

Supplemental Feeding of Honey Bee Colonies

ABSTRACT

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1977. Supplemental Feeding of Honey Bee Colonies. United States Department of Agriculture Agriculture Information Bulletin No. 413, 8 pages, illus.

This publication discusses the general food requirements of honey bees, *Apis mellifera L.*, and presents formulas for supplementary diets and methods for feeding such foods to bee colonies. In early spring, before pollen and nectar are available or at other times of the year when these materials are not available for bees in the field or in the hive, supplementary feeding may help the colony survive or sustain brood rearing and colony development. None of the protein supplemental foods fed to honey bees is a complete replacement for natural pollen; however, several brewer's yeast products, Wheat, and soybean flour, fed singly or in combination, can be used to improve the nutrition of colonies when natural pollen is scarce. Cane or beet sugar and isomerized corn syrup can be used to supplement the bees' diet of nectar or honey.

Trade names and the names of commercial companies are used in this publication solely to provide specific information. Mention of a trade name or manufacturer does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture nor an endorsement by the Department over other products mentioned.

INTRODUCTION

This publication contains information on the general food requirements of honey bees, *Apis mellifera L.*; formulas for supplementary diets; and methods for feeding such foods to bee colonies.

The natural food of the honey bee consists of pollen, nectar or honey, and water. In early spring, before pollen and nectar are available or at other times of the year when these materials are not available for bees in the field or in the hive, supplementary feeding may help the colony survive, or make it more populous so it will produce more honey or be better able to pollinate crops.

FOOD REQUIREMENTS OF THE HONEY BEE COLONY

Honey bees and other insects have no unusual nutritional requirements. They require carbohydrates, proteins, fats, minerals, vitamins, and water for growth, development, maintenance, and reproduction. Nectar and honeydew are the chief sources of supply for carbohydrates in the diet of bees, and pollen furnishes all the other indispensable constituents. Adult bees can survive on carbohydrates (that is, honey or sucrose) and water; however, proteins, lipids or fats, minerals, and vitamins are necessary for growth and development of young bees and in rearing larvae.

The adult bees of a colony obtain their dietary protein from the pollen the workers collect and bring back to the hive or from nitrogenous food-stuffs provided by the beekeeper. The proteins of some pollens are deficient in certain amino acids required by bees. Some of these amino acids are essential for bees and cannot be synthesized by them; therefore, the pollens or protein supplement diet of emerging bees and nurse bees should contain protein with an amount and variety of amino acids that will satisfy their nutritional need. Young bee larvae and the queen obtain their protein from the food (royal jelly) they are fed by nurse worker bees.

Proteins of a precise quality and definite amino acid composition are required for optimum growth of young adult bees and for development of the brood food-producing hypopharyngeal glands of nurse worker bees. If nurse bees do not get pollen or some other appropriate protein source, their brood food gland secretions are not adequate for support of normal growth and development of the larvae and egg production of the queen. When nursing duties are finished (between the 10th and 14th day of adult life) and field duties are undertaken, the requirement for protein decreases, and the chief dietary constituent becomes carbohydrates obtained from nectar and honey.

Carbohydrates form a large part of the diet of the colony and are required by both the larva and adult for normal growth and development. Carbohydrates in the bees' diet are used mainly to generate energy for muscular activity, body heat, and vital functions of certain organs and glands, such as wax production. Nectar and honey are the chief sources of carbohydrates in the honey bee's natural diet. Adult bees can live on the carbohydrates glucose, fructose, sucrose, trehalose, maltose, and melezitose. They cannot utilize the carbohydrates galactose, mannose, lactose, raffinose, dextrin, inulin, rhamnose, xylose, or arabinose. Cane and beet sugars are suitable substitutes for the carbohydrates in the natural diet of adult bees. Bees also utilize the carbohydrates in certain fruit and plant juices.

Lipids (sterols and fats) are probably used by larvae and young adult bees as sources of energy and for the synthesis of reserve fat and glycogen; however, scientific investigations have not conclusively demonstrated whether bees require lipids in their diets. The results of a few scientific studies suggest that young adult bees require and utilize some of the lipids in the pollen they consume. Since all insects studied critically have been found to require a dietary sterol, it is reasonable to assume bees also require this lipid. Also, certain lipids in the bees' diet probably play a significant role in the lubrication of food when it is ingested, digested, and metabolized.

The exact role played by vitamins in the growth and development of honey bees is not known. There is scientific evidence, however, that pantothenic acid is necessary for queen-worker differentiation and that riboflavin and nicotinic acid play a vital role in initiating brood rearing. Also, the presence of some vitamins or the absence of others may adversely affect the production and composition of brood food. In general, the vitamin needs of the colony are satisfied as long as pollen stores or protein supplementary foods are adequate, abundant, and available in the hive.

The minerals known to be required in the diet of man and other vertebrates (sodium, potassium, calcium, magnesium, chlorine, phosphorus, iron, copper, iodine, manganese, cobalt, zinc, and nickel) have all been shown to be needed by some species of insects. Pollens contain all of these minerals, and honey bees utilize at least some of them in their vital life processes.

Little is known about the specific role of water in the vital life processes of honey bees. It is collected by bees and used primarily as a diluent for thick nectar and honey, to maintain optimum humidity within the hive, and to cool the atmosphere within the hive during hot weather. In general, the amount of water required and collected by a colony is related to the outside air temperature and relative humidity, strength of colony in terms of number of bees, and amount of brood rearing in progress. The water requirements of a colony are quite extensive in the spring when large amounts of brood are reared.

We estimate the natural food requirement of a colony of honey bees to be 300 to 500 pounds of honey and 50 to 75 pounds of pollen a year. When bee-pasture forage is insufficient, and little or no stores are in the hive, beekeepers can feed their bees certain artificial foodstuffs to prevent them from starving and insure continued colony development.

Why Honey Bees May Need Supplemental Foods

Supplemental foods are fed to honey bees to supply the nutritive requirements of colonies in areas and at times when natural food sources (pollen, nectar, or honey) are inadequate or not available. The brood rearing activity and nutritional state of the colony, the quantity and quality of incoming pollen and nectar, and the food reserves in the hive will determine whether the bees need supplemental foods.

In the South, Southwest, and Southeast, where bees may continue low levels of brood rearing in the winter months, they may require more winter food reserves than colonies in the Northern United States that generally cease brood rearing in late September or October. A colony being prepared for winter in the North should have about six combs containing large areas of stored pollen. Colonies in the southern and southwestern regions may not require as much pollen because of the pollen sources that periodically become available to the bees. Colonies in all regions of the United States should have at least 60 to 90 pounds of honey in the fall.

Normal colonies can be stimulated to have larger populations by providing them with adequate supplemental foods. This feeding should be started 6 to 8 weeks in advance of when package bees or queens are to be produced. Overwintered colonies in the Northern States can be fed supplementary foods early enough to be divided before the major nectar flow or the need for pollination service.

Colonies are usually fed supplemental foods for one or more of the following reasons:

1. To ensure continued colony development in places and times of shortage of natural pollen and nectar.
2. To develop colonies with optimum populations in time for nectar flows.
3. To develop colonies with optimum populations for pollination of crops.
4. To build up colony populations for autumn and spring division.
5. To sustain brood rearing and colony development during inclement weather.
6. To build colonies to high populations for queen and package-bee production.
7. To maintain colonies and extend the season for high drone populations for queen matings.
8. To maintain colonies in feedlot situations.
9. To build up colonies after pesticide losses.
10. To provide adequate food reserves for overwintering colonies.

The first examination of colonies in late winter or early spring should reveal any need for supplementary feeding. Unless the winter is extremely long, colonies provided with adequate food stores in the autumn may not need supplemental foods in the spring. However, before and after flowers bloom, especially if the weather is unusually cold and rainy, colonies may urgently need supplemental foods for subsistence and continued brood rearing until nectar and pollen collection again becomes adequate. A sudden curtailment of nectar and pollen income when brood rearing activities are in progress often causes the adult bee population in colonies to decline.

Protein Supplemental Foods for Honey Bees

The protein supplemental foods fed to honey bees are usually divided into two classes:

1. Pollen supplements (artificial high-protein diets containing 5 to 25 percent pollen) and (2) pollen substitutes (artificial high-protein diets containing no pollen).
2. None of the protein supplemental foods fed to honey bees is a complete replacement for natural pollen, nor can they be regarded as more than adequate supplements for natural pollens. However, beekeepers can use protein supplemental foods to improve the nutrition of their bees when natural pollen is scarce.

A good protein supplement food for bees is one that they will readily consume and has the quality and quantity of proteins, lipids, vitamins, and minerals required for growth and development of individuals and reproduction of the colony. Several brewer's yeast products, (2) Wheat, (3) and soybean flour, (4) fed singly or in combination, are palatable and contain the essential nutrients required for growth and development of individual bees and reproduction of the colony. The brewer's yeast products and soybean flour used in bee diet formulations presented in this publication can be supplied to bees as a dry mix inside or outside the hive or as a moist cake inside the hive (fig. 1). Bees are unable to collect Wheat in its original dry state because of its large particle size and, therefore, it must be fed as a moist cake inside the hive.

FEEDING PROTEIN SUPPLEMENTAL FOODS

As A Dry Mix

Dry diet formulations containing brewer's yeast or soybean flour can be supplied to bees inside the hive in division board-frame feeders in the brood nest or outside the hive in trays, boxes, tubs, or other open containers during periods of pollen dearth when bees are flying. A dry mix of the pollen substitute diet formulations is prepared by replacing the water with an equivalent amount of sucrose. When water and honey or syrup are available to bees, there is no need to mix sucrose with the pollen supplement dry mix. If the bees do not readily collect or consume the pollen supplement dry

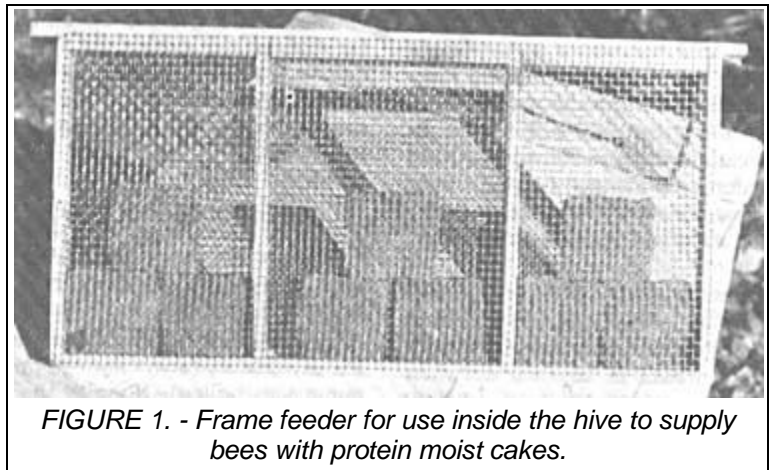


FIGURE 1. - Frame feeder for use inside the hive to supply bees with protein moist cakes.

mix, however, the addition of a little sugar may stimulate bees to use it. To protect the dry mix diet from rain or dew, the feeding container can be placed in a sheltered place under a roof or under a hive cover, but readily accessible to the bees. Feeding dry mix food preparations to honey bees outside the hive presents several problems of which the beekeeper should be aware. For example, the strongest colonies take the major share of the food whereas the weaker colonies, which may need it most, collect the least amount. Also, if there are neighboring colonies of bees (within a radius of 2 or 3 miles), they may collect some of this food.

As A Moist Cake or Candy Patty

When a pollen supplement or pollen' substitute diet is supplied to the bees as a moist cake or patty on the frame top bars inside the hive, it should be placed in close proximity to the un-sealed larvae in brood combs where nurse bees will feed on it readily. The hive cover should be removed, and the bees should be smoked down from the top of the frames. Then, the diet cake should be placed directly over the center of the cluster. The top of the cake should be covered with waxed paper to prevent moisture loss (fig. 2). If an inner cover is used, it should be replaced in an inverted position to provide space for the cake.

If the cake or candy patty diets are not fed on the day prepared, they can be held in a cool place for several days or a freezer for several weeks without deterioration or loss of food value.

Brood rearing requires a large amount of sugar (or honey) in addition to protein supplement foods. As consumption of the protein supplement increases, the depletion of honey reserves in the colony also increases. If an adequate reserve of honey is not present in the hive, the colony should be fed a sugar syrup (two parts sugar to one part water) to avert starvation. Beekeepers planning to feed protein supplements in late winter and early spring in the northern regions should leave no less than 90 pounds of honey per colony in October. In the southern and western regions, where bee flight is almost continuous, colonies should have a minimum of 60 pounds of honey and should be checked periodically for brood rearing and food supplies.

POLLEN SUPPLEMENT AND POLLEN SUBSTITUTE DIETS

Pollen supplements are usually more acceptable to bees than are pollen substitutes. Bee-collected pollen releases biostimulant chemicals in the artificial protein food supplement that are attractive to bees and contain other constituents that aid in keeping the supplement moist, soft, and palatable. Pollens used in bee protein supplemental artificial diets should be trapped by the beekeeper from his own colonies to avoid possible transmission of bee disease (fig. 3). Do not use trap pollen from diseased colonies. Pollen intended for use in protein supplemental diets should be stored in a freezer or dried and stored in airtight containers for no more than 2 years.

Pollen supplement diets containing 20 percent or more of either soybean flour or brewer's yeast are highly palatable to bees and have the nutritive requirements for their growth and reproduction. To prepare the pollen supplement diet as moist cakes for feeding inside the hive, first dissolve the pollen pellets in water (5) since they do not readily soften in sugar syrup. Then, stir in the sugar until it dissolves or is well mixed with the pollen. Finally, add the soybean flour, Wheat, or brewer's yeast to the water-pollen-sugar mixture and stir thoroughly. The bulk supplement should be made up into 1-1/2-pound cakes wrapped in waxed paper to prevent moisture loss. One 1-1/2-pound cake given to a colony will usually last 10 to 14 days. The colony should be provided with a new supplement cake before all the previous cake is consumed.

Pollen supplement diets can be made from any of the pollen substitute formulations by adding 10 percent by weight of a clean pollen. It may be necessary to increase the amount of water if pollen is added to the diet. Each beekeeper should experiment with the formulations to determine the amount of water necessary. In humid areas, the suggested amount of water may be excessive.

Protein supplement diets provide an excellent medium for feeding medicants to colonies if such materials are needed. All medicants that are presently recommended for the prevention or treatment of brood diseases and Nosema can be fed in protein supplement diets.

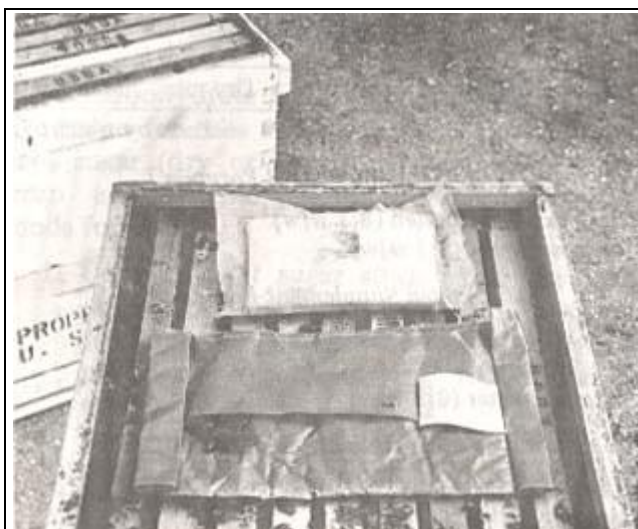


FIGURE 2. - Protein supplement diet (wrapped in brown waxed paper to prevent excessive loss of moisture) and a supply of water (water-soaked sponge enclosed in clear plastic bag with bee access hole on top) supplied to the colony on the frame top bars.



FIGURE 3. - Collecting trapped pollen pellets from a honey bee colony. Pollen trap collection tray is removed from back of hive.

The pollen supplement and pollen substitute diets presented in table 1 were formulated and tested at the USDA-SEA Bee Research Laboratory at Tucson, Ariz.; the Bee Management Investigations Laboratory at Madison, Wis.; and the Bioenvironmental Bee Laboratory at Beltsville, Md. The dietary protein sources and formulations are attractive to bees and will support growth and development of emerging bees and brood rearing.

PREPARING AND FEEDING CARBOHYDRATE SUPPLEMENTAL FOODS

Proper colony management should insure adequate honey reserves, but sometimes carbohydrate supplemental feeding may be necessary. Whenever colonies have little honey reserves, they should be fed. Carbohydrate foods have some value for stimulating queens to begin laying eggs, but no carbohydrate will support sustained egg laying or brood rearing in the absence of pollen or a protein supplementary food.

Honey is, of course, the ideal carbohydrate food for honey bees. It contains about 80-percent sugars, 18- to 19-percent water, traces of pollen, essential oils, tannins, various salts, minerals, and other materials. However, honey from unknown sources should never be fed to bees since it may contain pathogenic organisms (American foulbrood) injurious to bees. Although bees sometimes store honeydew and fruit juices, these are not good carbohydrate winter foods for bees because they contain materials the bees are unable to digest and utilize for either an energy source or growth and development.

Since the bloom of many plant species lasts only a short time, the beekeeper should pay special attention to timing supplemental feeding of his bees. Protein supplementary feeding should begin prior to the bloom for building up overwintered low-population colonies to optimum strength for a specific honey flow or pollination service.

Preparing and Feeding Sugar Syrup

All carbohydrate foods are not equal in nutritive value for bees and some are toxic. Cane or beet sugar (dry or syrup) and isomerized corn syrup are suitable carbohydrate supplement foods for bees.

1. Cane or beet sugar syrup.- Mix one part (spring feeding) or two parts (autumn feeding) of granulated sucrose with one part water (preferably 49° to 66° Centigrade).
2. Isomerized syrup. – Dilute syrup with an equal volume of water for spring feed (1:1 syrup:water, volume to volume).

Queen and package bee producers feed their colonies sugar syrup to stimulate brood rearing for the production of queens and package bees to meet early shipping date schedules.

Protein source	Dry mix	Moist patty
<i>Parts by weight</i>		
Pollen Supplement Formula 1		
Soybean flour:pollen (3:1 w/w)(1)	1	
Sucrose:water (2:1 w/w)	2	
Pollen Supplement Formula 2		
Wheast or brewer's yeast:pollen (3:1 w/w)	1	
Sucrose:water (6:1 w/w)	2	
Pollen Substitute Formula 1		
Brewer's yeast	2	3
Sucrose	3	3
		2-1/2
Pollen Substitute Formula 2		
Soybean flour	2	3
Sucrose	3	3
Water(2)		2-1/2
Pollen Substitute Formula 3		
Wheast		3
Sucrose		3
Water(2)		4
(1) w/w = weight to weight. (2) Add sufficient water to substitute diet mix to form a doughlike consistency.		

TABLE 1. - Pollen supplement and pollen substitute diets

When package colonies are established on empty combs or comb foundations, they should be fed thick syrup (two parts sugar and one part water) for 2 or 3 weeks. Thin syrup (one part sugar and one part water) should be fed for gorging package bees prior to release into hive equipment.

Almost any leak proof container, such as a trough, tray, pan, or tub, with an adequate surface area may be used to supply sugar syrup outside the hive. Rocks, pieces of wood, Spanish moss, or similar material on which bees can stand while imbibing these materials should be placed in the container. Open feeders should be covered with a roof to protect syrup from rain and other precipitation. Where wild animals or birds become a problem, provisions must be made to keep them out of the feeder.

Sugar syrup can be supplied to bees inside the hive by one of the following methods.

1. Friction-top pail. – Several such pails can be placed simultaneously on the top bars of the frames over a colony. An empty hive rim should be placed above the combs of the colony to accommodate the pails and the hive cover placed over all.
2. Combs within the brood chamber. – When some of the combs in the hive are essentially empty, as commonly occurs in the spring, sugar syrup can be poured directly into the cells with a sprinkling can.
3. Division board feeder. – This is a small box-like container that replaces a comb in the brood nest suitable for feeding sugar syrup to colonies in early spring or late fall.
4. In a plastic bag feeder. – The bag encloses much of one or two of the frames in the lower or outer edge of the brood nest, and can hold as much as 10 to 15 pounds of syrup. Bees feed from the upper opening, somewhat like they do from a division board feeder.

In commercial operations, where large numbers of colonies are kept at one location, 500- to 1,000-gallon tanks connected to a metal pan (fig. 4) can be used for supplying sugar syrup and water to bees.

When colonies in the Northern States must be fed sugar syrup to augment winter stores, this feeding should be completed by October 1 to

15. In Southern States, feeding sugar syrup in the fall is advisable if stores are low, and, when necessary, feeding should be augmented in January and February.

The following precautionary measures should be taken when feeding sugar syrup to bees:

1. Feed late in the day,
2. Disturb the bees as little as possible, and
3. Limit the size of the area (entrance) where bees enter and leave the hives.

Therapeutic drugs may be incorporated in syrup for treatment and control of bee disease; however, never feed any therapeutic drugs in candy or syrup to a colony during a honey flow or 5 weeks prior to the start of a major honey flow. (Feeding therapeutic drugs in candy or syrup at these times may contaminate the surplus honey with both sugar and the drug.)

Preparing and Feeding Sugar Candy

To prepare cane or beet sugar candy, mix one part granulated sucrose with one part water and heat this mixture until it becomes the thickness of fudge



FIGURE 4. - Metal pan connected to a 1,000-gal tank with 1/4-inch tubing provides a constant supply of water for large numbers of bee colonies. Mechanical floats in pan regulate flow of water from tank. Excelsior on top of wood slats in pan helps prevent bees from drowning. Steel grid on top of pan protects water supply from large animals.

(softball stage). Pour the candy mix on waxed paper and allow it to cool and harden. Feed the candy to bees by placing it on the frame top bars.

Feeding Dry Sugar

As an emergency measure in late winter, when it is too early to feed sugar syrup, bees may be fed dry sugar by placing a pound or two on the inverted inner cover. Some beekeepers increase the feeding space by providing a wooden rim on top of the inner cover. The bees should have access to water while being fed dry sugar.

SUPPLYING BEES WITH WATER

A supply of water should be available to bees at all times. Water is an essential part of the diet of bees, and a lack of it adversely affects their nutrition, physiology, brood rearing, and normal behavior. The beekeeper should anticipate the need for water and present it to the bees in open pans or trays in which floating supports such as wood chips, corks, or plastic sponge are provided.

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On January 24, 1978, four USDA agencies – Agricultural Research Service (ARS), Cooperative State Research Service (CSRS), Extension Service (ES), and the National Agricultural Library (NAL) – merged to become a new organization, the Science and Education Administration (SEA), U.S. Department of Agriculture.

This publication was prepared by the Science and Education Administration's Federal Research staff, which was formerly the Agricultural Research Service.

NOTES

(1) Standifer and Kauffeld are entomologists, U.S. Department of Agriculture (USDA), Science and Education Administration (SEA), Bee Research Laboratory, Tucson, Ariz. 85719; Moeller is an entomologist, USDA-SEA, Bee Management Investigations Laboratory, Madison, Wis. 53706; and Herbert and Shimanuki are entomologist and microbiologist, respectively, USDA-SEA, Bioenvironmental Bee Laboratory, Beltsville, Md. 20705.

(2) Trade names of brewer's yeast products suitable for pollen supplement or pollen substitute diets are Yeaco-20 yeast (spray-dried brewer's yeast, 43-percent protein) or Amber yeast (water washed brewer's yeast, 45-percent protein).

*(3) Wheast is a dairy yeast (*Saccharomyces fragilis*) grown in cottage cheese whey and contains 54- to 60-percent protein.*

(4) Soybean flour should be expeller processed (44-percent protein) to remove excess fat and improve biological availability of the protein.

(5) One-third gallon of water for each pound of pollen pellets.