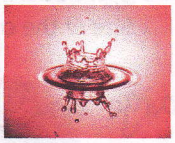
2013-09-24

"Web of science" show times of citation.



Week 3: Water

Function:

1. As a constituent of food → Quality of food.
2. As a beverage

Moisture or Water Content

- Amount of water in a food

% weight water in food /total weight of food

Cucumber : 96% water → lose weight low calorie.

Egg (raw): 75%

Bread: 38%

Raisins: 15%

Water as a constituent of food

Water and Ice

- Difference structures → Implications for food quality

Water Activity

- Availability of water in a food system (for chemical reactions) → implications for food quality might change ~~depends~~

- supporting the growth of microorganism.
- break down macro molecule → bad taste.

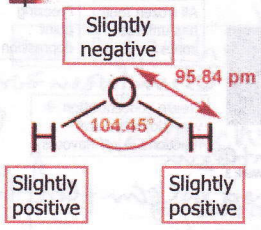
Freezing → preserve food

In Freezer, food quality ↓.

Consider this: ~~ice~~ icecream

You leave ~~ice~~ out on the counter and it partially melts. You put it back in the freezer. What will you find when you next take the ice cream out of the freezer?

Molecular Structure of Water

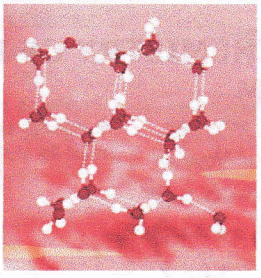


Support life.

H-bond in many molecule which has a strong H-bond will not react in others (molecule, organisms).

Ice has an ordered hexagonal structure

Crystal lattice structure of ice

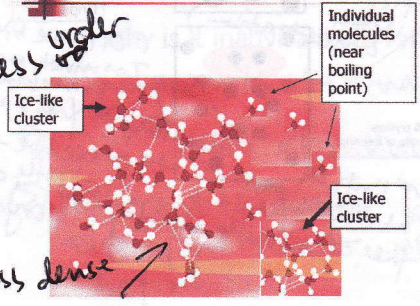


Source: http://www.lbl.gov/Science-Articles/Archive/sabl/2005/February/water-solid.html

more nrg → more disorganized

The structure of liquid water is described by the mixture model

much less ordered



ICE

Implications for density of water and ice

When water freezes it increases in volume.

Density of water: 1 g/ml

Density of ice: 0.92g/ml less densely packed

~~water: 1g water occupies~~ 1ml of ice has less molecule.

That same 1g is converted to ice. 1g of ice occupies 1g/0.92g/ml = 1.087ml

8.7% increase → 9%.

Ice formation has two steps

① **Nucleation**

- Initiation of ice crystal formation

② **Crystal Growrh**

- Increase in the size of the ice crystal

growth of crystal around the nucleus.

The size of ice crystals depends on the rate of cooling

- As the rate of cooling increases as the things
  - # of nuclei increases
  - Size of the crystals decrease

large nuclei → less crystal

Cool things down faster

more nuclei → smaller crystal

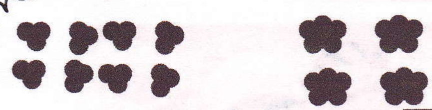
The size of the ice crystal depends on the rate of cooling

Crystal growth

Which was cooled rapidly?

Quick-frozen industrial freezing

Home freezer.



Foam

Dispersion

You leave ice out on the counter and it is partially melted. You put it back in the freezer. What will you find when you next take the ice cream out of the freezer?

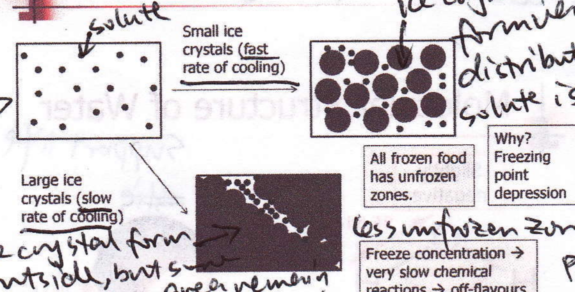
Lots of large crystal forming, not creamy anymore → Quality ↓↓.

if melt it completely and refreeze it, almost become a rock (very hard)

https://www.youtube.com/watch?v=n11MWg-gDFk&list=PLyRe8Fs_GoZjdGLUZUVKqWMtt622Z5HyF

THE CHEMISTRY OF ICE CREAM

As water freezes, solutes are concentrated in unfrozen zones, a process called freeze concentration.



solute

unfrozen food

ice crystal forms very quickly, distribution of solute is similar.

ice crystal form outside, but some area remain unfrozen

less unfrozen zone in industry product.

15 μm — threshold that we can feel the ice crystal

Solute will tend to concentrate in the centre of the food

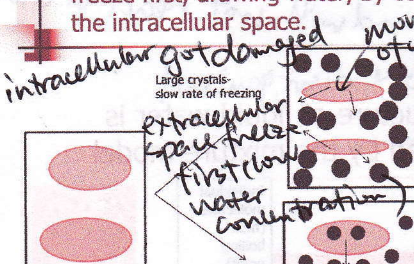
rxn is very slow, but [C] is high, so rxn is still there → can keep food in fridge fresh

Freezing will damage the cellular structure of plant or animal foods

- Fruits, vegetables, raw meat:
  - very high water content = high moisture content
    - 50-98%
- Water present in both intra-cellular and extra-cellular space

intercellular space.

During freezing the extracellular water will freeze first, drawing water, by osmosis, out of the intracellular space.



intracellular got damaged

extracellular space freeze first cause water concentration

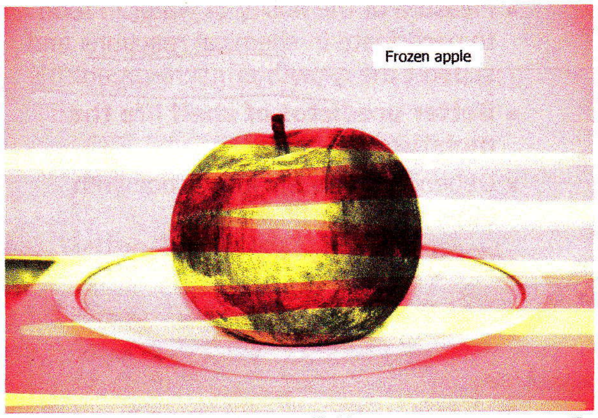
movement of water moving out (osmosis)

Water outside and inside the cell freeze simultaneously.

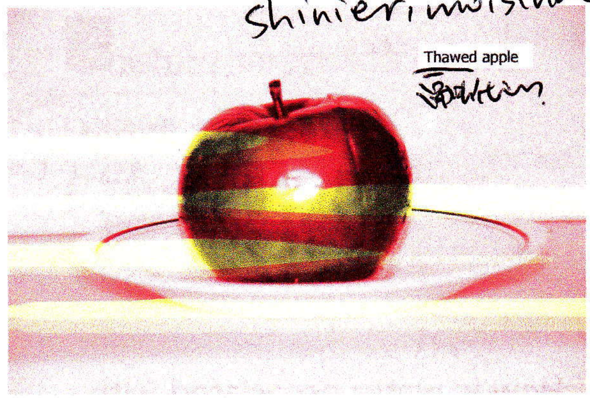
a little bit is common. Too much means the food is broken down.

rapid freezing tend to preserve the structure (a little damage) → crystal is large

muscle meat ~~fish~~ can stay in freezer longer than fish (∵ omega-3 fatty acid).



shinier, moistner.

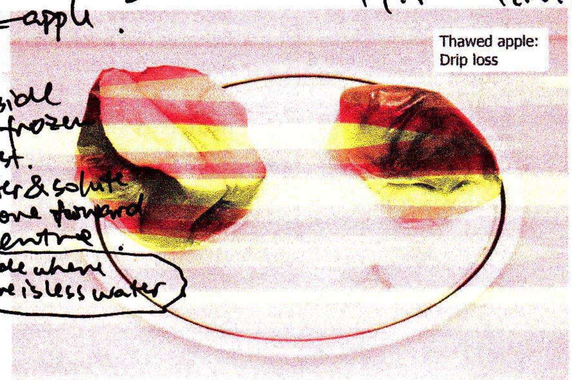


cellular damage: crystal will expend the cell and probaby make it burst.

2 levels (整个苹果 + 苹果外层的结冰).

browner in the centre → a sign of cellular damage

As the apple is frozen, water in the centre is moving out → structure is damaged → enzyme is mixed → brown inside.



How do you properly freeze apples at home?

Cut into thin slices. ↓ the distance of way that have to go through to cool it down [illegible].

Blanch before freezing (boil in water / steam)
↓
~~kill the enzy~~ inactivate the enzyme.

Freezing promotes two opposing forces

- Low temperatures
  - slow chemical reaction rates
  - slow the growth of microbes (does not completely kill them)

- Freeze concentration will increase reaction rates

solutes will concentrate in the area where it's not freeze yet → higher rxn rate.

Question:

- Why is it inadvisable to refreeze food?

compromise the quality of food (household freezing).

① 2nd cycle of cellular damage.

② put it out the freezer, microbes start to grow even put it back, still more microbes than before.

不会有冰留在冰箱上
↓
fross-free fridge: constantly pump water vapor out (dry food out)

Freezer burn occurs when ice, at the surface of a frozen food, undergoes sublimation.

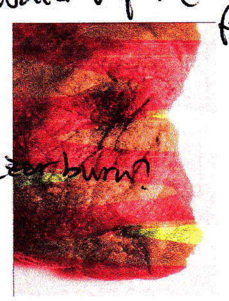
solid ice → water vapor (will dry the food).

- Sublimation:
- ice → water vapor
- Food dries at surface

(How do I prevent freezer burn?)

- Prevented by proper packaging

thick bag.



Dry or dried foods

raisins
~~beef~~ beef jerky
pasta
cereals
chips
rice
seaweed
(nuts) ← little water much oil

herbs & spices (sun-dry)
coffee.
Tea.

low water activity → can stay long.

Water activity

- Measure of the ability of water in food to participate in chemical reactions and support the growth of micro-organisms
- **Better predictor of shelf life than moisture content**
- Depends on waters interaction with other food constituents

may be H-bonded to other constituents → this water is not available for chemical rxn or support microbes

How is water associated with other food constituents?

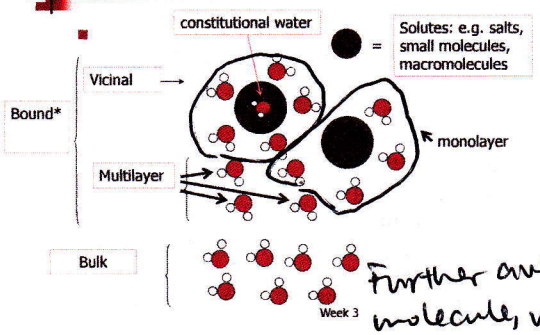
Bound water	Bulk water (more available)
▪ Hydrogen bonded to polar components of food ▪ Does not behave like a solvent ▪ Unavailable for freezing and chemical reactions ▪ Cannot support the growth of microorganisms	▪ Physically entrapped in food structure ▪ Behaves like a solvent ▪ Available for freezing and chemical reactions ▪ Supports the growth of micro-organisms

e.g. juice in orange

Continuum: Types of bound water

- Constitutional water (folded inside molecule)
  - bound to interior of molecule e.g. inside the fold of a protein
- Vicinal water
  - bound to outer surface of molecule
  - strongly interacts with hydrophilic sites by water-ion and water-dipole associations
- Monolayer water = constitutional + vicinal
- Multilayer water (beyond monolayer water)
  - forms several layers around hydrophilic groups

Vicinal, Multilayer Water, Bulk Water



Further away from molecule, less available, very reactive.

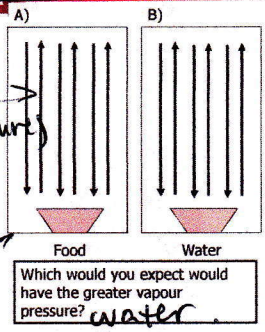
Bulk Water

(in narrow tube)

Capillary water	Free water
▪ Microbial growth is slow in capillary water ▪ Supports chemical reactions	▪ Both microbial growth and chemical reactions supported ▪ Impacts on quality

less available

Measuring water activity (a_w)



equilibrium (vapour pressure)

sealed compartment

a_w = p(food)/p(water)

p (food) = partial pressure of water vapor in equilibrium with the food at temperature (T) and 1 atmosphere total pressure

P(water)= saturation partial pressure of water at the same T and pressure

water

∴ some water in food is bound water.

Water Activity and Relative Humidity

particular water of water and pure water

- Aw= p(food)/p(water) ← partial pressure of pure water.
- = equilibrium relative humidity of food/100
- = ERH/100 ← 100% relative humidity.

equilibrium relative humidity.

50% of ERH → 0.5 AW.

Water activity and food quality

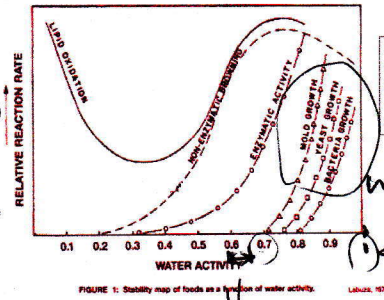


FIGURE 1: Stability map of foods as a function of water activity. Labuza, 1970

What is the highest water activity that a food can have without supporting microbial growth?

0.7

how quickly rxn take place.

microbial activity.

pure water

present food from contaminated by microbes.

Moisture sorption isotherms

- Graphical representation of the relationship between water activity and moisture content at a constant temperature.

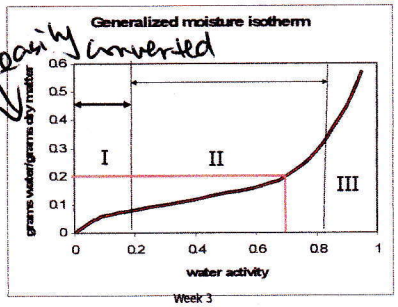
Generalized moisture isotherm

Moisture Content (%): water (g) X 100 / total weight (g)

easily converted

0.2g water/ 1g dry weight+0.2 water: 0.2/1.2 = 17%

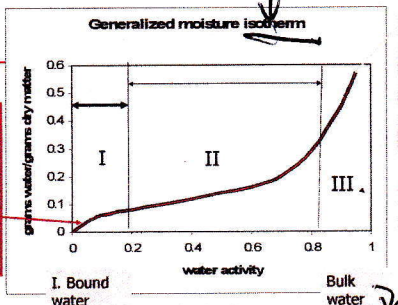
very dry food.



temperature is constant, 25°C.

Start with a food with a very high moisture content and dry it.

First water to be removed will be the bulk water; then bound water



Start with a dry food and add water to it: first bound water forms monolayer; then bulk water forms

I. Bound water

II. Mostly bound water

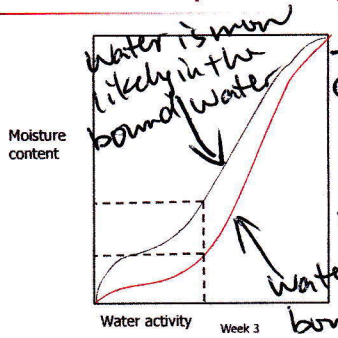
Bulk water

Add water to dry products. First bound water → then bulk water.

water is harder remove.

in physically bound to any molecule (easily vaporized)

Different foods have different isotherm shapes? Why?



water is more likely in the bound water

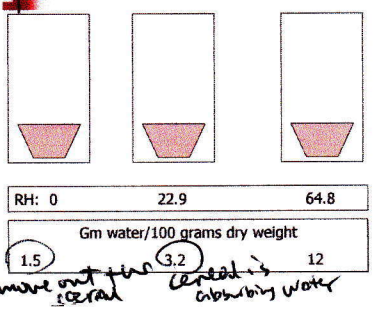
Two foods can have same water activity, in different moisture content

water is less tightly bound.

How to determine a moisture sorption isotherm

- Example: Breakfast Cereal
  - Place a cereal sample in a sealed chamber at a specific relative humidity and allow the sample to equilibrate with the relative humidity in the jar
  - Determine the weight change of the sample at equilibration

Breakfast Cereal Initial Moisture: 2.5 gm water/100 gm dry weight



chambers w different moisture relative humidity →

water move out the cereal

cereal is absorbing water

1. A sample of cereal is put into several equilibration chambers each adjusted to a specific relative humidity.
2. The sample is allowed to equilibrate in the chamber (as indicated when the sample's weight is constant).
3. The sample's moisture content is determined at equilibration.

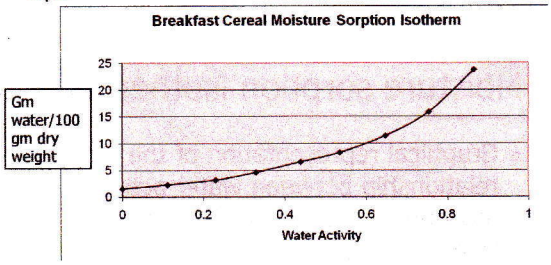
Breakfast Cereal Complete Experiment

same as water activity of food

% Relative humidity	Gm water/100 gm dry weight	Texture
0.0	1.5	Crisp
11.1	2.5	Crisp
22.9	3.2	Crisp
32.9	4.5	Soft
43.9	6.5	Soggy
53.5	8.3	Soggy
64.8	12	Soggy
75.5	16	Moldy
86.5	24	Moldy

microbes growing.

Breakfast Cereal Moisture Sorption Isotherm



How would a food processor ensure that the cereal maintains its quality during routine household use?

the packaging

Decrease water activity by:

- Dehydration: limited by quality decline ← take water out
- Add water-binding agents or humectants
  - Salt
  - Sugar — hydroxyl group
  - Glycerol — H-bond with water
  - Propylene glycol
- Proper packaging

What structural feature do sugar, glycerol, and propylene glycol have in common?

What do these two foods have in common?

common preservatives.

Salted fish

bind water

Apricot jam

sugar reduce water activity

lots of sugar → preservation of food.

low water activity.

Using water activity to improve shelf life

- Problem: Bakery's cake has a shelf-life of only three days. It becomes moldy before it can be shipped to stores and purchased by consumer?
- Solution: water activity is too high. Can add sugar to lower the water activity.

Source: (dead link) http://www.decagon.com/water_activity/intro/index.php?pg=3

Using water activity to prevent moisture migration

mix things together

- Problem: Fruit cake:
  - Cake 30% water
  - Fruit 50% water
  - Dry cake and soggy fruit. Why?

water activity: Aw (cake) > Aw (fruit) → moisture content → migration → depend on water activity

- Solution:

cakes have more water mobile, has more bulk water, not physically bound to food.

Can add sugar to the cake.

(dead link) http://www.decagon.com/food_science/info/moisture.php

lower the Aw of cake, so that water of cake will not migrate to fruit (equilize)

Don't want to add too much water to fruit → make microbe grow.

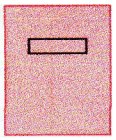
Using water activity to prevent clumping

- Problem: Soup base & pepper:
  - Soup base: 3% moisture: aw = 0.28
  - Addition of pepper: 3% moisture:aw =0.68
  - Clumping. Why?
- Solution: Add salt to peper base and bring its aw down to 0.28.

water in peppers move in soup base →

http://www.decagon.com/food_science/info/caking.php Dead link

Water as a beverage



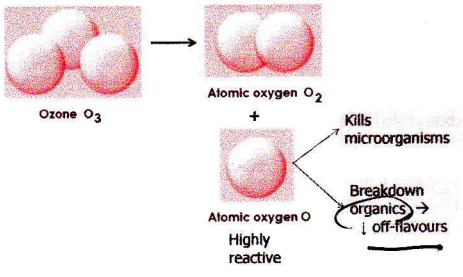
Water terminology

- Potable water =Water suitable for drinking
- Distilled water
  - Contains less than <10 ppm minerals
  - Achieved through a process of evaporation and then condensation

Water terminology

- Spring or mineral water
  - Underground source of water fit for human consumption at source
  - Its original composition cannot be modified
    - except for the addition of:
      - Carbon dioxide
      - Fluoride teeth
      - Ozone alternative for chlorine for killing microbes.

Ozone is used to treat bottled water. can taste better.



Bottled water: Spring or mineral water

- Label
  - List of ingredients (if more then one)
    - E.g. Natural spring water, carbon dioxide
  - Dissolved mineral salt content
    - E.g. mineral salt content 479 ppm; Ca, Na, K, HCO_3^-, $SO4_2^-$, Cl^-, NO_3^-, As, Cu, Pb, Zn, F
  - Ozone or fluoride added
    - fluoride
  - Source location where the water comes from
    - Source Perrier, Vergeze, France

Bottled Water

- Can bottled water be manufactured from municipal tap water?

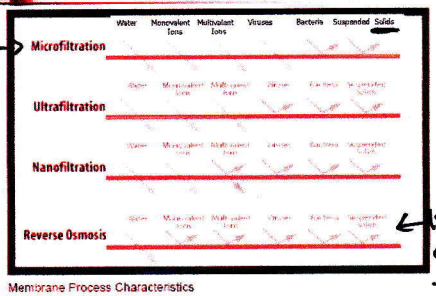
Yes.

Bottled water, not spring or mineral

- Label
  - list of ingredients and then add a few in.
    - Demineralized treated water, ozone
  - Nutritional information
  - Fluoride content
    - 0.3 ppm
  - Any treatment the water has undergone
    - Reverse osmosis, ozonized
  - "Aquafina... originates from public water sources...purification"

Demineralization: Water is filtered through a series of membranes

bacteria sized



Membrane Process Characteristics

pores of membranes get smaller and smaller

← [high] of solute. so need to use more to force water to come through

Are there bacteria in bottled water?

Yes.

but the organism isn't pathogen, not harmful

Is it safe to reuse the bottles that water is sold in by filling them with tap water?

NO

Waterbottle is hard to wash.

Why is bottled water controversial?

U of T to phase out bottled water sales

Move has environmental, social justice benefits

By Elaine Smith, posted Wednesday, August 24, 2011

http://www.news.utoronto.ca/lead-stories/u-of-t-to-phase-out-bottled-water-sales.html (dead link)

The Story of Bottled Water?

- http://www.youtube.com/watch?v=FnCnf-1-iRk
- Key points:
  - We don't need the product
  - Cost 2000X more than tap
  - Plastics bottle industry-polluter
    - Manufacturing
    - Disposal

Canadian Bottled Water Association: Water Usage

Annual bottled water production accounts for less than two-tenths of one percent (<0.2%) of the total groundwater withdrawn per year. Bottled water companies are required to conduct exhaustive hydro-geological studies on all groundwater resources used to ensure long term sustainability.

http://www.cbwa.ca/en/faq.htm#97

According to the Canadian Bottled Water Association: Water usage

According to the Ontario Minister of the Environment:

- The annual bottled water production in 2007 accounted for less than 0.0015 permitted water takings in Ontario.
- 97 percent of the water withdrawn by bottled water companies for bottling is actually bottled and consumed. It takes 1.3 litres of water to produce one litre of bottled water.
- The bottled water industry uses as much water as ten (10) golf courses in Ontario, and there are 700 golf courses in Ontario.

very efficient

http://www.cbwa.ca/en/faq.htm#92

Canadian Bottled Water Association: Water Usage

According to Environment Canada:

- It takes as much as 1,500 kg of water to produce a kg of potato.
- It takes up to 70,000 kg of water to produce a kg of beef.
- Approximately 300 litres of water is required to produce 1 kilogram of paper.
- It takes about 215,000 litres of water to produce one metric ton of steel.
- It takes nearly 14 gallons (about 53 litres) of water to grow a medium orange (4.6 onces/130 grams) and to prepare it, in a packing plant, for market.
- It take 48.3 gallons (about 183 litres) of water to product one eight-ounce glass of milk when you add together the amounts of water needed to provide food and water for the cows, to keep the dairy barns clean, and to process the milk.

http://www.cbwa.ca/en/faq.htm#92

Canadian Bottled Water Association: Environmental Impact of Bottles

- Over 97% of the population in Canada now has access to recycling PET beverage bottles.
- Provincial recycling organizations identify recycling rates of anywhere from 60 - 85 per cent.

Plastics are one the most valuable items in recycling today and when recycled are used to make playground equipment, automobile parts, carpeting, clothing, sleeping bags, other plastic containers, shoes, luggage, upholstery industrial strapping, sheet and film.

- The larger bottles for use with water coolers are typically reusable (40 to 60 times) before being recycled.
- Plastic water bottles account for 1/5 of 1% of waste in landfills.

http://www.cbwa.ca/en/faq.htm#91

Canadian Bottled Water Association: Cost

According to AC Nielsen Research, bottled water sells for about 36 cents per litre, or 18 cents for a 500 ml bottle. The typical purchase of bottled water is in cases of 24 bottles or the water cooler bottle. Bottled water critics routinely compare the price of a single-serve bottle versus a variety of products purchased in bulk or through a pipeline. These apples to oranges comparisons are not representative and therefore not accurate. Our member companies provide nearly 13,000 direct and indirect Canadian jobs.

http://www.cbwa.ca/en/faq.htm#98

Beverage Jeopardy

ANSWER:

- In 1904, a pharmacist and chemist named John J McLaughlin, working out of a plant in Toronto, developed this drink, which was marketed in the US with the slogan: "Down from Canada came tales of a wonderful beverage."

QUESTION:

- What is...

Canada Dry Ginger Ale.