11. OTHER PRODUCTS FROM BEES

POLLEN

What pollen is

Pollen grains appear as tiny, white or golden specks, produced in thousands inside flowers. Each pollen grain is a microspore containing a male gametophyte.

Pollination

When the pollen grain reaches the female part of a plant – the stigma within the same flower, or in another flower, the pollen grain germinates and a pollen tube develops into the stigma, allowing the male nuclei from the pollen to reach the eggs within the flower's ovules. This is the way that plants achieve fertilisation, and viable seeds can develop (see Chapter 3).

Because plants are literally rooted to the spot where they grow, to achieve cross fertilisation between plants, it is necessary for some part of the plant to be able to travel. This is achieved by the male pollen grains being dispersed to reach the female stigmas of other flowers. Different plants depend upon different 'pollination agents' to achieve this transport of pollen, or dispersal. Grasses usually depend upon wind power to disperse their pollen far and wide. Insect-pollinated plants depend upon bees and other insects to transfer their pollen. The reasons why bees are especially effective pollinators are outlined in Chapter 3. Other pollinating agents include water, birds, bats and other mammals.

The value of pollen for bees

Plants that need bees to transfer their pollen must provide incentive for the bees to do so, and nectar and pollen are the incentives that flowers use to encourage bees to visit them. Nectar and pollen are honeybees' only food sources: nectar is mainly a source of carbohydrate for honey production, while pollen provides all the other nutrients essential for honeybee development and growth. The anatomy of honeybees is beautifully adapted for collecting pollen and packing it into the 'baskets' on the back legs of forager bees for carrying back to the nest. Once inside, the forager may perform a dance to inform other bees how to locate her source of pollen, she then unloads her bounty into a cell, usually near to developing bee larvae. Many experiments have been done to analyse the pollen loads of honeybees as they arrive back at their nest or hive. These experiments show that although each honeybee is collecting pollen from just one plant species, the honeybee colony as a whole is collecting pollen from a great variety of plants, and thus ensuring that the colony has a diverse diet.

Like honey, pollen stored in beeswax cells is a safe and stable food store. It is eaten mainly by worker bees during their first days of adult life, and used by them to create brood food for developing bee larvae.

Pollen as food for humans

Some people regard pollen as a highly valuable nutritional supplement for humans, because of the range of constituents, including the minor constituents it contains. It consists of around 30 percent protein, including all the essential amino acids, a full spectrum of vitamins and minerals, lipids, trace elements, hormone precursors, enzymes, vitamins, carbohydrates and fatty acids, flavonoids and carotenoids, and many minor constituents, depending upon which plants the bees have been foraging. There can be no standard definition of pollen, in the same way that there can be none for honey: it depends upon the forage sources available to, and selected by, bees.

Other uses

Pollen is also harvested for other reasons than human nutrition: for use in plant breeding programmes, for pollination, for storage and subsequent feeding to bees in times of dearth, for use in the study of allergic responses such as hay fever, and increasingly for monitoring for environmental pollution – most especially for the presence of heavy metals or residues.

Harvesting pollen

After bees gather pollen from flowers they carry it back to their nest as pellets of pollen stored in hair 'baskets' on their back legs. It is possible to harvest these pollen pellets by placing a wire mesh at the hive entrance. As these results in little pollen being brought into the colony, bees must continue to forage for pollen, and therefore the honey production from this colony will be reduced. Pollen traps can only be left on the hives for short periods, as it is essential that the colony is able to bring in a sufficient volume of pollen to feed the developing bees. A bee colony collects yearly, for its own consumption, an average quantity of between 20 and 40 kilograms of pollen. The beekeeper must be careful not to over harvest (two to four kilograms at most), as pollen is essential for the bees survival.

After collection from a pollen trap, pollen must be air-dried for a ten-hour period, using a dry, warm airflow: the maximum air temperature should not exceed 40 °C. The objective is to reduce the water content to four percent, at which point the pollen will be conserved without the growth of yeasts. The best way to dry pollen is to use a pollen drier: this consist of trays on which the pollen is spread thinly, with a gentle airflow at 40 °C. This should be in the dark or lit with infrared. After drying, the pollen must be checked for any impurities that must be removed (insects, bee fragments, scraps of wood, etc.), and then stored cool and dry, to avoid insect or mite development. This method provides marketable pollen that is attractive, easy to store and sell. Pollen may be marketed in either this freshly dried form, or further dried and marketed in capsules. Drying allows pollen to be kept at normal temperatures, but it may also deprive pollen of many useful compounds, mainly anti-oxidants, enzymes, volatile components and some vitamin content. Other more exacting procedures are available which are claimed to conserve these properties. Pollen can also be frozen and sold in vacuum-sealed packs: this procedure may allow the preservation of more active ingredients. There are also other pollen processing methods, mainly used to prepare other pharmaceutical forms of pollen, such as tablets, granules and mixtures with honey.

Honey always contains some pollen that can cause the honey to look cloudy. To prevent this, some processors filter honey to remove all pollen – however, many consumers prefer to have honey that has not been treated in this way and retains its natural pollen content. See Chapter 11 for information concerning the immunotherapeutic potential of honey containing pollen.

Marketing pollen

Pollen can be a useful crop to harvest and market. Commercialised harvesting of pollen tends to be especially successful in dry areas: in humid climates, special effort is needed to prevent pollen from becoming mouldy. Significant amounts of pollen are harvested in Australia, Argentina, Brazil, China, Spain, Vietnam and many other countries.

TABLE 21
Production and trade in pollen

	Year	Annual production tonnes
South Korea[17]	2002	659*

* Retail price of US$10.41 per kg.

PROPOLIS

What propolis is

Apis mellifera honeybees collect resins and gums from buds or injured areas of plants. This glue-like substance, usually dark brown in colour, is called propolis. Just as with honey and pollen, propolis differs in composition according to the plants from which bees have been collecting. Propolis is usually coloured dark brown, but it can also be yellow, green or red.

Stingless bees use large amounts of resin in their nest construction. The constituents of these materials remain unknown and this 'propolis' cannot be used by the pharmaceutical industry.

[17] Kun-Suk Woo, 2004.

BOX 11
Where does propolis come from?

Plants are rooted to the spot where they grow and this means that if attacked by an enemy, plants cannot escape. Plants have therefore evolved chemical defence systems to protect themselves. These include toxins, bitter tastes and stinging repellents, which serve a prophylactic function for plants. Tender buds provide highly nutritious snacks for insects and need to be protected: often a plant protects its buds with sticky gums. When a tree is wounded, it secretes resin around the wound as the first stage of the healing process.
Humans also derive great benefit from these powerful plant chemicals: there are thousands of examples. Everyday substances include aspirin (from willow trees), penicillin (from a fungus), caffeine (from coffee) and menthol (from mint plants). Many medicines are derived from plants. Like humans, bees also harvest powerful plant chemicals. They do it by collecting tree gums and resins and placing them in their nest.

Foraging by bees

The bee bites off scraps of plant resin with her mandibles and packs them into the corbiculae (pollen baskets) on her hind legs. Each corbicula can carry about 10 milligrams of propolis. Because of its stickiness, propolis gathering is a slow business: it can take an hour to fill both baskets. Back at the hive, unloading can take another hour. Propolis is only collected when the temperature is above 18 ºC.

Sometimes bees collect man-made materials and use these in the same way as 'real' propolis. For example, bees will collect drying paint, road tar or varnish. Presumably, to bees these substances have a consistency and strong odour similar to plant resins.

It was generally believed that bees collected resins and gums without altering their composition. However, recent research has shown that bees' enzymes do indeed transform some components of propolis.

The uses of propolis by bees

Apis mellifera honeybees use propolis to keep their homes dry, draught proof, secure and hygienic. When *Apis mellifera* nest in the wild, for example in a hollow tree, the inside walls of the tree appear smoothly varnished with propolis. In this way, propolis is used to seal up any cracks where microorganisms could flourish, and its volatile oils most likely serve as a kind of antiseptic air-freshener. In addition, bees use propolis:

- As building material to decrease the size of nest entrances and to make the surface smooth for passing bee traffic.
- In thin layers to varnish inside brood cells before the queen lays eggs into them, providing a strong, waterproof and hygienic unit for developing larvae.
- To embalm bodies of mice or other predators too large for bees to eject from the nest, which would otherwise decay and be a source of infection.

Apis florea, one of the Asian honeybee species, places rings of plant resins (like grease bands) around the branch from which its single-comb nest is suspended, in order to deter predators, particularly ants. Different races of *Apis mellifera* use propolis to different extents: the Caucasian race is a particularly enthusiastic collector, and not all species of honeybees use propolis: *Apis cerana* is one species that does not. It is not known why propolis should appear so essential for one species of honeybees and yet not for another.

Use of propolis by humans

Propolis has antiseptic and anaesthetic properties and is commonly used as an ingredient in medicines, toothpastes, oral sprays and chewing gums, and in shampoos, soap, skin ointments and cosmetics. It is most commonly sold as a tincture of propolis made by dissolving it in alcohol.

In forest societies, propolis is still used for many purposes. Kikuyu beekeepers in Kenya carry with them a lump of propolis to rub inside empty hives to make them attractive to a colony in search of a

nesting place. Propolis is used as part of traditional medicines, and also as an effective glue to mend or seal containers (wood, metal or clay), and to seal up knots in wood.

Propolis has long been used for making wood varnishes. One famous use was as a varnish for violins made by Stradivarius, in Cremona in Northern Italy. The propolis in this region is gathered by bees from poplar trees.

Characteristics of propolis

Propolis quality

Propolis is extremely sticky when warm, but when cold is shiny, hard and brittle. Its physical properties make it an excellent sealant for sealing gaps and cracks in bees' nesting places.

Colour

The pigments in propolis make it usually appear dark brown, red, orange, and yellow or green, although like honey, propolis has been occasionally reported in all sorts of colours.

Constituents of propolis

The constituents of propolis depend upon the plants on which the bees have been foraging, and it is therefore difficult to state a standard definition for propolis, although some countries have endeavoured to do this. Propolis commonly contains over 300 constituents: major substances present in propolis include, flavonoids, organic acids and aldehydes, various alcohols and other organic molecules, minerals, sterols and steroids, sugars, and amino acids. These constituents mean that propolis does not dissolve in water: solvents for propolis include ethanol and other alcohols and organic solvents.

Categorisation

Generally propolis can be categorised into the 'European type', rich in flavonoids (which occurs in China, Japan, Uruguay and Argentina), and the 'Brazilian type', rich in artepillin C[18]. Tree species whose resins frequently occur in propolis include *Alnus* spp., *Bacchalis dracunclifolia*, *Betula* spp. and *Populus* spp.

Harvesting propolis

Propolis can be scraped from the hive and collected until there is sufficient volume to sell. For the commercial harvest of propolis from *Apis mellifera* kept in frame hives, a plastic sheet with multiple small slots (each less than six millimetres) is placed in the hive. The bees seal these gaps with propolis. The sheet is subsequently removed from the hive. If placed in a freezer, when cold enough it is easy to flex the sheet and release the many small pieces of propolis.

Propolis is usually kept in dark containers, protected from light and heat. Propolis can be lyophilised (freeze-dried) and this procedure maintains the physical and chemical properties. A method widely used in Eastern Europe is to dissolve propolis in ethyl alcohol. This extract is then dissolved in organic amine solution. The resulting solution is then filtered and the wax residues removed. It is then soluble in aqueous solution and can be freeze-dried.

Marketing propolis

In some countries, there is a good local market for propolis amongst manufacturers of health products. Elsewhere it can be difficult to find a buyer, and the best recourse is to contact one of the major companies buying propolis, who advertise for propolis in some bee journals (for example, *Bees for Development Journal*) and on the internet.

Propolis can be a useful income source. Current world price for propolis is around a minimum of US$10 per kilogram. For beekeepers in remote areas, gaining access to a market for propolis is much more of a problem than harvesting the product.

[18] Fujimoto, T. *et al* (2001).

TABLE 22
Production and trade in propolis

	Year	Annual production tonnes
South Korea[19]	2002	63*

* Retail price of US$41.60 per kg.

ROYAL JELLY

What royal jelly is

Royal jelly is a milky white liquid. It is a food for bee larvae, secreted from a complex of glands known as the "salivary gland complex" - the chief one of which is the hypopharyngeal gland of nurse worker bees (worker bees attending the brood). It also contains some sugars and proteins added from the worker bees' stomachs. A larva destined to become a queen bee develops in an especially large wax cell inside which worker bees place lavish amounts of royal jelly. Royal jelly contains many insect growth hormones and is valued as a medicine, tonic or aphrodisiac by people in some parts of the world. Royal jelly has many different components including proteins, sugars, fats, minerals and vitamins.

Royal jelly production

In some countries, especially China, Taiwan and Thailand, royal jelly is harvested and marketed commercially. Honeybee colonies are manipulated to start producing great numbers of queens, perhaps 50 or more, to produce royal jelly for harvest. Worker bees therefore produce vast amounts of royal jelly (feeding extra sugar to the colony is needed to achieve this) and place it in the queen cells. However, instead of the larvae feeding on this and developing into queen bees, the larvae are removed and the royal jelly is harvested. The harvesting and subsequent processing and packaging require skilled techniques for honeybee colony manipulation and hygienic protocols. Royal jelly deteriorates quickly after harvest and must be kept frozen or freeze-dried during handling, storage, transport and marketing.

Royal jelly quality

Some countries have introduced standards for royal jelly, for example, the Food and Drug Administration of Thailand has introduced standards based on the protein content and amount of 10-hydroxy-decanoic acid, a fatty acid unique to royal jelly.

The market for royal jelly

The main market for royal jelly is Japan, with lesser amounts imported by other industrialized countries.

TABLE 23
Production and trade in royal jelly

	Year	Annual production tonnes
South Korea[20]	2002	108*
Syria[21]	2003	0.3**
Thailand[22]	2002	5-6

* Retail price US$29.10 per 50 grams.
** Retail price €2 per 1 gramme.

[19] Kun-Suk Woo, 2004.
[20] Kun-Suk Woo, 2004.
[21] Fert, 2004.
[22] Deowanish, 2004.

MINOR PRODUCTS

Bee brood

In a few world areas, people eat the brood (eggs, larvae and pupae) of honeybees. For example, in Africa honey hunters often eat the bee brood as they plunder the colony. In Asia, eating of the brood of *Apis florea*, *Apis cerana*, and other species occurs widely. In Asia bee brood is also lyophilised and marketed as a powder for health foods and drinks.

Bee venom

Venom is harvested from honeybees for use in therapy against bee sting allergy, and for use in apitherapy, especially for treatment of rheumatism and arthritis. Venom is harvested by submitting bees to electric fields: when they feel the electric shock bees sting into metal gauze, behind which is a glass sheet. This is left in place in the hive for a few hours, after which dried venom is scraped from the glass sheet. It is possible to harvest one gramme of venom (equivalent to about 10 000 bee stings).

Most apitherapy practitioners would prefer to use live bees to administer stings (see Chapter 11), and may argue that dried venom has lost volatile, active ingredients.

TABLE 24
World production and trade in bee venom

	Year	Annual production
South Korea[23]	2002	8 kg*

* Retail price of $US81 per gramme.

[23] Kun-Suk Woo, 2004.