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## Economic benefits of using prebiotic and probiotic products as supplements in stimulation feeds administered to bee colonies

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**Abstract:** Spring stimulation feeding of honeybee colonies (*Apis mellifera carpatica*) is a very important technique for the encouragement of productive foraging. In addition to improving bee health by creating favorable conditions for the development of a beneficial intestinal bacterial flora, the use of prebiotic and probiotic supplements in the feed promotes good colony development, thus increasing the forager population. This paper presents the results for the economic benefit measured following use of supplements with acidifying substances (acetic and lactic acids) and probiotic products (Enterobiotics and Enterolactis Plus), as well as the synergism between them. A total of 110 bee colonies were studied, being fed with sugar syrup (1.4 L/colony weekly) between 25 March and 15 April, supplemented according to a controlled schedule. On 20 April the bees were transferred to a rapeseed field for foraging, and then at the beginning of May they were transferred elsewhere for acacia foraging. Honey production was measured for each experimental variant after each foraging period. Colonies fed with sugar syrup containing prebiotic and probiotic supplements registered higher honey production levels and showed a higher profit (ranging from +14.67% to +45.49%) in comparison with the control group.

**Key words:** Bees, nutrition, honey production, profit

### 1. Introduction

The obtaining of higher honey yields is closely linked to as early as possible a numerical growth of the bee colony and also to bee health. At the same time, maintaining them at a highly productive level requires a melliferous base sufficient to provide a sufficient supply of nectar and pollen for the foraging bees to exploit during the entire active season; it also necessitates supplementary feeding of the colony during periods when limited material is available for foraging, or when meteorological conditions are not conducive to the bees being able to exploit the available nectar and pollen (1).

The feeding of bee colonies with sugar syrup containing acidifying substances is aimed at intestinal pH reduction with favorable consequences for the inhibition of pathogenic microbial flora and the improvement of colony health (2).

The antimicrobial effects of acidifying substances on the *Paenibacillus larvae* bacterium, which is responsible for American foulbrood disease, have been studied

by some researchers (3–5). These researchers came to the conclusion that the use of acidifying substances may provide an alternative method for control of this disease. Furthermore, the acidifying substances act as prebiotics since, by creating an acid pH, they encourage the development of probiotic bacteria and maintain an environment favorable to them (6–8).

Probiotics are living microorganisms that can have a beneficial effect on digestive tract health in mammals and in insects. They help with stabilization of the local microfloral equilibrium, while at the same time also creating an intestinal immunological barrier (7–9). Corcionivoschi and Drănceanu (9) are of the opinion that when the probiotic bacteria reach the intestine they trigger an immune response as a result of their interaction with the intestinal cells.

In addition to the favorable effect on the health of bee colonies conferred by prebiotic and probiotic products, it has been established that they also stimulate the fecundity of the queen (10–12). Administered together, prebiotic

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and probiotic products act in a complementary way, on the one hand reducing the number of potentially pathogenic germs in the intestine while on the other bringing about its population with benign bacteria (2).

This study aimed to measure the economic effectiveness of using acidifying substances (acetic and lactic acids) and/or Enterobiotics probiotic products (*Lactobacillus acidophilus* LA-14 and *Bifidobacterium lactis* BI-04) and Enterolactis Plus (*Lactobacillus casei*) as supplements in the spring stimulation feeds administered to bee colonies.

## 2. Materials and methods

A total of 110 bee colonies (*Apis mellifera carpatica*), maintained in multisection hives, were studied in Berini, Romania. The colonies were allocated to 11 equally sized experimental treatment groups, each of 10 colonies of equal vigor with queens of the same age.

Between 25 March and 15 April 2011, the colonies were given sugar syrup feeds supplemented with acidifying substances (lactic or acetic acid) and/or probiotic products (Enterobiotics or Enterolactis Plus) in different doses according to the treatment schedule shown in Table 1. Each bee colony was supplied 1.4 L of sugar syrup weekly (1:1, 1 kg sugar/1 L water), modified by the addition of the aforementioned products. At the end of the stimulation feeding period colonies were transported to the field for rapeseed foraging, and later relocated for acacia foraging.

## 3. Results

Evaluation of the effect of prebiotic and probiotic supplementation on honey production was carried out by weighing the rapeseed and acacia honey yields produced by each treatment group during May and June 2011. The production of rapeseed honey obtained from the colonies under study lay between 17 kg and 26.8 kg, while acacia honey production lay between 18.9 kg and 25.6 kg (Table 2).

From the data presented in Table 2 it may be observed that colonies fed with sugar syrup containing acidifying substances (lactic or acetic acid) and/or probiotic products (Enterobiotics or Enterolactis Plus) achieved a higher honey production than the control group of between 16.43% and 48.74%, with the best results being obtained by groups EG<sub>6</sub> and EG<sub>9</sub>. Such higher honey production has been previously reported (11,12) to be positively correlated with a significantly greater development of the colony, involving production of a higher number of brood cells (by between 10.67% and 28.18%) at the end of the stimulation feed period.

The total cost of bee transportation to the fields for rapeseed and acacia foraging was 2.16 euro per colony (Table 3). The selling prices of rapeseed and acacia honeys were 2 euro/kg and 3 euro/kg, respectively. Expenditure on 2 prophylactic administrations against *Varroa destructor* mite infestation was 1 euro per colony in all cases. Manual

**Table 1.** Experimental treatment scheme.

No.	Experimental variants	Feed composition				
		Sugar syrup (mL)	98% Lactic acid (mL)	Acetic acid (mL)	Enterobiotics (g)	Enterolactis Plus (g)
1.	Control group (CG)	1000	–	–	–	–
2.	Experimental group 1 (EG <sub>1</sub> )	1000	2	–	–	–
3.	Experimental group 2 (EG <sub>2</sub> )	1000	2.5	–	–	–
4.	Experimental group 3 (EG <sub>3</sub> )	1000	–	30	–	–
5.	Experimental group 4 (EG <sub>4</sub> )	1000	–	20	–	–
6.	Experimental group 5 (EG <sub>5</sub> )	1000	–	–	1.25	–
7.	Experimental group 6 (EG <sub>6</sub> )	1000	–	–	2.5	–
8.	Experimental group 7 (EG <sub>7</sub> )	1000	–	–	–	1.2
9.	Experimental group 8 (EG <sub>8</sub> )	1000	–	–	–	2.4
10.	Experimental group 9 (EG <sub>9</sub> )	1000	2.5	–	2.5	–
11.	Experimental group 10 (EG <sub>10</sub> )	1000	2.5	–	–	2.4

**Table 2.** Honey yields obtained from the bee colonies studied.

No.	Experimental variant	Honey yield (kg)		
		Rapeseed	Acacia	Total
1.	Control group (CG)	17.00	18.90	35.90
2.	Experimental group 1 (EG <sub>1</sub> )	20.20	22.00	42.20
3.	Experimental group 2 (EG <sub>2</sub> )	24.90	23.60	48.50
4.	Experimental group 3 (EG <sub>3</sub> )	21.80	20.00	41.80
5.	Experimental group 4 (EG <sub>4</sub> )	21.80	20.00	41.80
6.	Experimental group 5 (EG <sub>5</sub> )	25.00	22.40	47.40
7.	Experimental group 6 (EG <sub>6</sub> )	26.60	26.80	53.40
8.	Experimental group 7 (EG <sub>7</sub> )	21.20	23.60	44.80
9.	Experimental group 8 (EG <sub>8</sub> )	22.60	21.60	44.20
10.	Experimental group 9 (EG <sub>9</sub> )	26.80	25.60	52.40
11.	Experimental group 10 (EG <sub>10</sub> )	23.00	23.60	46.60

**Table 3.** The economic benefits of using prebiotic and probiotic products as supplements in the spring stimulation feed administered to bee colonies.

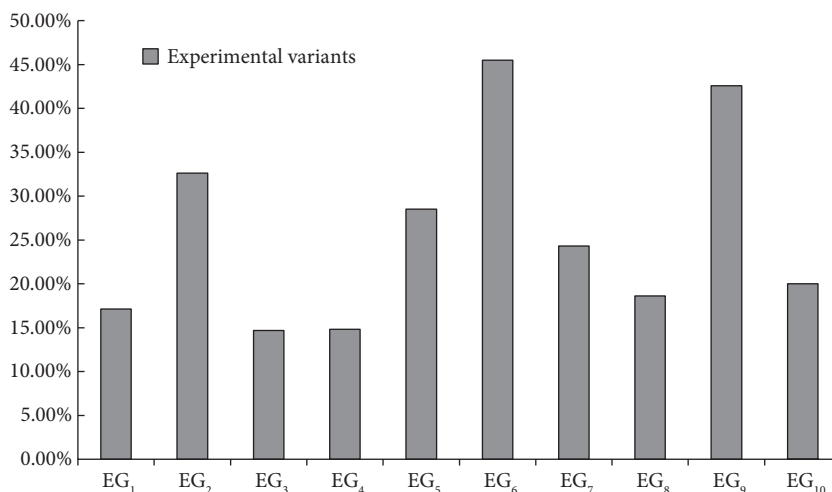
No.	Experimental variant	Income (euro/colony)	Colony feeding costs (euro/colony)	Profit (euro/colony)
1.	Control group (CG)	90.7	2.90	85.64
2.	Experimental group 1 (EG <sub>1</sub> )	106.2	3.74	100.3
3.	Experimental group 2 (EG <sub>2</sub> )	120.6	4.87	113.57
4.	Experimental group 3 (EG <sub>3</sub> )	103.6	3.23	98.21
5.	Experimental group 4 (EG <sub>4</sub> )	103.6	3.12	98.32
6.	Experimental group 5 (EG <sub>5</sub> )	117.2	4.99	110.05
7.	Experimental group 6 (EG <sub>6</sub> )	132.4	5.68	124.6
8.	Experimental group 7 (EG <sub>7</sub> )	113.2	4.58	106.46
9.	Experimental group 8 (EG <sub>8</sub> )	110.0	6.26	101.58
10.	Experimental group 9 (EG <sub>9</sub> )	130.4	6.15	122.09
11.	Experimental group 10 (EG <sub>10</sub> )	116.8	6.73	107.91

labor costs, being essentially the same for each colony, were not taken into consideration since all hive maintenance activities were carried out by the beekeeper's family.

Stimulation feeding with sugar syrup containing prebiotic products (lactic acid or acetic acid) resulted in a 14.67%–32.61% increase in profit as compared to the control group (with the highest value added being registered for the treatment with sugar syrup acidified

with lactic acid down to a pH value of 3) (Figure). The experimental groups EG<sub>3</sub> and EG<sub>4</sub>, fed with sugar syrups respectively containing 20 mL and 30 mL/L of acetic acid, registered the same income, showing that using higher than a 30-mL dosage (EG<sub>3</sub>) is not justifiable.

The use of Enterobiotics probiotic products (*Lactobacillus acidophilus* LA-14 and *Bifidobacterium lactis* BI-04) or Enterolactis Plus (*Lactobacillus casei*)



**Figure.** Comparison of profits obtained by using prebiotic and probiotic supplements in spring-administered stimulation feeds of bee colonies. Percentages shown are enhanced economic yield for each group as compared with the control group (no prebiotic or probiotic supplement).

in bee nutrition after their spring cleaning flight led to an increase in profit from honey sales of between 18.6% and 45.49% as compared to the control group, which was fed with unmodified sugar syrup. The best results were registered with the experimental variants fed with Enterobiotics product (EG<sub>5</sub> and EG<sub>6</sub>). It can be seen that a double dose (2.5 g) of the Enterobiotics product (EG<sub>6</sub>) resulted in an increased yield of 6 kg of honey per colony, giving a 13.22% higher profit than the experimental group EG<sub>5</sub>, where only 1.25 g was added (Figure).

The association of an acidifying substance (lactic acid) with a probiotic product (Enterobiotics or Enterolactis Plus), although raising the cost of feeding the colony, brought about a profit increase of between 26% and 45.56% compared to the group fed with plain sugar syrup (CG), the highest profit being registered by group EG<sub>9</sub> (sugar syrup + 2.5 mL lactic acid + 2.5 g Enterobiotics) (Figure).

#### 4. Discussion

The prebiotic and probiotic products administered in sugar syrup to the bee colonies had a favorable effect on them, acting both to improve their health and to stimulate queen fecundity.

Feeding bee colonies on sugar syrup and prebiotic products (lactic acid or acetic acid) has been shown to have the effect on the one hand of reducing the total number of germs in the intestine by a factor of between 6.33 and 47.88 (2), and on the other of significantly ( $P < 0.05$ ) increasing the number of brood cells in comparison with the control group (11,12).

As reported elsewhere, the use of probiotic products (Enterobiotics or Enterolactis Plus) caused a fall in the total

number of intestinal germs by a factor of between 1.60 and 2.99 and population of the intestines with benign bacteria contained in the administered products (2). At the same time, a significant ( $P < 0.05$ ) growth in the area of capped and uncapped brood comb was observed in comparison with the group fed on plain sugar syrup (13,14).

Addition of lactic acid in combination with one of the studied probiotic products had a favorable effect on colony health by reducing the total number of germs by a factor of between 15.96 and 18.73 (2) and achieving a better degree of colony development following the 3-week administration period (14).

The production of larger numbers of brood cells (between 10.67% and 28.18% more in the groups treated with prebiotic and probiotic products) and the improvement in health helped the colonies to accumulate between 18.83% and 57.64% more rapeseed honey and between 5.82% and 44.79% more acacia honey in comparison with the control group.

Although wax production was not analyzed, histological studies carried out by Pătruică et al. (15) showed that the prebiotic and probiotic products used have an influence on wax secretion, with colonies fed these products registering a growth in the size of wax secreting cells (7.17%–28.28% more than the control).

In this study, stimulation feeding of bee colonies in spring, after the cleaning flight, with sugar syrup containing acidifying substances (lactic or acetic acid) and/or probiotic products (Enterobiotics or Enterolactis Plus) has been shown to have resulted in an excellent growth of the colony, with the number of brood cells increasing

by between 10.67% and 28.18% compared to the control, thus producing an increase in the foraging worker bee population, which resulted in the effective collection of larger quantities of nectar for honey production.

The use in bee nutrition of the prebiotic and probiotic products studied led to a profit increase ranging between 14.22% and 45.97% from the sale of rapeseed and acacia honey when compared to the control group fed plain sugar syrup.

The total costs of the stimulation feeding of the colonies during the 3-week treatment period ranged from 2.9 euros per colony (CG) to 6.73 euro per colony (EG<sub>10</sub>). The profit obtained as a result of the use of acidifying substances

(lactic acid or acetic acid) and/or probiotic products (Enterobiotics or Enterolactis Plus) in stimulation feeding was 14.67%–42.56% higher, allowing us to recommend the use of these products.

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