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Studies on the impact of vitamin supplemented pollen substitutes on honey production of *Apis mellifera* L. colonies during dearth period in Kashmir

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Abstract
The present investigations on "Studies on the impact of vitamin supplemented pollen substitutes on honey production of *Apis mellifera* L. colonies during dearth period in Kashmir" were carried out during the dearth period of 2020 and 2021 at Research and Training Centre for Pollinators, Pollinisers, and Pollination Management, (Division of Entomology) SKUAST-K Shalimar. Eleven treatments were given which include six water soluble vitamins (thiamine, riboflavin, pyridoxine, cyanocobalamin, niacin and ascorbic acid), basic PAU pollen substitute mixed with all the vitamins, basic PAU pollen substitute without any supplemented vitamins, Pollen supplemented (Basic PAU pollen substitute + 10% bee collected pollen) and: Pollen feeding (check1): Normal colony (check 11).Besides, this the unsealed honey store was highest in PAU pollen substitute (358.92 g,457.60 g) and lowest in mixture excluding pyridoxine (178.47 g, 200.27 g), however the sealed honey store was highest in mixture (365.86 g, 386.99 g) and lowest in colonies given the diet mixture excluding niacin (91.14 g, 80.60 g).

Keywords: *Apis mellifera* colonies, vitamins, PAU pollen substitute

Introduction
Apiculture plays an important role in improving crop productivity all over the world. The Beekeeping plays an important role in Indian economy, as it directly impacts agricultural sector through pollination. As per report published by the Ministry of Agriculture and Farmer's Welfare, Govt. of India, for the year 2016-17 the total geographical area of India is 328.7 million hectares, out of which 200.9 million hectares is the gross cropped area and141.4 million hectares is the net sown area (Anonymous, 2017) [2]. Honey bees acts as bio-indicators of environment and eusocial hymenopterans maintaining the natural ecosystem and beneficial to mankind directly which are reliant on floral wealth like nectar and pollen (Manzoor *et al.*, 2013) [9]. Honeybees not only provide honey, bee wax, royal jelly, propolis and bee venom which are useful products from medical and commercial point of view but also play a vital role in pollination of various fruits and crops (Kumar & Kundal, 2016) [12].
Honeybees require pollen and nectar rich flowers to satisfy their nutritional requirements. But such flowers of bee's interest are not available round the year. Almost every place in the world there is dearth period of floral resources (Prakash *et al.*, 2007) [10]. Therefore, honey bees require special care and management during dearth periods. The palatability, consumption and effects of protein-rich diet(s) were assessed on honey bee colonies of *Apis mellifera*. To complete their growth and development honeybee need proteins, vitamins, carbohydrates, lipids, minerals and water (Funari *et al.*, 2003) [6].

Material and Methods
The experiments were conducted during the dearth period of the year 2020 and 2021. Feeding phase of the experiment were restricted to natural pollen dearth period.

Plan of work

Experimental site and lab	Research and Training Centre for Pollinators, Pollinisers, and Pollination Management, (Division of Entomology) SKUAST-K Shalimar.
Apis spp.	*Apis mellifera* L.
Study target	Efficacy of vitamin supplemented pollen substitutes on the development of *Apis mellifera*.
Location	Apiary at Research and Training Centre for Pollinators, Pollinisers, and Pollination Management, (Division of Entomology) SKUAST-K Shalimar.
No. of treatments	Eleven (11)

Treatment details

Code		Details
T_1	:	Basic PAU pollen substitute, supplemented vitamin mixture thiamine (36 ppm) + riboflavin (72 ppm) + pyridoxine (26.5 ppm) + cyanocobalamin (0.08 ppm) + niacin (720 ppm) + ascorbic acid (7500 ppm).
T_2	:	Diet T_1 excluding Thiamin (36 ppm)
T_3	:	Diet T_1 excluding Riboflavin (72 ppm)
T_4	:	Diet T_1 excluding Pyridoxine (26.5 ppm)
T_5	:	Diet T_1 excluding Cyanocobalamin (0.08 ppm)
T_6	:	Diet T_1 excluding Niacin (720 ppm)
T_7	:	Diet T_1 excluding Ascorbic acid (7500 ppm)
T_8	:	Basic PAU pollen substitute without any supplemented vitamins
T_9	:	Pollen supplemented (Basic PAU pollen substitute +10% bee collected pollen)
T_{10}	:	Pollen feeding (check 1)
T_{11}	:	Normal colony (check 11)

Replication: Three (3)

Design of Experiment: Completely Randomized Design (CRD)

Results and discussion

First and Second fortnight of treatments on unsealed honey store (g) in *Apis mellifera* colonies during the year 2020 and 2021

The finding on unsealed honey store (g) in *Apis mellifera* colonies during the year 2020 and 2021 in Table 1 and 2 were highest in treatment T_8 (358.92g), followed by treatment T_3 (352.17 g) and lowest in treatment T_4 (178.47) in first fortnight and second fortnight was again highest in treatment T_8(457.60 g), followed by treatment T_3 (452.17 g) and lowest in treatment T_4 (200.17g) when treated with eleven treatments *viz.*, T_1: Basic PAU pollen substitute, supplemented vitamin mixture thiamine + riboflavin + pyridoxine + cyanocobalamin + niacin + ascorbic acid, T_2: Diet T_1 excluding Thiamin,T_3: Diet T_1 excluding Riboflavin, T_4: Diet T_1 excluding Pyridoxine, T_5: Diet T_1 excluding Cyanocobalamin, T_6: Diet T_1 excluding Niacin,T_7: Diet T_1 excluding Ascorbic acid, T_8: Basic PAU pollen substitute without any supplemented vitamins, T_9: Pollen supplemented (Basic PAU pollen substitute + 10% bee collected pollen), T_{10}: Pollen feeding (check1) and T_{11}: Normal colony (check 11). These findings do find favour with earlier records of Abdellatif *et al.* 1971 [1] who reported that from colonies feeding with pollen substitute increased honey production during dearth period, Chhuneja *et al.* (1992) [3] found that higher consumption of pollen substitute diet resulted in producing more honey. Also, Erickson and Herbert, (1980) [5]; De Grandi *et al.* (2008) [4]; and Kumar *et al.* (2014) [8] who also reported that colonies fed with artificial diet produced significantly more honey as compared to unfed control colonies.

First and Second fortnight of treatments on sealed honey store (g) in *Apis mellifera* colonies during the dearth period of 2020 and 2021(pooled)

Among eleven treatments given to *Apis mellifera* colonies during the dearth period the results revealed that in Table 3 and 4 sealed honey stores during the year's were highest in treatment T_1 (365.86 g), followed by treatment T_9 (323.22 g) and lowest in treatment T_6 (91.14g) in first fortnight and in second fortnight the sealed honey store (g) was highest in treatment T_1 (386.99 g), followed by treatment T_2 (285.53 g) and lowest in treatmentT_6 (80.60 g). These findings do find favour with earlier records of Kumar *et al.* 1995 reported that stronger colonies produce more honey than weak colonies. Similarly, Abdellatif *et al.* 1971 [1] who reported that from colonies feeding with pollen substitute increased honey production during dearth period. Also, Chhuneja *et al.* 1992 [3] found that higher consumption of pollen substitute diet resulted in producing more honey and Rashid *et al.* (2013) [11] who also reported that colonies provided different pollen substitute diets have higher honey yield.

Table 1: First fortnight treatments on unsealed honey store (g) in *Apis mellifera* colonies during the dearth period of 2020 and 2021 (pooled)

Treatments	June	July	August	September	October	November	Mean
T_1:Mixture	58.50	319.17	407.33	482.83	222.00	135.33	270.86
T_2:Mixture excluding Thiamin	69.83	178.17	237.67	575.67	157.83	97.50	219.45
T_3:Mixture excluding Riboflavin	79.50	451.00	686.83	796.00	44.00	55.67	352.17
T_4:Mixture excluding Pyridoxine	67.67	194.17	310.33	341.50	79.50	77.67	178.47
T_5:Mixture excluding Cyanocobalamin	70.50	619.33	295.83	359.67	138.17	114.17	266.28
T_6:Mixture excluding Niacin	65.00	176.67	599.17	621.17	163.33	124.83	291.69
T_7:Mixture excluding Ascorbic acid	57.83	127.83	314.17	418.33	271.33	154.33	223.97
T_8:PAU pollen substitute	61.17	286.83	587.67	780.17	284.17	153.50	358.92
T_9:PAU pollen substitute +10% bee collected pollen	64.50	338.00	448.33	201.67	99.67	86.17	206.39
T_{10}: Pollen feeding	82.67	407.17	318.17	666.83	272.00	242.00	331.47
T_{11}:Normal colony	97.83	94.67	490.50	408.33	201.00	123.17	235.92
C.D($p \leq 0.05$)	1.91	2.00	2.47	28.69	1.83	1.76	2.36

Mixture: Basic PAU pollen substitute, supplemented vitamin mixture thiamine (36 ppm) + riboflavin (72 ppm) + pyridoxine (26.5 ppm) + cyanocobalamin (0.08 ppm) + niacin (720 ppm) + ascorbic acid (7500 ppm)

Table 2: Second fortnight treatments on unsealed honey store (g) in *Apis mellifera* colonies during the year 2020 and 2021

Treatments	July	August	September	October	November	
T_1:Mixture	466.00	325.50	521.50	140.50	148.00	320.30
T_2:Mixture excluding Thiamin	393.00	270.50	834.00	123.00	142.67	352.63
T_3:Mixture excluding Riboflavin	481.83	219.00	1547.33	136.67	134.33	503.83
T_4:Mixture excluding Pyridoxine	237.50	103.50	496.67	71.50	92.17	200.27
T_5:Mixture excluding Cyanocobalamin	423.50	153.67	627.00	97.33	120.00	284.30
T_6:Mixture excluding Niacin	380.00	41.33	916.17	60.00	67.50	293.00
T_7:Mixture excluding Ascorbic acid	93.00	387.83	897.00	180.17	193.33	350.27
T_8:PAU pollen substitute	641.50	335.17	1001.33	144.83	165.17	457.60
T_9:PAU pollen substitute +10% bee collected pollen	385.50	115.83	786.33	85.50	120.33	298.69
T_{10}:Pollen feeding	419.17	280.50	1047.00	248.00	266.17	452.17
T_{11}:Normal colony	261.00	202.33	603.33	132.00	134.83	266.69
C.D(P≤0.05)	1.89	1.89	1.86	2.02	2.00	1.95

Mixture: Basic PAU pollen substitute, supplemented vitamin mixture thiamine (36 ppm) + riboflavin (72 ppm) + pyridoxine (26.5 ppm) + cyanocobalamin (0.08 ppm) + niacin (720 ppm) + ascorbic acid (7500 ppm).

Table 3: First fortnight of treatments on sealed honey store (g) in *Apis mellifera* colonies during the dearth period of 2020 and 2021 (pooled)

Treatments	June	July	August	September	October	November	Mean
T_1:Mixture	74.17	212.83	746.67	804.83	332.67	24.00	365.86
T_2:Mixture excluding Thiamin	32.67	314.17	409.67	413.33	282.67	9.67	243.69
T_3:Mixture excluding Riboflavin	222.00	327.17	411.67	483.00	250.50	87.33	296.95
T_4:Mixture excluding Pyridoxine	91.67	184.83	254.83	266.33	215.33	37.33	175.05
T_5:Mixture excluding Cyanocobalamin	76.33	164.67	313.50	375.00	262.83	43.17	205.92
T_6:Mixture excluding Niacin	12.67	43.33	124.17	266.00	90.17	10.50	91.14
T_7:Mixture excluding Ascorbic acid	109.00	173.00	316.00	346.00	219.33	38.17	200.25
T_8:PAU pollen substitute	203.83	362.33	339.33	417.33	250.50	106.50	279.97
T_9:PAU pollen substitute +10% bee collected pollen	163.17	382.83	450.00	482.50	383.00	77.83	323.22
T_{10}: Pollen feeding	223.00	292.50	404.33	479.00	344.17	64.50	301.25
T_{11}:Normal colony	68.17	93.33	248.00	245.67	269.83	46.17	161.86
C.D(p≤0.05)	2.18	42.78	3.56	1.88	1.91	1.79	3.33

Mixture: Basic PAU pollen substitute, supplemented vitamin mixture thiamine (36 ppm) + riboflavin (72 ppm) + pyridoxine (26.5 ppm) + cyanocobalamin (0.08 ppm) + niacin (720 ppm) + ascorbic acid (7500 ppm).

Table 4: Second fortnight of various treatments on sealed honey store (g) in *Apis mellifera* colonies during years 2020 and 2021 (pooled)

Treatments	July	August	September	October	November	Mean
T_1:Mixture	484.00	615.83	632.33	145.00	57.83	386.99
T_2:Mixture excluding Thiamin	419.00	317.83	471.00	124.33	95.50	285.53
T_3:Mixture excluding Riboflavin	353.00	467.83	371.33	74.33	70.17	267.33
T_4:Mixture excluding Pyridoxine	107.67	339.33	179.67	27.17	40.33	138.83
T_5:Mixture excluding Cyanocobalamin	30.00	466.17	345.50	8.50	18.83	173.80
T_6:Mixture excluding Niacin	6.67	327.67	39.17	4.17	25.33	80.60
T_7:Mixture excluding Ascorbic acid	150.50	299.00	284.33	47.33	43.00	164.83
T_8:PAU pollen substitute	173.50	709.50	293.33	9.33	23.83	241.89
T_9:PAU pollen substitute +10% bee collected pollen	116.83	652.00	398.50	43.83	56.00	253.43
T_{10}:Pollen feeding	204.33	525.50	346.17	79.83	93.00	249.77
T_{11}:Normal colony	123.67	268.83	145.83	56.17	54.83	129.87
C.D(P≤0.05)	1.64	1.79	1.74	1.83	1.95	1.89

Mixture: Basic PAU pollen substitute, supplemented vitamin mixture thiamine (36 ppm) + riboflavin (72 ppm) + pyridoxine (26.5 ppm) + cyanocobalamin (0.08 ppm) + niacin (720 ppm) + ascorbic acid (7500 ppm).

Conclusion

The highest unsealed honey store(g) was observed in PAU pollen substitute followed by mixture excluding Riboflavin (358.92, 457.60:352.17, 452.17) whereas, highest sealed honey store (g) was observed in mixture which contain PAU pollen substitute along with all vitamins (365.86,386.99) followed by PAU pollen substitute +10% bee collected pollen (323.22,253.43) during the dearth period of 2020 and 2021.

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