Tsp = 5 ml = 5 gm H2O
Moisture in Honey

Honey
- Made from nectar
- - Nectar 4 – 65 % sugar
- - - 3 Main sugars in nectar
- - - - Sucrose - (12 C)
- - - - Fructose - (6 C) also known as Levulose
- - - - Glucose - (6 C) also known as Dextrose
- Nectar moisture and sugar content varies during day
Moisture in Honey

Honey
- Made from nectar
- Nectar can be mostly Sucrose
- Nectar can be approx. equal Sucrose, Fructose, and Glucose – Nectar that Bees preferred
- Nectar can be mostly Fructose and Glucose, with some Sucrose
Moisture in Honey

Honey

Conversion of Nectar to Honey
- Forager bees add enzymes but do not remove moisture
- Foragers transfer nectar to house bees
- House bees reduce moisture and add more enzymes
- House bees regurgitate nectar to reduce moisture
- When finished honey placed into cells and fanned
Moisture in Honey

Honey
Enzymes used in conversion of nectar to honey
- Sucrose 12 C broken by Invertase
- - Fructose 6 C
- - Glucose 6 C
- - - Glucose broken down by Glucose Oxidase
- - - - Gluconic acid – preservative – low pH
- - - - - Hydrogen peroxide – preservative
Moisture in Honey

Honey

Enzymes used in conversion of nectar to honey
- Glucose broken down by Glucose Oxidase
- Glucose Oxidase heat sensitive and needs >19% H2O- reactivates when honey diluted
- - Gluconic acid – preservative – low pH
- - - Hydrogen peroxide – preservative- not stable and breaks down into Water and Oxygen
Moisture in Honey

Honey
Sugar in Honey
- Sucrose 12 C – approx. 2%
- Fructose 6 C – approx. 41% (Levulose)
- Glucose 6 C – approx. 34% (Dextrose)

Sweetness --- (H) Fructose – Sucrose – Glucose (L)
Ratio of Fructose to Glucose varies in honeys
Note: Fructose is preferred in baked goods due to sweetness and moisture retention
Moisture in Honey

Hygroscopicity – ability to absorb water
- Depends on RH and moisture content of honey
- Water rapidly absorbed on honey surface and diffuses slowly to depth of container
- Water is slowly lost due to the formation of a dry surface skin on the honey container (open paint)
- Water can be gained and lost through the cappings
- Water can be gained and lost through the storage container seal
# Moisture in Honey

Hygroscopicity – ability to absorb water
- Equilibrium relationship of RH and water in honey

<table>
<thead>
<tr>
<th>Water in honey (%)</th>
<th>Relative humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.1</td>
<td>52</td>
</tr>
<tr>
<td>17.4</td>
<td>58</td>
</tr>
<tr>
<td>18.6</td>
<td>60</td>
</tr>
<tr>
<td>21.5</td>
<td>66</td>
</tr>
<tr>
<td>28.9</td>
<td>76</td>
</tr>
<tr>
<td>33.9</td>
<td>81</td>
</tr>
</tbody>
</table>

Approx. hive RH

Ideal moisture for table honey is 16.5 -17.5%
# Moisture in Honey

<table>
<thead>
<tr>
<th>Material</th>
<th>% H2O</th>
<th>30%RH</th>
<th>50%RH</th>
<th>60%RH</th>
<th>70%RH at 68 F</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Clover Honey</td>
<td>17.0</td>
<td>-8.98</td>
<td>-4.41</td>
<td>+1.36</td>
<td>+9.01</td>
</tr>
<tr>
<td>Tupelo Honey</td>
<td>18.2</td>
<td>-10.38</td>
<td>-6.18</td>
<td>-0.59</td>
<td>+6.37</td>
</tr>
<tr>
<td>Buckwheat Honey</td>
<td>17.0</td>
<td>-8.44</td>
<td>-5.91</td>
<td>+0.45</td>
<td>+6.80</td>
</tr>
<tr>
<td>Tulip Popular Honey</td>
<td>18.2</td>
<td>-10.73</td>
<td>-6.54</td>
<td>-0.65</td>
<td>+5.81</td>
</tr>
<tr>
<td>Mesquite Honey</td>
<td>17.8</td>
<td>-9.45</td>
<td>-5.83</td>
<td>+0.76</td>
<td>+7.30</td>
</tr>
<tr>
<td>Commercial Invert</td>
<td>20.0</td>
<td>-12.78</td>
<td>-8.48</td>
<td>-2.54</td>
<td>+3.23</td>
</tr>
<tr>
<td>Sugar 1/2 Fructose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 Glucose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fructose Syrup</td>
<td>17.8</td>
<td>-9.67</td>
<td>-5.11</td>
<td>+0.92</td>
<td>+9.03</td>
</tr>
<tr>
<td>Comm Glucose</td>
<td>12.5</td>
<td>-4.32</td>
<td>-3.16</td>
<td>+0.54</td>
<td>+5.43</td>
</tr>
</tbody>
</table>
Moisture in Honey

Hygroscopicity – ability to absorb water
- Largely due to the amount of Fructose
- Sucrose and Glucose not as Hygroscopic
- Fructose retains moisture in baked goods

Granulation of Honey
- Glucose forms crystals (granules) and releases water
- Most favorable temp for granulation is 57 F and 50-60 F favor granulation
# Moisture in Honey

## Components of 100 grams Honey at 17% Moisture

<table>
<thead>
<tr>
<th>Component</th>
<th>Grams in Soln</th>
<th>% of Solids</th>
<th>Gms H2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fructose</td>
<td>41</td>
<td>49.4</td>
<td>8.4</td>
</tr>
<tr>
<td>Glucose</td>
<td>34</td>
<td>41</td>
<td>7.0</td>
</tr>
<tr>
<td>Sucrose</td>
<td>2</td>
<td>2.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>7.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Water</td>
<td>17</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100 gms</td>
<td><strong>100% solids</strong></td>
<td><strong>17 gms H2O</strong></td>
</tr>
</tbody>
</table>
Moisture in Honey

Funny math involving glucose granulation
We have 34 grams of glucose in the honey
Glucose Hydrate is 10 parts glucose to 1 part water
34 grams of glucose needs 3.4 grams of water to have the 10:1 ratio
The weight of the solid glucose hydrate is therefore 37.4 grams and disappears from the active solution
100 – 37.4 = 62.6 grams left
Moisture in Honey

Components of 100 grams Honey at 17% Moisture

<table>
<thead>
<tr>
<th>Fructose</th>
<th>Glucose</th>
<th>Sucrose</th>
<th>Other</th>
<th>Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grams in Soln</td>
<td>41</td>
<td>34</td>
<td>2</td>
<td>6</td>
<td>17</td>
</tr>
</tbody>
</table>

83 grams are solids

<table>
<thead>
<tr>
<th>% of Solids</th>
<th>49.4</th>
<th>41</th>
<th>2.4</th>
<th>7.2</th>
<th>-</th>
<th>100% solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gms H2O</td>
<td>8.4</td>
<td>7.0</td>
<td>0.4</td>
<td>1.2</td>
<td>-</td>
<td>17 gms H2O</td>
</tr>
</tbody>
</table>

(7.0 – 3.4 = 3.6)

Glucose hydrate is 10:1 glucose to water when granulated you lose 37.4 gms of the original 100 grams as a solid and free 3.6 gms of H2O

(100 – 37.4 = 62.6) (17 – 3.4 = 13.6)

The remaining honey is 62.6 gms of solution containing 13.6 gm of H2O or 21.72% moisture
Moisture in Honey

Components of 100 grams Honey at 16% Moisture

<table>
<thead>
<tr>
<th>Fructose</th>
<th>Glucose</th>
<th>Sucrose</th>
<th>Other</th>
<th>Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grams in Soln</td>
<td>41.50</td>
<td>34.41</td>
<td>2.02</td>
<td>6.07</td>
<td>16</td>
</tr>
</tbody>
</table>

84 grams are solids

% of Solids | 49.4 | 41 | 2.4 | 7.2 | - | 100% solids
Gms H2O | 7.91 | 6.56 | 0.38 | 1.15 | - | 16 gms H2O

(6.56-3.44=3.12)

Glucose hydrate is 10:1 glucose to water when granulated you lose 37.85 gms of the original 100 grams as a solid and free 3.12 gms of H2O

(100-37.85=62.15)   (16-3.44=12.56)

The remaining honey is 62.15 gms of solution containing 12.56 gm of H2O or 20.21% moisture
# Moisture in Honey

**Components of 100 grams Honey at 15% Moisture**

<table>
<thead>
<tr>
<th>Component</th>
<th>Grams in Soln</th>
<th>Glucose</th>
<th>Sucrose</th>
<th>Other</th>
<th>Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fructose</td>
<td>41.98</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>34.82</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>2.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>6.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100 gms</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100 gms</strong></td>
<td><strong>85</strong></td>
<td><strong>15</strong></td>
<td><strong>6.15</strong></td>
<td><strong>15</strong></td>
<td><strong>100 gms</strong></td>
</tr>
</tbody>
</table>

85 grams are solids

<table>
<thead>
<tr>
<th>Component</th>
<th>Gms H2O</th>
<th>Glucose</th>
<th>Sucrose</th>
<th>Other</th>
<th>Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Solids</td>
<td>49.4</td>
<td>41</td>
<td>2.4</td>
<td>7.2</td>
<td></td>
<td>100% solids</td>
</tr>
<tr>
<td>Gms H2O</td>
<td>7.41</td>
<td>6.15</td>
<td>0.36</td>
<td>1.08</td>
<td></td>
<td>15 gms H2O</td>
</tr>
</tbody>
</table>

(6.15 - 3.48 = 2.67)

Glucose hydrate is 10:1 glucose to water when granulated you lose 35.30 gms of the original 100 grams as a solid and free 2.67 gms of H2O

(100 - 38.30 = 61.7)  (15 - 3.48 = 11.52)

The remaining honey is 61.7 gms of solution containing 11.52 gm of H2O or 18.67% moisture
Moisture in Honey

Components of 100 grams Honey at 14% Moisture

<table>
<thead>
<tr>
<th>Component</th>
<th>Grams in Soln</th>
<th>Glucose</th>
<th>Sucrose</th>
<th>Other</th>
<th>Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fructose</td>
<td>42.48</td>
<td>35.22</td>
<td>2.07</td>
<td>6.22</td>
<td>14</td>
<td>100 gms</td>
</tr>
<tr>
<td>Glucose</td>
<td>35.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>2.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>6.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

86 grams are solids

% of Solids

- Fructose: 49.4%
- Glucose: 41%
- Sucrose: 2.4%
- Other: 7.2%
- 100% solids

Gms H2O

- Fructose: 6.92 gms H2O
- Glucose: 5.74 gms H2O
- Sucrose: 0.34 gms H2O
- Other: 1.01 gms H2O
- Total: 14 gms H2O

(5.74 - 3.52 = 2.22)

Glucose hydrate is 10:1 glucose to water when granulated you lose 38.74 gms of the original 100 grams as a solid and free 2.22 gms of H2O

(100 - 38.74 = 61.26)  (14 - 3.52 = 10.48)

The remaining honey is 61.26 gms of solution containing 10.48 gm of H2O or 17.11% moisture
Moisture in Honey

Fermentation
- Yeast belongs to Genus *Zygosaccharomyces* like 30 to 80% sugar, spores universally present
- 50 F and below and 80 F and above prevents fermentation

Yeast convert

Sugar to Ethyl Alcohol and Carbon Dioxide

\[ C_6H_{12}O_6 \rightarrow 2 \cdot C_2H_5OH + 2 \cdot CO_2 \]
Moisture in Honey

Wax moth and small hive beetle attack honey supers awaiting processing

Freezing is one control method to kill these pests on cut comb honey and unextracted frames of honey

Cold honey supers can cause moisture gain
Cold treatment to honey house

Honey House Environment

Frames in freezer

Absolute humidity [g/m³] vs. Air temperature [°C]

14 23 32 41 50 59 68 77 86 F
Daily Temp cycle

Night Temp

Day Temp
Moisture in Honey

Using warm dry air you can remove up to 1% moisture in 24 hours from supers filled with honey – need to keep RH as low as possible

- Need good air flow over surface of frames and honey in extractor, settling tanks, pump sump etc.
- Need to dehumidify supply air
- Honey is stable from fermentation <18.6% moisture
- Beware of granulation increasing moisture %, even in closed containers
Moisture in Honey

Need to dehumidify air
- Both window air conditioners and room dehumidifiers are sold based on room size
- Want a air conditioner that is for a smaller sized room
- Want a dehumidifier for a larger sized room
- Use a HEPA filter on your forced air system
Questions