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Effect of *Hibiscus rosa-sinensis* and *Delonix regia* extracts on the sensory quality of paneer

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Abstract

Paneer is a traditional Indian dairy product and highly perishable due to its high moisture and nutrient content. This study investigated the effect of *Hibiscus rosa-sinensis* (HRS) and *Delonix regia* (DR) flower extracts on the sensory quality of paneer. Sensory evaluation of paneer was conducted to assess colour and appearance, flavour, texture, and overall acceptability using a 9-point hedonic scale. Results indicated that the combination of *Hibiscus rosa-sinensis* and *Delonix regia* extracts consistently produced higher sensory scores than individual extracts. Among the tested concentrations, 500 mg/mL (C3) achieved the greatest overall acceptability, while higher concentrations (750-1000 mg/mL) caused a decline in sensory quality, likely due to excessive pigmentation and phytochemical content. These findings demonstrate that the synergistic use of HRS and DR extracts can enhance the visual appeal, flavour, and texture of paneer, offering a natural and consumer-friendly approach to improve its sensory characteristics.

Keywords: *Hibiscus rosa-sinensis*, *Delonix regia*, paneer, sensory quality

1. Introduction

Paneer is one of the most widely consumed traditional dairy products in India. The term "Paneer" referred to the product obtained from any variant of milk, with or without added milk solids, by precipitation with permitted acidulants and heating (FSSAI, 2023) ^[9]. It is considered a nutritionally rich food, supplying high-quality casein protein, essential amino acids, milk fat, calcium, phosphorus, and vitamins (Alam *et al.*, 2024) ^[2]. Paneer is marble white in colour, with a cohesive and spongy body, a close-knit texture, and a mildly sweet, slightly acidic, and nutty flavour. Paneer accounts for around 7% of total milk production in India (Kapoor *et al.*, 2021) ^[11]. Buffalo milk is pre better for paneer making because it contains higher levels of fat, casein, and total solids than cow milk, leading to a better yield, firmer texture, and richer taste (Khan & Pal, 2011) ^[12]. Buffalo milk has low carotene but high levels of vitamin A in the form of colourless retinol. This gives paneer made from buffalo milk a desirable, bright white appearance (R Ullah *et al.*, 2017) ^[24]. Despite its nutritional significance, paneer has a major drawback: it is highly perishable due to its high moisture content, nearly 50-70% and nearly neutral pH, which makes it an excellent medium for microbial growth, lipid oxidation, and enzymatic degradation. Even under refrigeration, its shelf life rarely exceeds a week, which limits large-scale commercialisation (Kumar & Rao, 2006; Prajapati *et al.*, 2023) ^[13, 16].

To overcome these challenges, several preservation methods have been investigated, including refrigeration, packaging innovations, and the use of chemical preservatives (benzoates, sorbates, H₂O₂, BHT, and BHA), (Bhardwaj *et al.*, 2024) ^[5]. However, growing consumer demand for naturally preserved, chemical-free foods has prompted the dairy industry to explore plant-derived bioactive compounds as potential natural alternatives (Teshome *et al.*, 2022) ^[21]. Plant extracts are rich in polyphenols, flavonoids, anthocyanins, and other phytochemicals that exhibit antioxidant and antimicrobial properties. Their incorporation into dairy products can suppress lipid peroxidation, reduce microbial spoilage, and simultaneously enhance the functional and sensory profile of the final product (Ullah *et al.*, 2022) ^[23].

Hibiscus rosa-sinensis, commonly referred to as “Chinese rose” or “Jasud,” and is an evergreen ornamental shrub widely cultivated in tropical and subtropical regions. The plant belongs to the family Malvaceae and is well recognized for its large, brightly coloured flowers that are traditionally valued for medicinal purposes (Ruban & Gajalakshmi, 2012) [18]. *Hibiscus rosa-sinensis* is rich in anthocyanins, phenolics, and flavonoids, which not only impart natural pigmentation but also exhibit strong free-radical scavenging activity. These properties make hibiscus extracts suitable for enhancing oxidative stability and providing antimicrobial protection when incorporated into foods such as dairy products, beverages, and bakery items (Mejía *et al.*, 2023) [14].

Delonix regia (Boj. Ex Hook.), commonly known as the flame tree or Gulmohar, belongs to the family Fabaceae and is native to Madagascar, but is now cultivated extensively in tropical and subtropical countries as an ornamental species. Its petals contain polyphenols, tannins, and flavonoids that contribute to both antioxidant and antimicrobial activity. *Delonix regia* flower extract also exhibits antibacterial activity against various pathogenic microorganisms, including *Shigella flexneri*, *Staphylococcus epidermidis*, and *E. coli*. (Bhokare *et al.*, 2018; Shabir *et al.*, 2011) [6, 19]. Extracts of *D. regia* can inhibit foodborne pathogens and delay lipid oxidation, highlighting their potential as natural preservatives. Moreover, the presence of bioactive pigments supports their application as natural colorants in food systems (Ebada *et al.*, 2023) [8].

2. Materials and methods

2.1 Buffalo Milk

Buffalo milk required for the experiment was purchased from local market of Junagadh city.

2.2 *Hibiscus rosa-sinensis*

Hibiscus rosa-sinensis powder was purchased from local market of Junagadh city.

2.3 *Delonix regia*

Delonix regia flowers were collected from the local area and washed with water to remove dirt. After identification collected flower was dried at 45 ± 5 °C in an oven until the dried weight of the flower became constant. Following that, dried flowers grinded into a mixture and sieved through a mesh size 36.

2.4 Preparation of *Hibiscus rosa-sinensis* and *Delonix regia* Flower Extracts

20 gram dried powders of *Hibiscus rosa-sinensis* and *Delonix regia* were separately extracted in 500 mL distilled water with continuous stirring at 1100 rpm for 20 hr at room temperature. The mixtures were centrifuged at $3000 \times g$ for 6 min at 15 °C, and the supernatants were filtered through Whatman No 41 filter paper. The filtrates were freeze-dried using a lyophilizer (-55 °C, -105 kPa, 42 h). The dried extracts were collected in amber-colored airtight bottles and stored at -12 °C until further use.

2.5 Preparation of Paneer

Paneer was prepared from buffalo milk using the method given by Umaraw *et al.* (2022) [25], with slight modifications.

Treatment detail

T₁ = *Hibiscus rosa-sinensis* flower extract

T₂ = *Delonix regia* flower extract

T₃ = *Hibiscus rosa-sinensis* + *Delonix regia* (1:1) flower extract

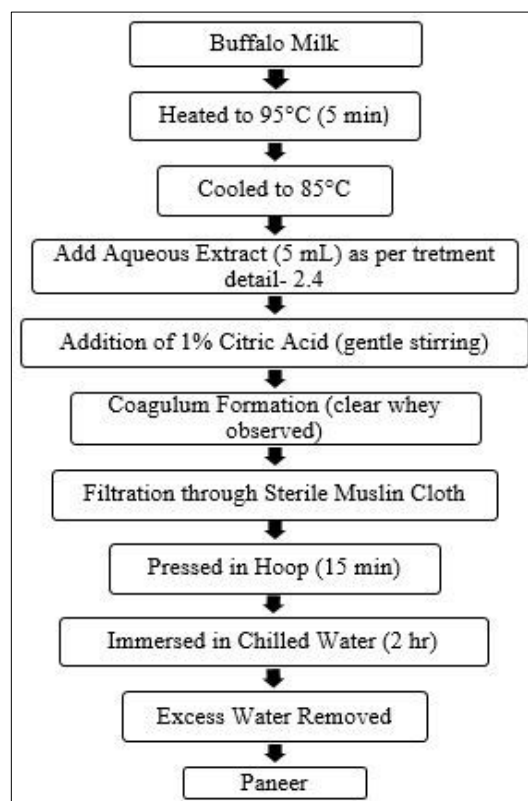
C1 = 0 mg/mL extract

C2 = 250 mg/mL extract

C3 = 500 mg/mL extract

C4 = 750 mg/mL extract

C5 = 1000 mg/mL extract



3. Results and Discussion

The sensory attributes of paneer incorporated with varying levels of herbal preservatives were assessed to identify the most acceptable formulation. The prepared paneer samples were evaluated for sensory attributes by a panel of judges using a 9-point hedonic scale.

3.1 Colour and appearance

The colour and appearance scores of paneer prepared with different flower extracts and their combination are presented in Table 1. The combination of *Hibiscus rosa-sinensis* and *Delonix regia* extracts recorded higher values compared to the individual extracts. The highest score was observed at C3 (8.95 ± 0.047) concentration, where the combination treatment was significantly higher, reflecting its positive contribution to the visual appeal of paneer. At lower concentrations (C1 and C2), no significant differences were observed among treatments, indicating minimal impact on colour enhancement at these levels. In contrast, at the higher concentration (C5), all treatments showed a decline in scores, which was more pronounced in the individual extracts than in their combination. That might be due to the development of an overly intense or undesirable colouration. Anthocyanins derived from *Hibiscus rosa-sinensis* and carotenoids from *Delonix regia* contribute to the reddish-orange colouration and enhance the overall visual appeal of

the product (Anand and Sarkar, 2017; Veigas *et al.*, 2012) [4, 26]. These results suggest that the synergistic effect of HRS and DR may improve the colour and appearance of paneer up to an optimum concentration.

Table 1: Effect of various levels of *Hibiscus rosa-sinensis* (HRS) and *Delonix regia* (DR) flower extracts on the colour and appearance of paneer

	T ₁	T ₂	T ₃
C1	8.33±0.144 ^{aA}	8.33±0.144 ^{aBC}	8.33±0.144 ^{aBC}
C2	8.38±0.146 ^{bA}	8.52±0.112 ^{aAB}	8.57±0.111 ^{aB}
C3	8.67±0.105 ^{bA}	8.71±0.101 ^{bA}	8.95±0.047 ^{aA}
C4	8.29±0.156 ^{bAB}	8.50±0.153 ^{aAB}	8.56±0.161 ^{aB}
C5	7.90±0.153 ^{cB}	8.05±0.146 ^{bC}	8.19±0.131 ^{aC}

Note: Values are means±SEM, n=6 per treatment group.

Means in a row without a common superscript small letter differ ($p<0.05$) and Means in a column without a common superscript capital letter differ ($p<0.05$).

Tomar *et al.* (2021) [22] reported higher appearance scores in control yoghurt compared to flower extract treated yoghurt, and concluded that increasing the concentration of extracts led to a reduction in appearance scores. Among the treated samples, yoghurt incorporated with 0.1% *Hibiscus sabdariffa* recorded the highest appearance score, followed by *Mentha piperita* and *Ocimum basilicum*. Ebada *et al.* (2023) [8] also reported comparable colour scores between the control and *Delonix regia* pigment incorporated beverages. Supported the findings of the present study and reported the highest colour score in yoghurt fortified with 1% *Hibiscus rosa-sinensis* flower extract, whereas both the control and the 2% extract-incorporated yoghurt exhibited lower scores compared to the 1% treatment.

Abdulrashid (2024) [1] also found that the 2% mint juice added paneer had a higher colour and appearance score as compared to control, 1%, and 3% mint juice added paneer and concluded that as the concentration of mint juice increased, there was a reduction in colour and appearance score of paneer. Chaudhari *et al.* (2022) [7] indicated that the colour and appearance scores of the paneer improved noticeably with the incorporation of spinach powder, particularly at levels of 0.5% and 1%. However, higher concentrations may result in excessively intense colouration, which could negatively affect the visual appeal and colour of the paneer.

3.2 Flavour

The flavour scores of paneer prepared with varying levels of flower extracts and their combination blends are summarised in Table 2. The combination treatment (HRS+DR) consistently received higher flavour scores compared to the individual extracts across all concentrations. The highest flavour score was observed at C3 concentration for the combination treatment, which was significantly higher to the corresponding individual extracts added paneer. At lower concentrations (C1 and C2), no significant differences were observed among treatments, indicating a minimal impact of extracts on flavour at these levels. At higher concentration (C5), the flavour scores declined for all treatments, with the combination treatment still performing better than the individual extracts added paneer. This may be attributed to the presence of bioactive compounds such as flavonoids, phenolics, and natural aromatic constituents in the flower, which impart subtle floral and herbal notes, enhancing the flavour of paneer (Pralhad, 2023) [17]. A decline trend was observed, as

increase in concentration may be due to excessive phytochemicals (polyphenols, tannins, and flavonoids) present in flower extract (Osakabe *et al.*, 2024) [15].

Table 2: Effect of various levels of *Hibiscus rosa-sinensis* (HRS) and *Delonix regia* (DR) flower extracts on the flavour of paneer

	T ₁	T ₂	T ₃
C1	8.19±0.148 ^{aBC}	8.19±0.148 ^{aBC}	8.19±0.148 ^{aC}
C2	8.38±0.146 ^{aAB}	8.43±0.111 ^{aAB}	8.48±0.131 ^{aAB}
C3	8.62±0.109 ^{bA}	8.67±0.105 ^{bA}	8.86±0.078 ^{aA}
C4	8.33±0.144 ^{aAB}	8.40±0.130 ^{aAB}	8.44±0.211 ^{aB}
C5	7.86±0.159 ^{bC}	7.90±0.136 ^{bC}	8.10±0.136 ^{aC}

Note: Values are means±SEM, n=6 per treatment group.

Means in a row without a common superscript small letter differ ($p<0.05$) and Means in a column without a common superscript capital letter differ ($p<0.05$).

Similarly, reported that yoghurt fortified with 1% *Hibiscus rosa-sinensis* flower extract achieved the highest flavour score, whereas both the control and the 2% extract added yoghurts recorded lower scores. Ebada *et al.* (2023) [8] also observed similar flavour scores between the control and beverages incorporated with *Delonix regia* pigments. Yashvantha *et al.* (2020) [27] reported that paneer incorporated with lemon rind achieved higher flavour scores compared to the control paneer. Similarly, Abdulrashid (2024) [1] reported that paneer supplemented with 2% mint juice exhibited the highest flavour scores compared to the control, 1%, and 3% treatments, and concluded that further increases in mint juice concentration led to a decline in visual quality.

3.3 Texture

The texture scores of paneer, prepared with *Hibiscus rosa-sinensis*, *Delonix regia* and a combination of both, are presented in Table 3. The flavour score ranged from 8.90-7.76 in all paneer groups. Across all concentrations, the combination treatment achieved higher scores than the individual extracts added paneer. The highest score was observed at C3 (8.90±0.065) concentration. At lower concentrations (C1 and C2), differences among treatments were less marked, whereas at higher concentrations (C4 and C5), a slight decline in scores was observed for all treatments, though the combination extract still maintained comparatively better values than individual extracts. The decrease in texture scores with increasing concentration of extracts may be attributed to the higher levels of phytochemicals, tannins, and organic acids present in the flowers, which can interfere with the protein matrix of paneer (Joseph, 2016) [10].

Table 3: Effect of various levels of *Hibiscus rosa-sinensis* (HRS) and *Delonix regia* (DR) flower extracts on the texture of paneer

	T ₁	T ₂	T ₃
C1	8.29±0.156 ^{aB}	8.29±0.156 ^{aB}	8.29±0.156 ^{aC}
C2	8.32±0.175 ^{bB}	8.48±0.154 ^{aAB}	8.52±0.131 ^{aB}
C3	8.64±0.109 ^{bA}	8.62±0.109 ^{bA}	8.90±0.065 ^{aA}
C4	8.22±0.156 ^{bB}	8.43±0.130 ^{aB}	8.48±0.112 ^{aB}
C5	7.76±0.136 ^{bC}	7.95±0.146 ^{bC}	8.10±0.153 ^{aC}

Note: Values are means±SEM, n=6 per treatment group.

Means in a row without a common superscript small letter differ ($p<0.05$) and Means in a column without a common superscript capital letter differ ($p<0.05$).

Similarly, Chaudhari *et al.* (2022) [7] found that the 1% spinach powder added paneer highest texture score as

compared to the control, 0.5% and 1.5% spinach added paneer. Singh *et al.* (2022) [25] also assessed the texture scores of control and periwinkle powder incorporated paneer and reported that paneer with 1% periwinkle powder exhibited the best texture quality, followed by those with 2% and 3%, while the control sample recorded the lowest score. Likewise, Tomar *et al.* (2021) [22] evaluated the texture scores of yoghurt supplemented with different plant extracts and reported that the control sample obtained the highest score, followed in order by yoghurt treated with 0.1% *Hibiscus sabdariffa*, 0.1% *Mentha piperita*, and 0.1% *Ocimum basilicum*. They also noted that lower texture score at higher concentration of plant extracts. Correspondingly, Ebada *et al.* (2023) [8] observed that beverages fortified with 800 µg/g of *Delonix regia* pigment extract achieved the highest texture score when compared with beverages containing other concentrations as well as the control.

3.4 Overall acceptability

The score for overall acceptability is presented in Table 4, and a decrease in the score was observed with increasing levels of *Hibiscus rosa-sinensis* and *Delonix regia*. At C3 concentration, highest overall acceptability was observed among flower extracts added paneer. Paneer prepared with a combination of both flower extracts had a higher overall acceptability as compared to individual extract treated paneer. Result showed that higher concentrations had a negative effect on consumer preference. Thus, C3 treatment group can be considered the optimum level for achieving the best overall acceptability.

The increase in overall acceptability scores up to C3 treatment may be attributed to the balanced improvement in flavour, texture, and appearance imparted by the combined effect of HRS and DR. At these levels, the additives possibly enhanced the sensory profile without imparting any undesirable characteristics. However, at higher concentrations (C4 and C5), products showed slight bitterness, off-flavour, or changes in texture and colour, which negatively influenced consumer preference.

Table 4: Effect of various levels of *Hibiscus rosa-sinensis* (HRS) and *Delonix regia* (DR) flower extracts on the overall acceptability of paneer

	T ₁	T ₂	T ₃
C1	8.33±0.144 ^{aB}	8.33±0.144 ^{aB}	8.33±0.144 ^{aB}
C2	8.43±0.130 ^{aB}	8.48±0.112 ^{abAB}	8.52±0.112 ^{aAB}
C3	8.62±0.109 ^{aA}	8.76±0.095 ^{aA}	8.90±0.065 ^{aA}
C4	8.31±0.154 ^{bB}	8.47±0.231 ^{abAB}	8.48±0.131 ^{aAB}
C5	7.95±0.146 ^{bC}	8.00±0.138 ^{abC}	8.19±0.164 ^{aC}

Note: Values are means ± SEM, n=6 per treatment group.

Means in a row without a common superscript small letter differ ($p < 0.05$) and Means in a column without a common superscript capital letter differ ($p < 0.05$).

According to Tomar *et al.* (2021) [22], yoghurt fortified with 0.1% *Hibiscus sabdariffa* extract received the highest overall acceptability compared to both control and other plant extract treatments, and a rise in plant extract concentration led to a reduction in overall acceptability. Likewise, observed that yoghurt containing 1% *Hibiscus rosa-sinensis* extract resulted in superior acceptability as compared to control and 2% added yoghurts. The findings of Umaraw *et al.* (2022) [25] supported the present study, and reported that paneer prepared with a combination of turmeric and aloe vera achieved the highest overall

acceptability compared to the control and those treated individually with either turmeric or aloe vera. Singh *et al.* (2022) [25] also reported that paneer incorporated with 1% periwinkle flower showed higher overall acceptability compared to the control and other concentration levels. Chaudhari *et al.* (2022) [7] observed that paneer supplemented with 1% spinach powder achieved the highest overall acceptability in comparison to the control and the 0.5% and 1.5% spinach powder treatments.

4. Conclusions

The combination of *Hibiscus rosa-sinensis* and *Delonix regia* flower extracts added paneer had a higher sensory score as compared to individually treated paneer. The sensory quality was initially increased at 500 mg/mL concentration. After that, it was reduced at a higher concentration. The incorporation of a 1:1 mixture of both flower extracts at 500 mg/mL resulted in the highest sensory score compared to other treatments.

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