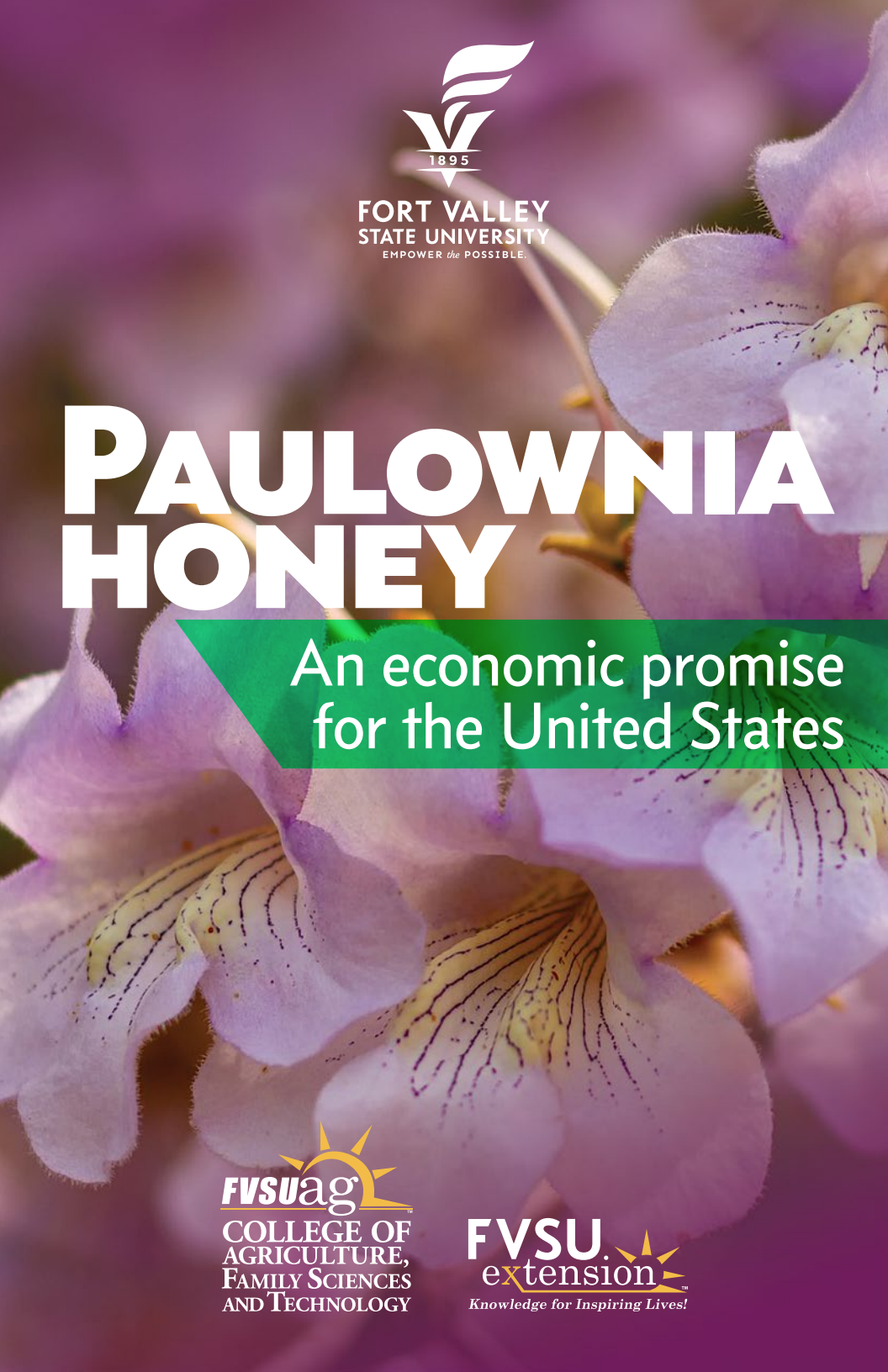
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Natural Honey for Human Health and Wealth

The first written reference to honey that dates back to 2100-2000 BCE, a Sumerian tablet writing mentions honey as a drug and ointment. Manuka honey has been shown to exhibit antibacterial activity against *Staphylococcus aureus* and *Helicobacter pylori*, making it a promising functional food.

Honey is one of the most appreciated and valued natural products introduced to humankind. It is used not only as a nutritional product, but also in health, described in traditional medicine. Practices include alternative treatment for clinical conditions ranging from wound healing to cancer treatment. Traditionally, honey is used in the treatment of eye diseases, bronchial asthma, throat infections, tuberculosis, thirst, hiccups, fatigue, dizziness, hepatitis, constipation, worm infestation, piles, eczema, healing of ulcers and wounds. It is also used as a nutritious supplement. The ingredients of honey have been reported to exert antioxidant, antimicrobial, anti-inflammatory, antiproliferative, anticancer and antimetastatic effects.

Graduate students work on honey production.

Honey has a potential therapeutic role in the treatment of disease by phytochemical, anti-inflammatory, antimicrobial and antioxidant properties. Flavonoids and polyphenols, which act as antioxidants, are two main bioactive molecules present in honey. According to modern scientific literature, honey may be useful and has protective effects for the treatment of various disease conditions such as respiratory, gastrointestinal, cardiovascular and nervous systems.

About 150,000 beekeepers manage approximately 2.5 million colonies of honeybees in the United States, producing around 175 million pounds of honey annually. Beekeepers derive income from their bees in a variety of ways. Some move their colonies several times during the season to produce a variety of honey crops and/or to pollinate various crops for a fee (apples,

peaches, blueberries or pumpkins, for example). Some stationary beekeepers have apiaries in good honey producing locations and make honey crops without moving their bees. Without the pollinating service of honeybees, the cost of many fruits, vegetables, legumes, nuts and seeds would be many times what it is today (extension.psu.edu/beekeeping-honey-bees).

Paulownia tree and honey production

The genus paulownia is indigenous to China. It is very adaptable, widely distributed and extremely fast growing. These trees grow in the U.S. Department of Agriculture (USDA) Hardiness Zones 5 to 9. These are deciduous trees, meaning they drop their leaves in the fall and grow new leaves in the spring. In zones 6 through 9, the paulownia tree blooms prolifically in early spring, producing long panicles of lavender to pinkish-lavender trumpet-shaped flowers. The edible flowers emit a vanilla-type fragrance. Their large, heart-shaped, deep green leaves commonly grow to between 8 and 12 inches long.

Data collection in the paulownia field.

The fast growth rate of paulownia trees may be capitalized upon for establishing bioenergy farms to maintain a constant supply of cellulosic biomass involving local farmers, agroforestry, land reclamation and animal waste remediation system. It is an environmentally sound alternative thriving on marginal land. Paulownia produces sawn timber in eight to 10 years and grows two to four times more lumber than most other commercial trees in the same period. Our studies show that at the end of three years, trimmings from paulownia trees can yield up to 1,800 pounds/acre fresh biomass. Short rotation crops that require partial shade (medicinal plants and spices, culinary herbs, etc.) do very well in between the rows of paulownia trees.

Paulownia wood is known for its moisture resistance and flame retardant properties, as well as its flexibility and distinctive texture, grain and color. As a fast-growing tree, paulownia has also been suggested as a bioenergy crop, potentially useful for both carbon sequestration or as a source for biomass for conversion to transportation fuel (Basu et al., 2015; Vaughn et al., 2015). In addition to its usefulness as wood and related industrial products (Joshee,

2012), the fruits, wood, bark, roots, seeds, leaves and flowers of paulownia have also been reported to have several useful medicinal properties (Yadav et al., 2013; He et al., 2016). In addition, the leaves of paulownia from managed farms are beneficial as a fertilizer and fodder and the nectariferous flowers for honey production (Yadav et al., 2013). The potential use of paulownia foliage as livestock fodder has thus far received less attention (Stewart et al., 2018). Once a paulownia tree is established, it can regenerate from stump sprouts (coppicing), which means that it does not have to be replanted for numerous rotations (Bergmann et al., 1997).

A 5-acre paulownia demonstration farm was established at Fort Valley State University's experimental station and evaluated for honey production after three years of growth. Sixteen honeybee colonies were placed near the plot on a tractor-trailer in March immediately after bloom initiation and kept in the field for a period of eight weeks. After completion of flowering, honey was harvested from the beehives to record total yield and three replicate samples were sent to a commercial lab for biochemical analysis (Columbia Food Laboratories Inc., Portland, Oregon). A total of 191 kg (420 pounds) of honey was produced, which appeared light-colored with a characteristic fragrance. Honey samples subjected to biochemical and pesticide residue analysis indicated the samples were found to be free of pesticides. Harmful products of sugar degradation (5-HMF) were present within acceptable limits.

Paulownia research at FVSU

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Paulownia in pictures

Three-month-old paulownia trees

Six-year-old paulownia tree in bloom

A close-up of paulownia flower

Fruits

Coppiced tree with new shoots

Honey processing

Honey extraction

Bottled honey

Paulownia demonstration farm at FVSU's new farm

Arrow indicates the location of trailer with beehives. Two plantings of 2.5 acres each were established; 8 feet by 8 feet spacing (680 trees/acres) was done to test paulownia for biomass production, whereas 12 feet by 12 feet spacing (300 trees/acres) was evaluated for timber production.

Courtesy: Google Maps.

Paulownia Honey Composition (Columbia Food Laboratories Inc., Portland, Oregon)

Lab #	Test Name	Analyte	Result	Units	Note
001	Micro Profile B (Aerobic Plate count, Yeast & Mold)	Aerobic Plate Count	20	cfu/g	
		Mold	<10	cfu/g	
		Yeast	<10	cfu/g	
001A	Honey Pesticide Profile	Bromopropylate	ND	mg/kg	MDL: 0.02 mg/kg (ppm)
		Chlordimeform	ND	mg/kg	MDL: 0.02 mg/kg (ppm)
		Coumaphos	ND	mg/kg	MDL: 0.02 mg/kg (ppm)
		Fenpyroximate	ND	mg/kg	MDL: 0.02 mg/kg (ppm)
		Fluvalinate (Apistan)	ND	mg/kg	MDL: 0.02 mg/kg (ppm)
001B	Antibiotics Profile (for Honey)	Antibiotic Profile	ND	µg/kg	
001C	Acidity, free (in Honey)	Acidity (normal: 8.7 - 59.5; mean 29.1)	20.1	meq/kg	
001D	Ash, muffle furnace	Ash	0.05	%	
001E	Color of Honey (Pfund scale)	Color	48	mm	Extra light amber
001F	Electrical Conductivity (in Honey)	Electrical Conductivity	0.235	mS/cm	at 20 °C
001G	Foreign Material, (80/60 mesh)	Foreign Material	None	+/-	
001H	Hydroxymethylfurfural, in (HMF)	Hydroxymethylfurfural, in Honey (HMF)	38	mg/kg	MDL: 5 mg/kg (ppm)
001I	Insoluble Solids in Honey	Insoluble Solids in Honey	0.097	g/100g	
001J	Moisture, refractometer (in honey)	Moisture	19.2	%	

Lab #	Test Name	Analyte	Result	Units	Note
001K	Sugar Profile (in Honey)	F/G ratio (norm: 0.80 - 1.86; mean 1.23)	1.11	%	
		Fructose (normal: 31% - 44%; mean 38%)	34.9	%	
		Glucose (normal: 23% - 41%; mean 30%)	31.6	%	
		Maltose (normal: 0% - 4%; mean 1.9%)	2.25	%	
		Maltotetrose (normal: < 0.1%)	ND	%	
		Maltotriose (normal: < 1%)	ND	%	
		Melezitose (normal: < 0.3%)	0.020	%	
		Raffinose (normal: < 0.3%)	0.049	%	
		Sucrose (normal: 0% - 8%; mean 1.3%)	ND	%	
		Sugars, Reducing	68.7	%	
		Sugars, Total	68.7	%	
001L	UF Profile (in honey)	HMF (Normal: Max. 40)	38	ppm	MDL: 5 mg/kg (ppm)
		Metals: Iron (Normal: Max. 8.0)	<MDL	ppm	MDL: 0.2 ppm
		Metals: Sodium (Normal: Max. 45)	<MDL	ppm	MDL: 2 ppm
		Metals: Zinc (Normal: Max. 4.7)	<MDL	ppm	MDL: 0.2 ppm
		Non-Volatiles	Normal		
001M	Diastase (Amylase), in Honey	Diastase Activity	11.3	DN	

Abbreviations used: MDL: Method detection limit; µg/kg: parts per billion (ppb) ng/g; DN: Diastase number; Ppm: parts per million; ND: not detectable; Cfu/g: colony forming units per gram; Mg/kg: milligram per kilogram; Meq/kg: milliequivalents per kilogram; mS/cm: millisiemens per centimeter

Paulownia research at Fort Valley State University attracts Northeast farmer

A Parkesburg, Pennsylvania, resident is benefiting from the many uses of a fast-growing crop after searching online for guidance.

Patricia Doyle and her partner, John Kopacz, purchased a small farm in eastern Pennsylvania in 2019. Two acres of the land hold an orchard of approximately 140 large paulownia trees in the lower portion of the property, which the previous owner planted about 20 years ago.

"They were badly overgrown with poison ivy," Doyle said. "We hand trimmed them and cut back as many of the vines as we could. It was a lot of work, and we still have some work to do."

With a lack of knowledge about paulownia trees, she was curious to know if there was still a market for paulownia wood, but she received conflicting answers. Native to China, paulownia is a multipurpose crop used for honey, timber, tea, lip balm, medicinal purposes and much more. It is easy to grow for reforestation and could help farmers establish sustainable income.

"Most of the people in my area had never heard of paulownia," Doyle said. "Then, I found out about the study at Fort Valley State University."

The Wait & See Farm owner searched online and discovered a story about two FVSU graduate students researching the versatility of this royal express tree. She contacted one of the students who referred her to Dr. Nirmal Joshee, an FVSU professor of plant science.

"Dr. Joshee said the paulownia trees help a lot with greenhouse gases, are good for the environment and make good honey. So, we decided to keep them," Doyle said. "When the trees blossom, they have these beautiful purple flowers."

Joshee, who has more than 15 years of experience researching paulownia, said paulownia honey is a quality product. With 2,500 paulownia trees on FVSU's campus, his team of researchers produced 420 pounds of honey several years ago.

"I suggested to her that she could easily produce it as an additional income. Paulownia honey is healthy and helpful for companion crops because of the bees," he advised. "I sent her our research publications and recommended that she raise bee colonies."

After a year, Doyle contacted Joshee to confirm that she took his advice and experimented with making paulownia honey. She purchased approximately 10,000 bees in the spring and harvested her first batch of honey (20 pounds) in June. "The honey was light in color and taste. Everyone I gave it to loved it," she said.

With plans to expand their small operation, Doyle said her daughter works at a local fudge shop, where the owner is interested in selling her paulownia honey. "It has been received so well and we are really excited about it," she beamed. "We have sold out our next harvest and have a waiting list."

The Pennsylvania farmer is grateful for Joshee's guidance and expertise.

"I would have never known it if it were not for Dr. Joshee. It changed our whole way of how we view that grove of trees," she said. "We were busy wondering how we could get rid of it. Now, it is the most significant part of our property, and we are working on giving our mature paulownia a healthy environment. I am so grateful for Dr. Joshee's invaluable work."

Doyle admitted that she always wanted to keep bees, but she did not know much about them. She said Joshee encouraged her to do it, and now it is an awesome hobby for her and her family.

"Look at the impact of our research," Joshee said. "With 1 pound of honey, she could earn at least $30. Paulownia is a versatile crop and could be a good, consolidated project for farmers. For 10 good weeks, farmers with 5 to 10 acres could easily make $5,000 to $10,000, and if they grow it organically, they could earn twice as much."

About 140 paulownia trees sit in the lower portion of the Wait & See Farm.

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