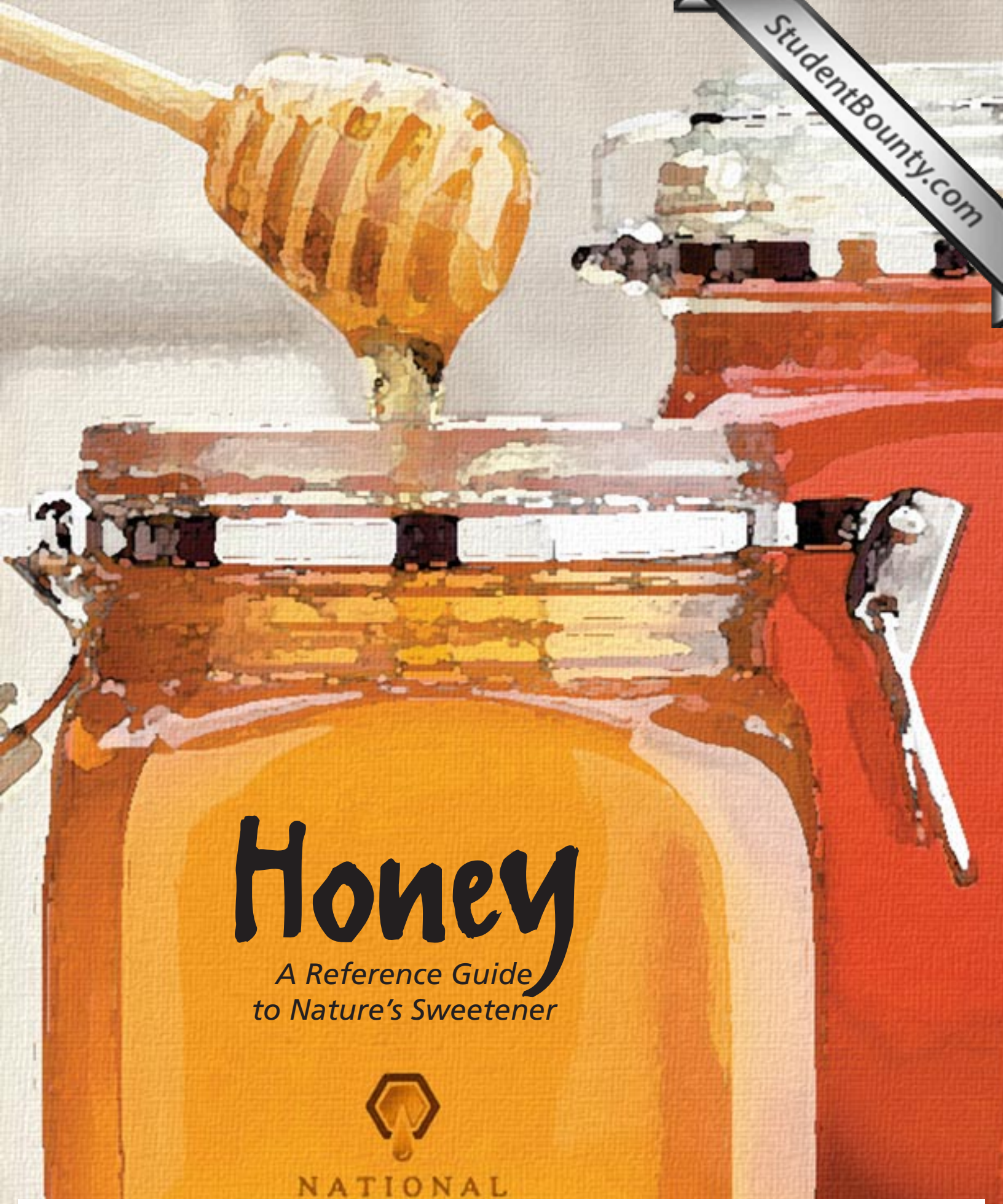

Honey

A Reference Guide to Nature's Sweetener

NATIONAL

Antimicrobial Properties

Honey has the capacity to serve as a natural food preservative. Research has demonstrated the potential for honey to reduce enzymatic browning in fruits and vegetables and prevent lipid oxidation in meats. Most of the antibacterial activity of the honeys occurs due to hydrogen peroxide generation.[1] Other researchers have identified the flavonoids in honey, particularly caffeic acid and ferulic acid, as the most likely contributors.[2]

Antioxidants[3]

Honey contains a variety of phytochemicals (as well as other substances such as organic acids, vitamins, and enzymes) that may serve as sources of dietary antioxidants (Gheldof and Engeseth 2002; Gheldof et al. 2002). The amount and type of these antioxidant compounds depends largely upon the floral source/variety of the honey (Gheldof et al. 2002). In general, darker honeys have been shown to be higher in antioxidant content than lighter honeys (Gheldof et al. 2002). Researchers at the University of Illinois Champaign/Urbana examined the antioxidant content (using an assessment technique known as Oxygen Radical Absorbance Capacity or ORAC) of 14 unifloral honeys compared to a sugar analogue. ORAC values for the honeys ranged from 3.0 µmol TE/g for acacia honey to 17.0 µmol TE/g for Illinois buckwheat honey. The sugar analogue displayed no antioxidant activity.

Antioxidant Activity (Measured by Oxygen Radical Absorbance Capacity or ORAC) and Total Phenolic Content of Honeys from Various Sources Compared to a Sugar Analogue*+ (mean ± SD)

	ORAC (µmol TE/g)	Total Phenolics (mg/kg)
IL Buckwheat	16.95 ± 0.76	796 ± 32
Buckwheat	9.81 V 0.34	No data
NY Buckwheat	9.75 ± 0.48	456 ± 55
Soy	8.34 ± 0.51	269 ± 22
Hawaiian Christmas Berry	8.87 ± 0.33	250 ± 26
Clover	6.53 ± 0.70	No data
Tupelo	6.48 ± 0.37	183 ± 9
Fireweed	3.09 ± 0.27	62 ± 6
Acacia	3.00 ± 0.16	46 ± 2
Sugar analogue*	1.00 ± 0.16[a]	No data

*The sugar analogue contained 40% fructose, 30% glucose, 10% maltose and 20% water

+Data from: Gheldof N and Engeseth NJ. Antioxidant capacity of honeys from various floral sources based on the determination of oxygen radical absorbance capacity and inhibition of in vitro lipoprotein oxidation in human serum samples. J Agric Food Chem. 2002;50:3050-3055.

Calories

Honey is a natural source of readily available [illegible] providing 64 calories per tablespoon

Chemical Characteristics

pH

Honey contains a number of acids which include amino acid[illegible] and organic acids (0.57%, range: 0.17-1.17%). The average pH of h[illegible] (with a typical range of 3.4 to 6.1).

Proteins, Amino Acids & Isoelectric Point

Protein	0.266%
Nitrogen	0.043%
Amino Acids	0.05 – 0.1%
Isoelectric Point	4.3

Color

Honey is classified by the U.S. Department of Agriculture into seven color categories: water white, extra white, white, extra light amber, light amber, amber and dark amber.

Table 1

Color Name	Pfund Scale (mm)	Optical Density
Water White	< 8	0.0945
Extra White	9-17	0.189
White	18-34	0.378
Extra Light Amber	35-50	0.595
Light Amber	51-85	1.389
Amber	86-114	3.008
Dark Amber	> 114	—

Composition

Honey is composed primarily of the sugars glucose and fructose; its third greatest component is water. Honey also contains numerous other types of sugars, as well as acids, proteins and minerals.[4,5] Carbohydrates are described by the number of sub-units they contain. Fructose and glucose are monosaccharides, that is, simple sugars. Sucrose, which is composed of fructose and glucose linked together, is a disaccharide; it comprises a little over 1 percent of the composition of honey. Honey contains other disaccharides which make up over 7 percent of its composition. Some of the disaccharides in honey are maltose, sucrose, kojibiose, turanose, isomaltose, and maltulose. In addition, honey also contains carbohydrates known as oligosaccharides. These are medium-sized carbohydrates, containing more than three simple sugar sub-units, often made of mono- and disaccharides.

Crystallization

Honey sometimes takes on a semi-solid state known as crystallized or granulated honey. This natural phenomenon happens when glucose, one of three main sugars in honey, spontaneously precipitates out of the supersaturated honey solution. Honey crystallizes because it is a supersaturated solution. This supersaturated state occurs because there is so much sugar in honey (more

Diabetes

In the past, people with diabetes were advised to avoid "simple sugars" including honey. It was thought that consuming simple sugars would cause a sharp and rapid elevation in blood glucose levels and an overwhelming insulin demand. Some even speculated that eating simple sugars could cause diabetes, a notion that has not been supported by scientific research. In fact, research has shown that some complex carbohydrates raise blood glucose levels more significantly than certain simple sugars (see Glycemic Index). Both honey and sucrose have been shown to produce a lower glucose response than starchy foods such as white bread. Moreover, it has been shown that the total amount of carbohydrate consumed is probably more important than the type of carbohydrate when it comes to blood sugar levels. Thus, experts agree that diabetics may include moderate amounts of "simple sugars" in a balanced diet.[6]

Dried Honey

Dried honey products available commercially for industrial use are derived from pure liquid honey (1) to which have been added processing aids and other ingredients, (2) which has been dried to a low moisture content, and (3) which in most cases has been converted to a free-flowing product. Processing aids and other ingredients are added to keep the dried honey free-flowing and to modify and enhance the functionality of the product.

Enzymes

Honey naturally contains small amounts of enzymes that are introduced into honey by the bees during various phases of the honey manufacturing process. The predominant enzymes in honey are diastase (amylase), invertase (α-glucosi-dase) and glucose oxidase. Other enzymes such as catalase and acid phosphatase, are generally present in lesser amounts. While enzyme type is fairly uniform across honey varieties the amount of enzyme present can vary widely[7]. Enzymes play an important role in honey and contribute to its functional properties.

Fermentation

Fermentation in honey is caused by osm[illegible]lt will not occur in honey that has a carbohydrate content > 83%, [illegible]ent < 17.1%, a storage temperature < 52° F (11° C), or that has be[illegible]. Properly extracted, treated and stored honey should not ferment.

Flavor Enhancement

The carbohydrates found in honey have the ability to improve the [illegible] desirable flavors and reduce the intensity of others. Honey enhances swe[illegible] intensity, decreases sourness, decreases the bitterness intensity and increas[illegible] the acceptability of savory products by modifying saltiness perception.

Floral Sources

There are over 300 floral sources for honey in the United States, including clover, alfalfa, buckwheat and orange blossom. Honey's color and flavor vary with its floral source.

Freezing Point Depression

15% honey solution: 29.44 to 29.25 °F (-1.42 to -1.53 °C). A 68% honey solution freezes at 21.6 °F (-5.78 °C).

Table 2

Common names	Name	Chemical reactions catalyzed
Diastase, Amylase	α- and β-amylase	transforms starch to other carbohydrates (dextrins, oligo-, di- and monosaccharides)
Invertase , Sucrase, Sucrose Hydrolase, Saccharase	α-glucosidase	converts sucrose to glucose and fructose (invert sugar)
Glucose Oxidase	belong to the peroxidases group	converts glucose to gluconolactone, which in turn yields gluconic acid and hydrogen peroxide
Catalase	belong to the oxidoreductases group	converts peroxide to water and oxygen
Acid Phosphatase		removes phosphate from organic phosphates
Protease	group of protein hydrolases	hydrolyzes proteins and polypeptides to yield peptides of lower molecular weight
Esterase	belong to the hydrolases group	breaks down ester bonds

Functional Characteristics

		Applications								
Characteristics	**Functions**	**Bakery**	**Beverages**	**Cereals**	**Confections**	**Dairy**	**Meats**	**Sauces**		**eads**
Antimicrobial Properties	Delays Spoilage	x				x	x	x		
Carbohydrate Composition	Flavor Enhancement		x				x	x	x	
Color	Coloring Agent	x				x	x			
Composition	Decrease Burn Perception						x	x	x	
Crystallization	Texture				x					x
Flavor	Flavoring Agent	x	x	x	x	x	x	x	x	x
Humectancy	Adds Moisture	x						x		x
Hygroscopic	Retains Moisture		x					x		
Lower Freezing Point	Freezing Point Depression		x			x				
Low Glycemic Index	Reduces Rebound Hypoglycemia		x						x	
Miscibility	Water Soluble	x				x		x		x
Maillard Reaction Precursors	Antioxidation						x			
Nutrition	Healthy Appeal	x	x	x	x	x			x	x
pH Balance	Inhibits Bacterial Growth		x			x				
Preservation	Slows Staling	x								
Pro-biotic	Enhances Bifidobacteria					x				
Proteins	Clarification		x							
Pumpable	Extrudable	x			x			x		x
Reducing Sugars	Enhances Browning	x		x			x	x	x	
Spreadability	Improves Reduced-fat Products	x		x	x		x			x
Viscosity	Binding Agent		x	x			x	x	x	x
Water Activity	Extends Shelf-life	x		x				x		

Glycemic Index

Glycemic Index (GI) is defined as the *incremental area under the blood glucose response curve of a 50 g portion of a test food expressed as a percentage of the response to the same amount of a reference food (generally white bread or glucose).* In other words, the GI describes the rate and extent to which 50 grams of a carbohydrate-rich food will raise blood glucose levels.

It has been hypothesized that floral variety can impact the GI of honey due, at least in part, to differences in the simple sugar concentrations (particularly the fructose:glucose ratio). According to the most recently published International Table of Glycemic Index Values (Foster-Powell et al. 2002), the GIs for honeys from different floral varieties and origins (including Australia, Canada, and Romania) ranges from 35-87. Researchers at San Diego State University recently examined the GI of four US honeys varying in fructose:glucose ratio (Ischayek et al. 2005). The average GI value for the honeys was 72.6 and there were no significant differences between the four honey varieties indicating that small differences in fructose: glucose ratio do not impact the GI of honey.

Grades

The USDA sets standards for extracted honey. These voluntary standards, made effective in 1985, are a point system based upon water content, flavor and aroma, clarity and absence of defects.

Minimum Total Solids (%) Maximum WaterContent (%)

Heat Treatment

Honey is heat-treated to prevent unwanted fermentation by osmophilic yeasts and to delay crystallization. One common heat treatment is 170 °F (77 °C) for two minutes followed by rapid cooling to 130 °F (54 °C). Other effective treatments include heating honey to 140 °F (60 °C) for 30 minutes or 160 °F (71 °C) for one minute or some straight line gradient between those two temperatures. Honey may be damaged by too much heat.

HMF

Hydroxymethylfurfural (5-hydroxymethyl-2 furalde-hyde), also called HMF, is a compound that results from the breakdown of simple sugars (such as glucose or fructose) at pH 5 or lower. HMF occurs naturally in honey, especially in warm climates.

Infant Botulism

Infant botulism is a rare but serious paralytic disease caused by the microorganism Clostridium botulinum. After ingestion, C. botulinum spores can germinate, grow and produce toxin in the lower bowel of some infants under one year of age. C. botulinum spores are widely distributed in nature. They can be found in soil, dust, the air and raw agricultural products. Honey is also a potential source of C. botulinum spores. Infants are susceptible to infant botulism until their intestinal microflora develop. Children and adults with normal intestinal

Microbiology

Honey has antimicrobial properties that discourage the growth or persistence of many microorganisms. The microbes that may be found in honey are primarily yeasts and spore-forming bacteria. No vegetative forms of disease-causing bacterial spores have been found in honey. Because bacteria do not replicate in honey, if high numbers of vegetative bacteria were to be detected, it may indicate contamination from a secondary source.

Nutrient Values Table 3

Nutrient	Average amount per 1 Tbsp. serving (21 g)	Average amount per 100 g
Water	3.6 g	17.1 g
Total Carbohydrates	17.3 g	82.4 g
Fructose	8.1 g	38.5 g
Glucose	6.5 g	31.0 g
Maltose	1.5 g	7.2 g
Information for nutritional labeling*		
Total Calories (kilocalories)	64	304
Total Calories (kilocalories) (from fat)	0	0
Total Fat	0	0
Saturated Fat	0	0
Cholesterol	0	0
Sodium	0.6 mg	2.85 mg
Total Carbohydrates	17 g	81 g
Sugars	16 g	76 g
Dietary Fiber	0	0
Protein	0.15 mg	0.7 mg
Vitamins		
Thiamin	< 0.002 mg	< 0.01 mg
Riboflavin	<0.06 mg	< 0.3 mg
Niacin	<0.06 mg	< 0.3 mg
Biotin	N/A	N/A
Pantothenic Acid	<0.05 mg	< 0.25 mg
Vitamin B-12	N/A	N/A
Vitamin C	0.1 mg	0.5 mg
Vitamin A	0	0
Vitamin D	0	0
Vitamin E	0	0
Minerals		
Calcium	1.0 mg	4.8 mg
Iron	0.05 mg	0.25 mg
Zinc	0.03 mg	0.15 mg
Potassium	11.0 mg	50.0 mg
Phosphorous	1.0 mg	5.0 mg
Magnesium	0.4 mg	2.0 mg
Selenium	0.002 mg	0.01 mg
Copper	0.01 mg	0.05 mg
Chromium	0.005 mg	0.02 mg
Manganese	0.03 mg	0.15 mg
Ash	0.04 g	0.2 g

*Contains less than 2% of the Daily Value for vitamin A, vitamin C, iron and calcium

Pre- and Pro-biotics

Bifidobacteria are a subclass of a group of bacteria considered important to tant to maintaining optimal gastrointesti bacteria populations in the gut can be increased by consuming pro tics. A probiotic is a live microbial feed supplement which benefici st organism by improving its intestinal microbial balance. A prebioti tible dietary supplement that modifies the balance of the intestinal m stimulating the growth and/or activity of the beneficial bacteria w the growth of the harmful bacteria. The most common prebiotics a oligosaccharides including fructo-oligosaccharides (FOS), galacto charides (GOS), and inulin. Honey contains a variety of oligosaccharid may function as prebiotics. Research conducted at Michigan State Univer has shown that adding honey to fermented dairy products such as yogurt can enhance the growth, activity, and viability of Bifidobacteria as well as other commercial oligosaccharides.

Refractive Index

The moisture, or conversely the soluble solids in honey, is determined by measuring the refractive index of honey using a refractometer. Because the refractive index of honey is different from that of a sucrose solution at the same concentration, a special moisture chart must be used. This chart is found in AOAC Method 969.38 (see Analytical Methods). Using the "Brix" or "Sucrose" scale will provide inaccurate values for honey.

Specific Gravity

Dependent upon water content:

Water Content (%)	Specific Gravity (20 °C)
15	1.4350
18	1.4171

Other factors such as floral source slightly affect the specific gravity of honey. Honeys from different origins or batches should be thoroughly mixed to avoid layering.

Specific Heat & Thermal Conductivity

The specific heat of honey is in the 0.54-0.60 cal/g/°C range for liquid honey, and is equal to 0.73 cal/g/°C for finely granulated honey. The thermal conductivity of honey increases with temperature and total solids, ranging from 118 x 10 -5 to 143 x 10 -5 cal/cm sec °C.

Sports Nutrition

It is well-known that carbohydrate consumption prior to, during and after exercise enhances performance and speeds recovery. Honey is a natural source of readily available carbohydrates, providing 17 grams of carbohydrates per tablespoon and may serve as an inexpensive alternative to commercial sports

Storage

At room temperature, crystallization begins within weeks or months (but rarely days). The crystallization process can be avoided with proper storage, with emphasis on proper storage temperature. For long-term storage, the use of air-tight, moisture-resistant stainless steel drums is recommended.

Cool temperatures [below 50°F (10°C)] are ideal for preventing crystallization. Moderate temperatures [50-70°F (10-21°C)] generally encourage crystallization. Warm temperatures [70-81°F (21-27°C)] discourage crystallization but degrade the honey. Very warm temperatures [over 81°F (27°C)] prevent crystallization but encourage spoilage by fermentation as well as degrading the honey.

Sweetness

In most honeys, fructose predominates and tends to make honey taste slightly sweeter than sugar. On the average, honey is 1 to 1.5 times sweeter (on a dry weight basis) than sugar.

Viscosity

The viscosity of honey is affected by temperature, moisture content and floral source. Table 4 shows how the viscosity changes as temperature, moisture content and floral source change. The viscosity of honey decreases rapidly as its temperature rises. 1% moisture is equivalent to about 3.5°C in its effect on viscosity.

Table 4

Water Content	Viscosity (poise) at 25°C
15.5 %	138.0
17.1 %	69.0
18.2 %	48.1
19.1 %	34.9
20.2 %	20.4
Temperature (°C)	**Viscosity (poise) at 25°C**
13.7	600.0
29.0	68.4
39.4	21.4
48.1	10.7
71.1	2.6
Floral Source	**Viscosity (poise) at 25°C (16.5% H_2O)**
Sage	115.0
Clover	87.5
White Clover	94.0

Water Activity

Honey's water activity varies between 0.5 (16% moisture) and 0.6 (18.3% moisture) in the 40-100 °F (4-37 °C) temperature range.

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