



Influence of pollen substitute feeding on colony development of *Apis mellifera* during resource scarcity

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Summary

Honey bees play a vital role in both the production of high-value hive products and the pollination of a wide range of crops, making them indispensable to global agriculture. However, during dearth periods when natural sources of nectar and pollen are limited, colony strength often declines, threatening brood rearing and overall productivity. Nutritional supplementation through pollen substitute diets has emerged as an important strategy to sustain colonies under such conditions. To evaluate their effectiveness, experiments were conducted during the dearth seasons of 2021 and 2022 at the apiary of the Horticultural Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Pooled results from both years revealed that treatment T10 (Bee Pollen + Honey) produced the highest mean colony strength (8.21 frames), demonstrating a significant positive impact on brood development and foraging activity. This superior performance was attributed to the synergistic nutritional benefits of combining natural pollen with honey. The second-best results were obtained with treatment T7 (a formulated diet of dehusked parched gram flour, deactivated yeast, skimmed milk powder, sugar, water, turmeric powder, multivitamins, and pollen), which achieved a mean strength of 7.48 frames. This was followed by T6 (T3 + 10% Bee Pollen) with a mean of 7.20 frames, suggesting that the inclusion of yeast, turmeric, and multivitamins enhanced colony vitality, possibly by boosting immunity and resilience. Overall, the findings highlight that carefully formulated pollen substitute diets can effectively maintain colony strength during forage scarcity, with Bee Pollen + Honey proving to be the most beneficial option.

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Introduction

Summers in India are lasting longer, leading to periods of nectar and pollen scarcity for bees (Kumar et al. 2013). No area on earth can provide a continuous and sufficient amount of bee flora. Many studies have confirmed a long dearth period from May to November of these resources in North India (Sihag, 1990; Chaudhary, 2003a, 2003b, 2004; Bodla et al. 2009; Haldhar et al. 2025). To avoid this situation, colonies are either physically moved to a new bee flora-rich region or provision of feeding nectar and pollen supplements is made to sustain the beekeeping industry. But there are some disadvantages to both migration and artificial feeding. The shifting of bee colonies is a tedious work, which causes huge loss to honey bees in terms of mortality during and after migration. Also, a lot of time and labour is required for packaging and moving the colonies to distant places (Mishra 1995). Secondly, beekeepers usually neither collect and feed natural pollen to bee colonies, nor is pollen available in the market commercially. Further, commercial pollen may be contaminated with various pathogens (Kumar & Agrawal 2014). Therefore, efforts

nutritionally balanced pollen substitute to help the colonies overcome the dearth period, and it will lead to further strengthening of commercial beekeeping in India. Providing pollen supplements or substitutes to colonies can support their brood development during dearth periods, leading to rapid colony growth during favourable conditions (Prakash et al. 2007). Various types of pollen substitutes, such as powdered skimmed milk, brewer's yeast, soybean products, fish meal and meat scraps, etc., are used to feed the honey bee colonies during the floral dearth period (Sihag & Gupta 2013). Supplementing bee diets with sugar syrup or pollen during dearth periods can help to build up the strength of the foraging bees (Somerville & Collins 2007; Haldhar et al. 2021 a&b). Artificial diets for honey bees should be designed to mimic the taste, texture, and nutritional content of natural food sources. These diets must provide essential nutrients while avoiding substances that could harm the bees (Saffari et al. 2010). The necessity and formulation of artificial diets for honey bees have been the long-standing interest of the apiculturists and is the most challenging apicultural research problem (Kumar & Agrawal 2014; Pande et al. 2015; Shehata 2016; Abd el-Wahab et al. 2016; Singh et al., 2022).

Material and Methods

To study the effect of feeding different pollen substitutes on the bee strength of *Apis mellifera* L.

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should be made to formulate a highly palatable and

colonies during the dearth period, the various pollen substitute diets (Table 1) were fed to *A. mellifera* colonies during the pollen dearth period, i.e. from mid-May to September, 2021 and 2022. Pollen of mixed floral sources collected from bee hives by installing pollen traps during pollen flow season was dried, stored and used for the study. Before experiment, all the colonies were equalised with respect to their bee strength, sealed and unsealed brood area, pollen area, and unsealed and sealed honey area. Starting from mid-May, 200 grams of each pollen substitute was provided to a colony of *Apis mellifera* bees at a 15-day interval till

mid-September. Each treatment was replicated three times under a randomized block design. The two checks in the above treatments were feeding of corbicular pollen with honey (T₁₀) and a set of normal colonies (T₁₁) without feeding any diet. However, colonies in all eleven treatments were fed 500 g sugar solution (sugar: water = 1:1, w/w), at a weekly interval throughout the diet feeding phase of the experiments. The strength of the colonies was recorded in terms of the number of bee frames, by taking the bees' coverage on both the faces of the combs into account at 15-day intervals.

Table 1. Composition of various pollen substitutes

T1	Dehusked parched gram flour (8.00 g) + Deactivated Yeast (84.00 g) + Skimmed milk powder (8.00) + Sugar (50.00 g) + Water (50.00 g)
T2	Moong flour (37.50 g) + Deactivated Yeast (25.00 g) + Skimmed milk powder (37.50 g) + Honey (100.00 g)
T3	Defatted Soyabean flour (75.00) + Deactivated Yeast (25.00 g) + Sugar (66.66 g) + Water (33.34 g)
T4 = T1+ 10% Bee Pollen	Dehusked parched gram flour (7.20 g) + Deactivated Yeast (75.60 g) + Skimmed milk powder (7.20) + Sugar (45.00 g) + Water (45.00 g) + Pollen (20 g)
T5 = T2+ 10% Bee Pollen	Moong flour (33.75 g) + Deactivated Yeast (22.50 g) + Skimmed milk powder (33.75 g) + Honey (90.00 g) + Pollen (20 g)
T6 = T3+ 10% Bee Pollen	Defatted Soyabean flour (67.50 g) + Deactivated Yeast (22.50 g) + Sugar (59.99 g) + Water (30.01 g) + Pollen (20 g)
T7 = T4+ Turmeric Powder + Multivitamin	Dehusked parched gram flour (7.16 g) + Deactivated Yeast (75.18 g) + Skimmed milk powder (7.16 g) + Sugar (44.75 g) + Water (44.75 g) + Turmeric Powder (0.50 g) + Multivitamin (0.50 g) + Pollen (20 g)
T8 = T5+ Turmeric Powder + Multivitamin	Moong flour (33.56 g) + Deactivated Yeast (22.37 g) + Skimmed milk powder (33.56 g) + Honey (89.50 g) + Turmeric Powder (0.50 g) + Multivitamin (0.50 g) + Pollen (20 g)
T9 = T6+ Turmeric Powder + Multivitamin	Defatted Soyabean flour (67.12 g) + Deactivated Yeast (22.37 g) + Sugar (59.66 g) + Water (29.84 g) + Turmeric Powder (0.50 g) + Multivitamin (0.50 g) + Pollen (20 g)
T10 = Bee Pollen+ Honey	Bee/Corbicular Pollen (120 g) + Honey (80 g)
T11	Control

T1= Dehusked parched gram flour (8.00 g) + Deactivated Yeast (84.00 g) + Skimmed milk powder (8.00) + Sugar (50.00 g) + Water (50.00 g)

T2= Moong flour (37.50 g) + Deactivated Yeast (25.00 g) + Skimmed milk powder (37.50 g) + Honey (100.00 g)

T3= Defatted Soyabean flour (75.00) + Deactivated Yeast (25.00 g) + Sugar (66.66 g) + Water (33.34 g)

T10 = Bee/Corbicular Pollen (120 g) + Honey (80 g)

Result and Discussion

At the end of the feeding phase (mid-September, 2021), data on bee strength (Table 2) across treatments revealed significant differences in colony performance. The highest mean bee strength was observed in Treatment T10 (Bee Pollen + Honey) at 9.00 frames, which was statistically superior to all other treatments. Treatment T7 (T4 + Turmeric Powder + Multivitamin), followed by a mean of 7.38 frames, showed significantly higher performance than low-performing treatments such as T2 (5.67), T5 (5.66), and T8 (5.77). Treatments T4 (7.24), T1 (7.17), T9 (7.14), T6 (7.00), and T3 (6.93) were not significantly different from T7, forming a statistically similar high-performing group. In contrast, T2, T5, and T8 represented a statistically lower-performing group, while T11 (Control), with a

mean bee strength of only 3.10 frames, was significantly lower than all other treatments.

The overall mean bee strength across treatments showed clear differences in colony performance. Treatment T10, which involved feeding bees with a combination of bee pollen and honey, recorded the highest average strength at 8.19 bee frames, indicating excellent colony development. This was followed by T7, which included bee pollen along with turmeric powder and multivitamins, with an overall mean of 7.46 frames. T4, T9, T6, and T1 also showed strong performance, with average values ranging from 7.18 to 7.33 frames, reflecting their effectiveness in maintaining healthy bee colonies. Mid-range treatments like T3, T8, T5, and T2 had moderate bee strength, while the control group (T11), which did not receive any dietary enhancements, showed the lowest overall mean of 4.52 frames.

Table 2. Effect of feeding various pollen substitute diets on bee strength in *A. mellifera* colonies from mid-May to September, 2021

Treatment/Diet	Bee Strength (No. of bee frames)									
	May	June		July		August		September		Overall mean
	II	I	II	I	II	I	II	I	II	
T1	7.00 (2.84)	7.43 (2.90)	7.25 (2.87)	7.33 (2.89)	7.50 (2.92)	7.33 (2.89)	7.23 (2.87)	7.17 (2.86)	7.17 (2.86)	7.27
T2	7.00 (2.84)	7.00 (2.83)	6.67 (2.77)	6.67 (2.77)	6.00 (2.65)	6.00 (2.65)	5.83 (2.61)	5.67 (2.58)	5.60 (2.57)	6.27
T3	7.00 (2.84)	7.17 (2.86)	7.17 (2.86)	7.50 (2.92)	7.50 (2.92)	6.90 (2.81)	6.93 (2.82)	6.93 (2.82)	6.93 (2.82)	7.11
T4 = T1+ 10% Bee Pollen	7.00 (2.84)	7.51 (2.92)	7.32 (2.89)	7.41 (2.90)	7.58 (2.93)	7.41 (2.90)	7.31 (2.88)	7.24 (2.87)	7.24 (2.87)	7.33
T5 = T2+ 10% Bee Pollen	7.00 (2.84)	7.07 (2.84)	6.73 (2.78)	6.73 (2.78)	6.06 (2.66)	6.06 (2.66)	5.89 (2.62)	5.72 (2.59)	5.66 (2.58)	6.33
T6 = T3+ 10% Bee Pollen	7.00 (2.84)	7.24 (2.87)	7.24 (2.87)	7.58 (2.93)	7.58 (2.93)	6.97 (2.82)	7.00 (2.83)	7.00 (2.83)	7.00 (2.83)	7.18
T7 = T4+ Turmeric Powder + Multivitamin	7.00 (2.84)	7.66 (2.94)	7.47 (2.91)	7.55 (2.93)	7.73 (2.96)	7.55 (2.92)	7.45 (2.91)	7.38 (2.90)	7.38 (2.90)	7.46
T8 = T5+ Turmeric Powder + Multivitamin	7.00 (2.84)	7.21 (2.87)	6.87 (2.80)	6.87 (2.80)	6.18 (2.68)	6.18 (2.68)	6.01 (2.65)	5.84 (2.61)	5.77 (2.60)	6.44
T9 = T6+ Turmeric Powder + Multivitamin	7.00 (2.84)	7.38 (2.90)	7.38 (2.90)	7.73 (2.95)	7.73 (2.95)	7.11 (2.85)	7.14 (2.85)	7.14 (2.85)	7.14 (2.85)	7.31
T10 = Bee Pollen+ Honey	7.00 (2.84)	7.33 (2.89)	7.83 (2.97)	8.17 (3.03)	8.67 (3.11)	8.33 (3.05)	8.50 (3.08)	8.90 (3.15)	9.00 (3.16)	8.19
T11= Control	7.00 (2.84)	6.00 (2.65)	5.17 (2.48)	5.00 (2.45)	4.13 (2.27)	3.83 (2.20)	3.30 (2.07)	3.17 (2.04)	3.10 (2.02)	4.52
Overall mean	7.00	7.18	7.01	7.14	6.97	6.70	6.60	6.56	6.54	
C.D. (p=0.05)	NS	0.05	0.13	0.12	0.09	0.09	0.10	0.11	0.10	

T1= Dehusked parched gram flour (8.00 g) + Deactivated Yeast (84.00 g) + Skimmed milk powder (8.00) + Sugar (50.00 g) + Water (50.00 g)

T2= Moong flour (37.50 g) + Deactivated Yeast (25.00 g) + Skimmed milk powder (37.50 g) + Honey (100.00 g)

T3= Defatted Soyabean flour (75.00) + Deactivated Yeast (25.00 g) + Sugar (66.66 g) + Water (33.34 g)

T10 = Bee/Corbicular Pollen (120 g) + Honey (80 g)

At the end of the feeding phase (mid-September, 2022), data on bee strength (Table 3), revealed that the treatment T10 (Bee Pollen + Honey) recorded the highest bee strength with a mean of 9.04 bee frames, significantly outperforming all other treatments. This was followed by T7 (T4 + Turmeric Powder + Multivitamin) at 7.43, and T4 (T1 + 10% Bee Pollen) and T6 (T3 + 10% Bee Pollen) both at 7.28 and 7.04, respectively, all statistically higher than the untreated control. Treatments such as T9 (T6 + Turmeric Powder + Multivitamin) and T3 also maintained higher strength values of 7.19 and 6.97, respectively, while T1 recorded 7.21, suggesting consistency across the season. Conversely, treatments T2, T5 (T2 + 10% Bee Pollen), and T8 (T5 + Turmeric Powder + Multivitamin) showed reduced performance, with respective values of 5.63, 5.69, and 5.80, all significantly lower than the higher-performing groups. The control (T11) had the lowest bee strength, registering only 3.12 (2.03), indicating severe colony weakening in the absence of nutritional

supplementation. Overall, treatments supplemented with bee pollen, honey, and multivitamins, especially T10 and T7, exhibited statistically superior colony performance during the dearth period.

Based on the overall mean bee strength, among all treatments, T10 (Bee Pollen + Honey) recorded the highest overall mean of 8.24 bee frames, indicating that this combination was the most effective in promoting colony strength. This was followed by T7 (T4 + Turmeric Powder + Multivitamin) with a mean of 7.50 frames, also reflecting strong colony performance. Treatments such as T4, T6, and T9 showed slightly lower but still good overall means, ranging from 7.22 to 7.37 frames, suggesting that bee pollen and its combinations had a positive influence on colony strength. In contrast, treatments like T2, T5, and T8 had moderate overall means between 6.30 and 6.47, while the control group (T11) had the lowest mean bee strength of 4.54 frames, indicating poor colony development in the absence of dietary supplements.

Table 3. Effect of feeding various pollen substitute diets on bee strength in *A. mellifera* colonies from mid-May to September, 2022

Treatment/Diet	Bee Strength (No. of bee frames)									
	May	June		July		August		September		Overall mean
	II	I	II	I	II	I	II	I	II	
T1	7.00 (2.84)	7.48 (2.91)	7.29 (2.88)	7.38 (2.90)	7.55 (2.920)	7.38 (2.89)	7.28 (2.88)	7.21 (2.87)	7.21 (2.87)	7.31
T2	7.00 (2.84)	7.04 (2.84)	6.71 (2.78)	6.71 (2.78)	6.04 (2.65)	6.04 (2.65)	5.87 (2.62)	5.70 (2.59)	5.63 (2.58)	6.30
T3	7.00 (2.84)	7.21 (2.87)	7.21 (2.87)	7.55 (2.92)	7.55 (2.92)	6.94 (2.82)	6.97 (2.82)	6.97 (2.82)	6.97 (2.82)	7.15
T4 = T1+ 10% Bee Pollen	7.00 (2.84)	7.55 (2.92)	7.37 (2.89)	7.45 (2.91)	7.62 (2.94)	7.45 (2.91)	7.35 (2.89)	7.28 (2.88)	7.28 (2.88)	7.37
T5 = T2+ 10% Bee Pollen	7.00 (2.84)	7.11 (2.85)	6.77 (2.79)	6.77 (2.79)	6.10 (2.67)	6.10 (2.67)	5.93 (2.63)	5.76 (2.60)	5.69 (2.59)	6.36
T6 = T3+ 10% Bee Pollen	7.00 (2.84)	7.28 (2.88)	7.28 (2.88)	7.62 (2.94)	7.62 (2.94)	7.01 (2.83)	7.04 (2.84)	7.04 (2.84)	7.04 (2.84)	7.22
T7 = T4+ Turmeric Powder + Multivitamin	7.00 (2.84)	7.70 (2.95)	7.51 (2.92)	7.60 (2.93)	7.77 (2.96)	7.60 (2.93)	7.50 (2.91)	7.43 (2.90)	7.43 (2.90)	7.50
T8 = T5+ Turmeric Powder + Multivitamin	7.00 (2.84)	7.25 (2.87)	6.91 (2.81)	6.91 (2.81)	6.22 (2.69)	6.22 (2.69)	6.05 (2.65)	5.87 (2.62)	5.80 (2.61)	6.47
T9 = T6+ Turmeric Powder + Multivitamin	7.00 (2.84)	7.43 (2.90)	7.43 (2.90)	7.77 (2.96)	7.77 (2.96)	7.15 (2.85)	7.19 (2.86)	7.19 (2.86)	7.19 (2.86)	7.35
T10 = Bee Pollen+ Honey	7.00 (2.84)	7.38 (2.90)	7.88 (2.98)	8.22 (3.04)	8.72 (3.12)	8.38 (3.06)	8.55 (3.09)	8.95 (3.16)	9.04 (3.17)	8.24
T11= Control	7.00 (2.84)	6.04 (2.65)	5.20 (2.49)	5.03 (2.46)	4.16 (2.27)	3.86 (2.20)	3.32 (2.08)	3.19 (2.04)	3.12 (2.03)	4.54
Overall mean	7.00	7.23	7.05	7.18	7.01	6.74	6.64	6.60	6.58	
C.D. (p=0.05)	NS	0.06	0.13	0.12	0.09	0.09	0.10	0.11	0.10	

T1= Dehusked parched gram flour (8.00 g) + Deactivated Yeast (84.00 g) + Skimmed milk powder (8.00) + Sugar (50.00 g) + Water (50.00 g)

T2= Moong flour (37.50 g) + Deactivated Yeast (25.00 g) + Skimmed milk powder (37.50 g) + Honey (100.00 g)

T3= Defatted Soyabean flour (75.00) + Deactivated Yeast (25.00 g) + Sugar (66.66 g) + Water (33.34 g)

T10 = Bee/Corbicular Pollen (120 g) + Honey (80 g)

On a pooled mean basis of two years, 2021 and 2022 (Table 4), the highest bee strength was observed in T10 (Bee Pollen + Honey), with 9.02 bee frames significantly outperforming all other treatments. This was followed by T7 (T4 + Turmeric Powder + Multivitamin) at 7.41 and T9 (T6 + Turmeric Powder + Multivitamin) at 7.16, both showing strong performance and were better than the overall mean of 6.56. Treatments like T4 (T1 + 10% Bee Pollen) and T6 (T3 + 10% Bee Pollen) recorded

moderate values of 7.26 and 7.02, respectively, indicating consistent results with pollen supplementation. Conversely, the lowest bee strength was recorded in the control (T11) at 3.11, significantly lower than all other treatments, clearly demonstrating the negative impact of the absence of supplementation. Treatments T2 (5.62), T5 (5.67), and T8 (5.79) also remained below the overall mean, indicating limited effectiveness.

Table 4. Effect of feeding various pollen substitute diets on bee strength in *A. mellifera* colonies dearth period 2021 and 2022 (pooled)

Treatment/Diet	Bee Strength (No. of bee frames)									
	May	June		July		August		September		Overall mean
	II	I	II	I	II	I	II	I	II	
T1	7.00 (2.84)	7.46 (2.91)	7.27 (2.88)	7.36 (2.89)	7.52 (2.92)	7.36 (2.89)	7.26 (2.87)	7.19 (2.86)	7.19 (2.86)	7.29
T2	7.00 (2.84)	7.02 (2.83)	6.69 (2.77)	6.69 (2.77)	6.02 (2.65)	6.02 (2.65)	5.85 (2.62)	5.68 (2.59)	5.62 (2.57)	6.29

T3	7.00 (2.84)	7.19 (2.86)	7.19 (2.86)	7.52 (2.92)	7.52 (2.92)	6.92 (2.81)	6.95 (2.82)	6.95 (2.82)	6.95 (2.82)	7.13
T4 = T1+ 10% Bee Pollen	7.00 (2.84)	7.53 (2.92)	7.34 (2.89)	7.43 (2.90)	7.60 (2.93)	7.43 (2.90)	7.33 (2.89)	7.26 (2.87)	7.26 (2.87)	7.35
T5 = T2+ 10% Bee Pollen	7.00 (2.84)	7.09 (2.84)	6.75 (2.78)	6.75 (2.78)	6.08 (2.66)	6.08 (2.66)	5.91 (2.63)	5.74 (2.60)	5.67 (2.58)	6.34
T6 = T3+ 10% Bee Pollen	7.00 (2.84)	7.26 (2.87)	7.26 (2.87)	7.60 (2.93)	7.60 (2.93)	6.99 (2.83)	7.02 (2.83)	7.02 (2.83)	7.02 (2.83)	7.20
T7 = T4+ Turmeric Powder + Multivitamin	7.00 (2.84)	7.68 (2.95)	7.49 (2.91)	7.58 (2.93)	7.75 (2.96)	7.58 (2.93)	7.47 (2.91)	7.41 (2.90)	7.41 (2.90)	7.48
T8 = T5+ Turmeric Powder + Multivitamin	7.00 (2.84)	7.23 (2.87)	6.89 (2.81)	6.89 (2.81)	6.20 (2.68)	6.20 (2.68)	6.03 (2.65)	5.86 (2.62)	5.79 (2.61)	6.45
T9 = T6+ Turmeric Powder + Multivitamin	7.00 (2.84)	7.41 (2.90)	7.41 (2.90)	7.75 (2.96)	7.75 (2.96)	7.13 (2.85)	7.16 (2.86)	7.16 (2.86)	7.16 (2.86)	7.33
T10 = Bee Pollen+ Honey	7.00 (2.84)	7.36 (2.89)	7.86 (2.98)	8.19 (3.03)	8.69 (3.11)	8.36 (3.06)	8.53 (3.09)	8.93 (3.15)	9.02 (3.17)	8.21
T11= Control	7.00 (2.84)	6.02 (2.65)	5.18 (2.49)	5.02 (2.45)	4.15 (2.27)	3.84 (2.20)	3.31 (2.08)	3.18 (2.04)	3.11 (2.03)	4.53
Overall mean	7.00	7.20	7.03	7.16	6.99	6.72	6.62	6.58	6.56	
C.D. (p=0.05)	NS	0.05	0.13	0.12	0.09	0.09	0.10	0.11	0.10	

T1= Dehusked parched gram flour (8.00 g) + Deactivated Yeast (84.00 g) + Skimmed milk powder (8.00) + Sugar (50.00 g) + Water (50.00 g)

T2= Moong flour (37.50 g) + Deactivated Yeast (25.00 g) + Skimmed milk powder (37.50 g) + Honey (100.00 g)

T3= Defatted Soyabean flour (75.00) + Deactivated Yeast (25.00 g) + Sugar (66.66 g) + Water (33.34 g)

T10 = Bee/Corbicular Pollen (120 g) + Honey (80 g)

The pooled data of the overall mean of bee strength (2021 and 2022) revealed that among all treatments, T10 (Bee Pollen + Honey) demonstrated the highest overall mean bee strength of 8.21 frames, signifying its strong positive influence on colony development. This treatment consistently supported robust brood rearing and foraging activity, likely due to the synergistic nutritional benefits of both pollen and honey. The next best performances were recorded in T7 (T4 + Turmeric Powder + Multivitamin) and T6 (T3 + 10% Bee Pollen), with overall means of 7.48 and 7.20, respectively, indicating that the inclusion of turmeric and multivitamin supplements provided additional health benefits, possibly enhancing immunity and vitality. Similarly, T4 (T1 + 10% Bee Pollen) and T3 also maintained higher-than-average bee strength, showcasing the positive effect of bee pollen alone. On the other hand, treatments such as T2, T5, and T8, which had comparatively lower means (ranging from 6.29 to 6.45), were less effective, possibly due to limited nutritional diversity or availability. The control (T11), with the lowest mean of 4.53, displayed a continuous decline in bee frame strength, underlining the importance of supplemental feeding in maintaining colony vitality. Overall, the trend in mean values clearly indicates that colonies receiving nutritionally enriched diets, particularly those involving pollen or honey with additional supplements like yeast, turmeric, and multivitamins exhibited better health and sustained strength throughout the study period. Similar results have been disclosed by Moustafa (2000), Saffari et al. (2006), De Grandi-Hoffman et al. (2008), Sihag and Gupta (2013) and Nidhi et al. 2025, who observed that supplement diets produced more honey bee frames in comparison to non-supplemented fed control colonies.

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References

1. Abd el-Wahab TE, Ghania AMM & Zidan EW. 2016. Assessment of a new pollen supplement diet for honey bee colonies and their effect on some biological activities. *International Journal of Agricultural Technology*, 12: 55-62.
2. Bodla R, Kumar Y & Sharma SK. 2009. Effect of sugar feeding on *Apis mellifera* L. colonies build up and storage during dearth period. *Annals of Plant Protection Sciences*, 17(1): 103-106.
3. Chaudhary OP. 2003a. Evaluation of honey bee flora of the north eastern region of Haryana. *Journal of Palynology*, 39: 127-141.
4. Chaudhary OP. 2003b. Performance of *Apis mellifera* Linn. in the north eastern Haryana. *Indian Bee Journal*, 65 (1&2): 25-35.
5. Chaudhary OP. 2004. Prospects of beekeeping with *Apis mellifera* Linn. in Haryana. *Indian Bee Journal*, 66(3&4): 92-101.
6. DeGrandi-Hoffman G, Wardell G, Ahumada-Segura F, Rinderer T, Danka R & Pettis J. 2008. Comparisons of pollen substitute diets for honey bees: consumption rates by colonies and effects on brood and adult populations. *Journal of Apicultural Research and Bee World* 47:265-270.
7. Haldhar SM, Nidhi CN, Choudhary JP, Banra S, Singh KI, Rajkhowa D, Roy P & Shantibala T. 2025. Bacterial diversity associated with *Apis cerana himalaya* Smith 1991 across altitudinal gradients in the eastern hill region of India, *Journal of Apicultural Research*, DOI: 10.1080/00218839.2025.2531614.

8. Haldhar SM, Nidhi CN, Singh KI & Devi AS. 2021a. Honeybees diversity, pollination, entrepreneurship and beekeeping scenario in NEH region of India. *Journal of Agriculture and Ecology*, 12: 27-43.
9. Haldhar SM, Singh KI, Gupta MK & Devi AS. 2021b. Morphometric analysis on different species of honeybees in NEH region of India. *Journal of Agriculture and Ecology*, 12: 62-73.
10. Kumar R & Agrawal OP. 2014. Comparative performance of honey bee colonies fed with artificial diets in Gwalior and Panchkula region. *Journal of Entomology and Zoology Studies*, 2: 104-107.
11. Kumar R & Agrawal OP. 2014. Comparative performance of honey bee colonies fed with artificial diets in Gwalior and Panchkula region. *Journal of Entomology and Zoology Studies*, 2: 104-107.
12. Kumar R, Rajpoot GS, Mishra RC & Agrawal OP. 2013. Effect of feeding various diet formulations to honey bee colonies during dearth period under Gwalior (India) conditions. *Munish Entomology and Zoology*, 8: 267-272.
13. Mishra RC. 1995. Social behavior of bees and related management practices. In: Honey bees and their Management in India. Krishi Anusandhan Bhawan, Pusa, New Delhi. pp. 44-59.
14. Moustafa AM. 2000. Influence of some supplementary feeding on physiological characters and productivity of honey bees. Ph.D thesis, Assiut University 159 p.
15. Nidhi CN, Haldhar SM, Singh KI, Singh NO, Sinha B, Kencharddi RN, Mishra LK, Jat MK & Choudhary M. 2025. Physicochemical and antioxidant properties of honey across bee species from North Eastern Hill region of India. *Scientific Reports*, 15, 33759; <https://doi.org/10.1038/s41598-025-98040-w>.
16. Pande R, Karnatak AK & Pande N. 2015. Development of nectar supplements for dearth period management of honey bees (*Apis mellifera* L.) colonies in foothills of Shivalik range of Himalayan. *The Bioscan*, 10: 1599-1603.
17. Prakash S, Naik MI & Hanumantha Swamy BC. 2007. Evaluation of pollen supplement and substitute on honey and pollen stores of honey bee, *Apis cerana* Fabricius. *Karnataka Journal of Agricultural Sciences*, 20(1): 155-156.
18. Saffari A, Kevan PJ & Atkinson J. 2010. Consumption of three dry pollen substitutes in commercial apiaries. *Journal of Apicultural Science*, 54: 13-20.
19. Saffari AM, Kevan PG & Atkinson JK. 2006. Feed bee balances growth feeding colonies with a nutritious pollen supplement is beneficial. *Bee culture*, 134: 30-31.
20. Shehata IAA. 2016. Evaluation of Carniolan and Italian honey bee colonies fed on artificial diets in dearth and flowering periods under Nasr city conditions. *International Journal of Environment*, 5: 19-25.
21. Sihag RC & Gupta M. 2013. Testing the effect of some pollen substitute diets on colony development and economics of bee keeping with *Apis mellifera* L. *Journal of Entomology*, 31: 1-16.
22. Sihag RC & Gupta M. 2013. Testing the effects of some pollen substitute diets on colony build up and economics of beekeeping with *Apis mellifera* L. *Journal of Entomology*, 10:120-135.
23. Sihag RC. 1990. Seasonal management of honey bee (*Apis mellifera* L.) colonies in Haryana. (India). *Indian Bee Journal*, 52(1-4): 51-56.
24. Singh KI, Haldhar SM & Maheshwari K. 2022. Scientific cares and management of *Apis cerana himalaya*. Pub: College of Agriculture, CAU, Imphal pp-93; ISBN: 978-81-947184-6-8
25. Somerville DC & Collins D. 2007. Field trials to test supplementary feeding strategies for commercial honey bees. Rural Industries Research and Development Corporation, www.rirdc.gov.au/fullreports/index.htm.