 9.00 in the 7% pulp sample, compared to 8.00 in the control. Consistency was rated highest in the control and 3% pulp samples (8.25) but showed a slight decline at higher pulp levels, with the lowest score of 7.97 recorded for the 7% pulp yogurt. Flavor scores remained relatively stable across samples, ranging from 8.25 to 8.40, with the highest rating observed in the control and 3% pulp yogurts. Overall acceptability followed a similar trend, with scores increasing slightly from 8.00 in the control to 8.35 in the 7% pulp yogurt. These results indicate that while higher dragon fruit pulp concentrations enhanced visual appeal, they had a minor impact on texture, with overall acceptability remaining favorable across all formulations.

Table 2: Sensory evaluation of dragon fruit yogurt

Parameter	Control	3% pulp	5% pulp	7% pulp
Colour & appearance	8.00±0.10	8.00±0.10	8.35±0.10	9.00±0.10
Consistency	8.25±0.10	8.25±0.10	8.10±0.15	7.97±0.10
Flavour	8.40±0.12	8.40±0.12	8.25±0.10	8.35±0.06
Overall acceptability	8.00 ±0.10	8.10 ±0.10	8.13±0.06	8.35±0.06

Conclusion

The incorporation of dragon fruit (*Hylocereus costaricensis)* pulp into yogurt significantly enhanced its physicochemical, antioxidant, and sensory properties. The addition of pulp increased lactic acid content while reducing pH, indicating improved fermentation. Antioxidant activity (%RSA) showed a remarkable increase, highlighting the functional benefits of dragon fruit yogurt. Sensory evaluation revealed that higher pulp concentrations enhanced colour and appearance, with overall acceptability remaining favorable despite slight changes in consistency. These findings suggest that dragon fruit pulp is a valuable ingredient for developing functional dairy products with improved health benefits and consumer appeal.

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