



# Apple quality.....

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1. Maturity and ripening process in connection with Quality parameters

2. Quality parameters - measurement

maturity ↔ ripening

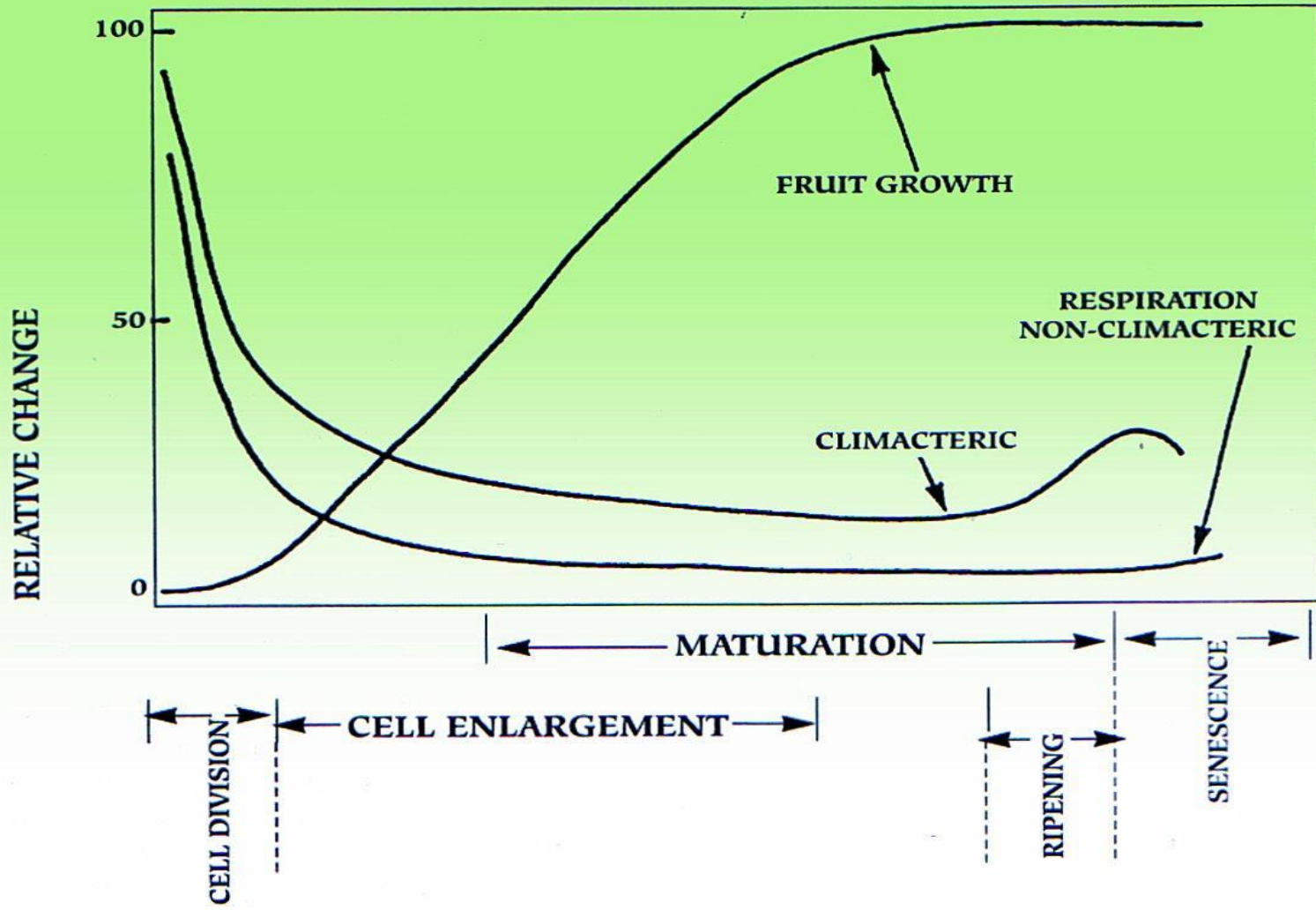


Stage of development of the fruits  
on the parental plant (only)



Stage when biochemical changes  
convert inedible fruit into an edible  
product

Respiration during climacteric and nonclimacteric fruit development (Biale, 1964).



# maturity

- that process occurs only when fruit is attached to the parental plant
- a minimum period of development must be undergone by any fruit before harvest time

# ripening

- stage when biochemical changes convert mature but inedible fruit into an edible product
- can occur on or off the plant
- ripening processes: softening, biosynthesis of volatile aroma, conversion of starch into sugar etc

Fruit can be harvested when,

1. has acceptable eating quality at the time of harvest (non-climacteric)
- or
2. has the potential to ripen into a product of acceptable quality (climacteric)

At harvest time fruit must be mature but can be unripen  
(climacteric)

## □ Non-climacteric

- Fruits which mature slowly while attached to the parent plant
- do not exhibit an increase in respiration rate when ripening begins,
- low ethylene production rate, low respiration rate
- their eating quality can not be improved after harvest
- blueberry, cherry, grape, pineapple, potatoes

## □ Climacteric

- fruits, vegetables with relatively rapid increase in respiration rate
- rapid ripening period = climacteric period
- high ethylene production during ripening
- can also be provoked to ripen by ethylene treatment
- apple, apricot, avocado, banana, kiwi, tomato

## How to estimate optimal Harvest Time ?

### CLIMACTERIC fruits (or vegetables )



#### pre-climacteric

- ripen slower
  - respiration rate slower
  - not yet producing significant quantities of ethylene
  - maintain quality for longer
- BUT
- fruit picked up too early; does not develop its full potential

#### Climacteric period

#### post-climacteric

- ripening proces is speeded up
- respiration rate increase faster
- producing ethylene
- quality cannot be kept for long

# How to estimate optimal Harvest Time ?

**Adam**





## Determination of harvest date:

- There are the principles which decided on which maturity and ripen stage fruit should be picked
- It is crucial for storage, marketable life and quality
  
- It is important to use objective criteria to decide when crop is ready to pick
- Several maturity standards has been set for the major crops

### Maturity standards can be:

- starch,
- firmness,
- titratable acidity,
- color changes,
- soluble solids content

## *Starch index / Harvest index*

- *starch SV*
- *solid soluble concentration RE*
- *firmness PE*
  
- *STREIF index of ripeness:  $\frac{PE}{RE \times SV}$*

# Starch Index

## Tool

- potassium-iodide test

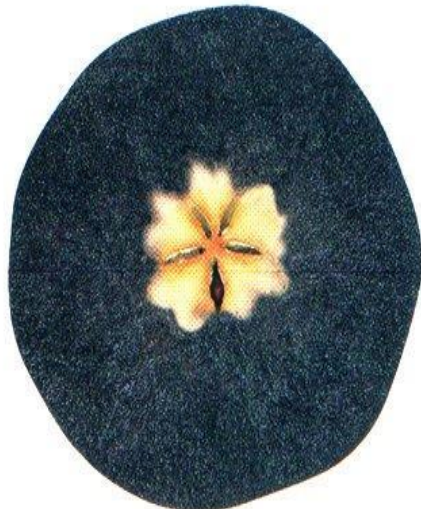
## How?

- 10 apples should be taken from the ten different trees
- cut apples equatorially into two halves
- the cut sides of apple dip in the potassium-iodine solution
- leave for 1-2 minutes
- compare apples with the color chart

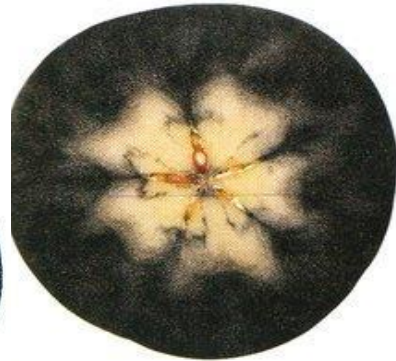




1



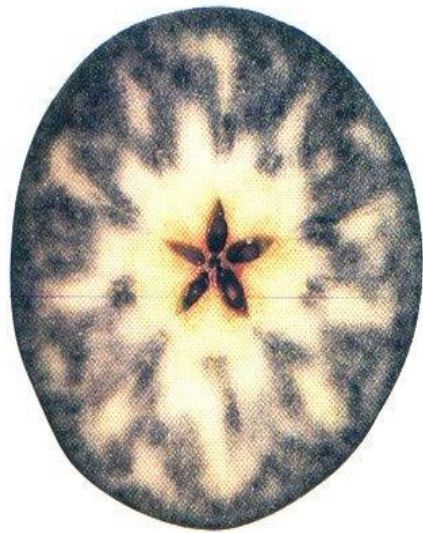
1,5



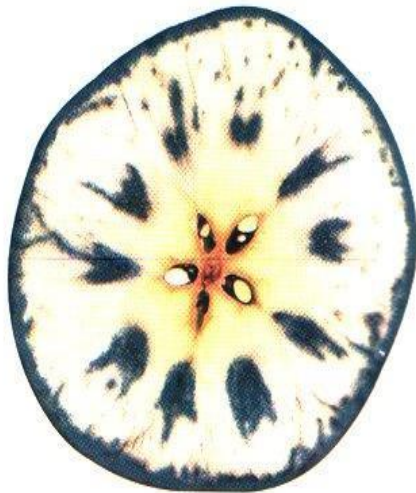
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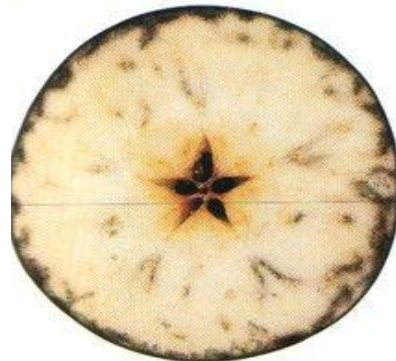
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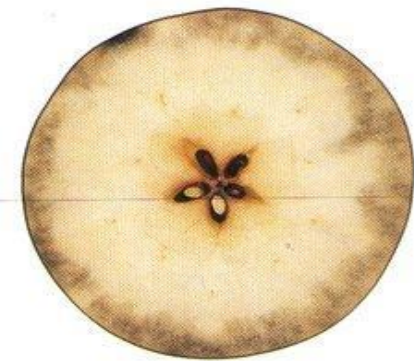
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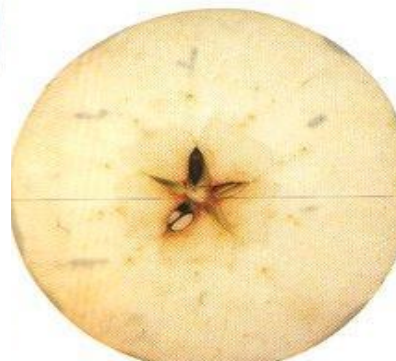
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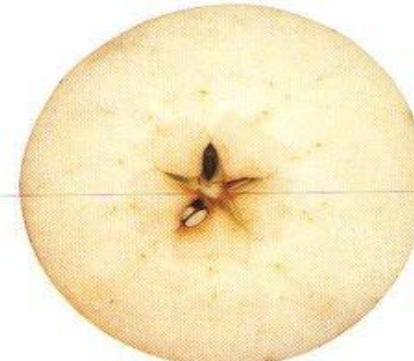
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5



>5

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What is quality?

# What is quality?

- „fitness for use“
- „is to meet the expectations of the consumer“

Quality means different for different people:

1. for the growers: quality is to achieve high yield and big fruit size
2. for the transporters: quality is long storage potential
3. for the consumers: quality is nutritional value, eating quality (good taste and nice aroma, flavour)

Sometimes those requirements are in conflict.

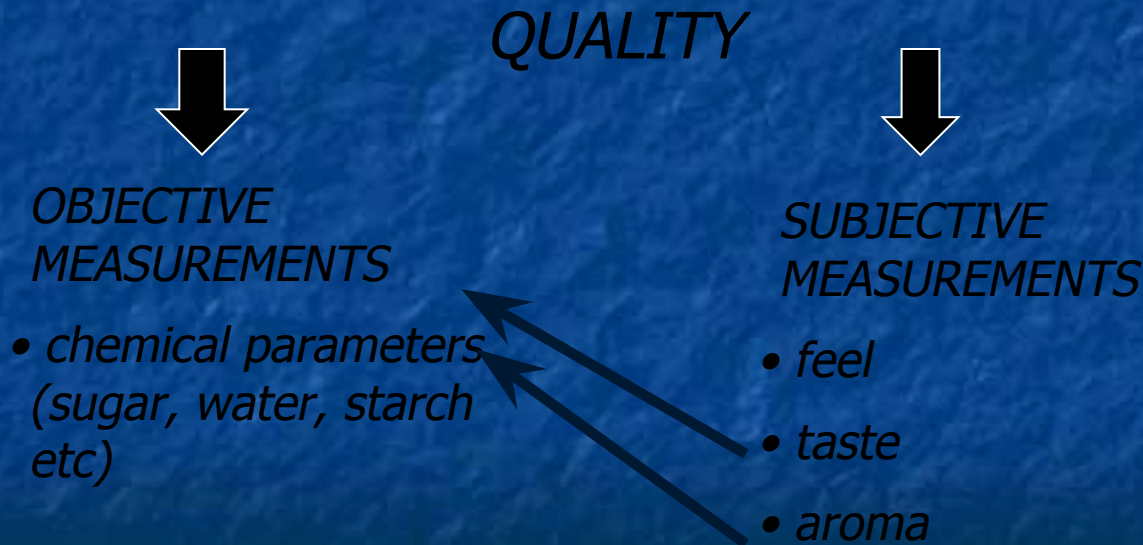
# What is quality?

- *Quality includes several characteristics of the products that consumers find or believe that are good indices of overall quality*



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- *Quality includes several characteristics of the products that consumers find or believe that are good indicis of overall quality*





**Table 5-3. Physical and Chemical Alterations That Occur During the Ripening of Fleshy Fruits**

	<i>Important Quality Attributes</i>
1. Seed maturation	
2. <u>Changes in pigmentation</u>	}
a. degradation of chlorophyll	
b. unmasking of existing pigments	
c. synthesis of carotenoids d. synthesis of anthocyanins	
3. <u>Softening</u>	}
a. changes in pectin composition	
b. possible alterations in other cell wall components c. hydrolysis of storage materials	
4. <u>Changes in carbohydrate composition</u>	}
a. starch conversion to sugar b. sugar interconversions	
5. <u>Production of aromatic volatiles</u>	}
6. <u>Changes in organic acids</u>	
7. Fruit abscission	
8. Changes in respiration rate	
9. Changes in the rate of ethylene synthesis	
10. Changes in tissue permeability	
11. Changes in proteins	
a. quantitative	
b. qualitative	
1. enzyme synthesis	
12. Development of surface waxes	

Color

Texture

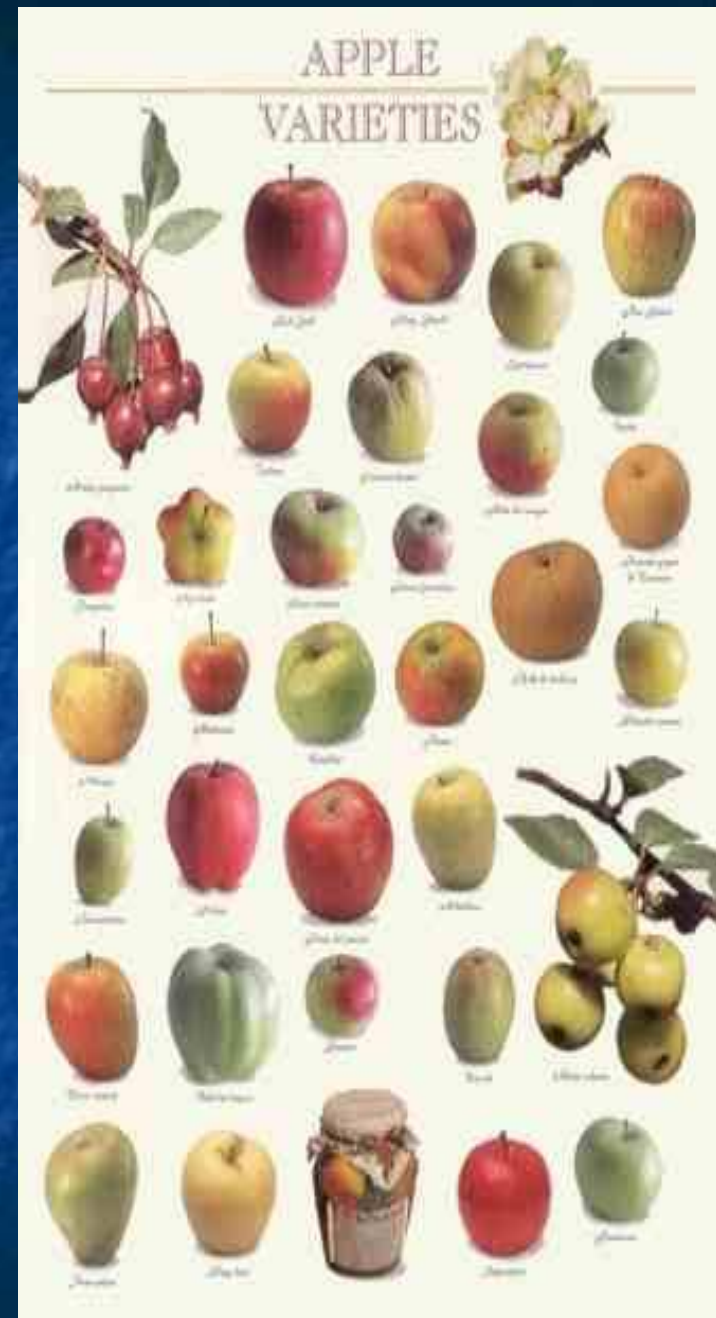
Flavor

## Quality parameters:

- Size and shape
- Skin color
- Firmness/texture
- Starch / sugar (soluble solids content)
- Titratable acidity
- Volatile compounds / aroma / odour
- Taste
- Flavour (taste and odour)

## Size and shape

- *Size* is an individual unit of the product, but can significantly affect consumer appeal
- Often the quality is discriminated based on size (consumer shopping), which is mistaken
- Size can also affect handling precise or storage potential
- *Shape* is individual factor in distinguishing between individual cultivars
- *Shape* can eliminate product from potential market





Braeburn



Cortland



Fuji



Gala



Ginger Gold



Golden Delicious



Red Delicious



Granny Smith



Honeycrisp



Jonathan



Jonagold



McIntosh



Pacific Rose



Paula Red



Wealthy





Braeburn



Cortland



Fuji



Gala



Ginger Gold



Golden Delicious



Red Delicious



Granny Smith



Honeycrisp



Jonathan



Jonagold



McIntosh



Pacific Rose



Paula Red



Wealthy

## Quality parameters:

- Size and shape
- *Skin color*
- Firmness/texture
- Starch / sugar (soluble solids content)
- Titratable acidity
- Volatile compounds / aroma / odour
- Taste
- Flavour (taste and odour)

# Color

## **Types of change in pigmentation:**

1. Degradation of chlorophyll

Color changes during apple maturation and ripening are largely results of chlorophyll breakdown → less chlorophyll

**Chlorophyllases**

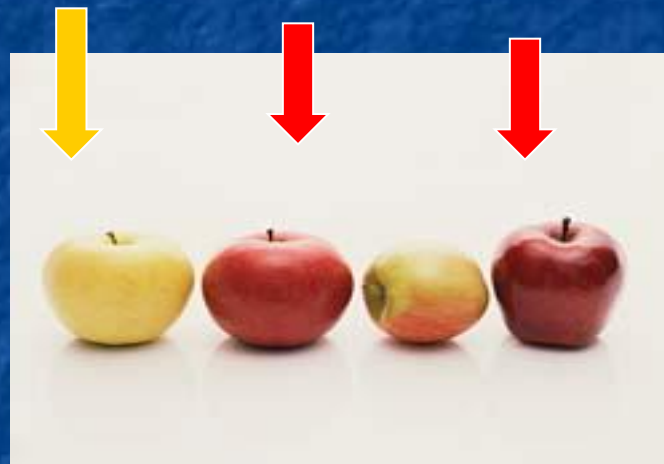
2. Unmasking of existing pigments
3. Synthesis of carotenoids
4. Synthesis of anthocyanins

# Color

- The loss of **chlorophyll** results in decreasing green color
- Synthesis and/or unmasking of **anthocyanins** result in red color
- Synthesis and/or unmasking of **carotenoids** result in yellow color

carotenoid

anthocyanin





# Color

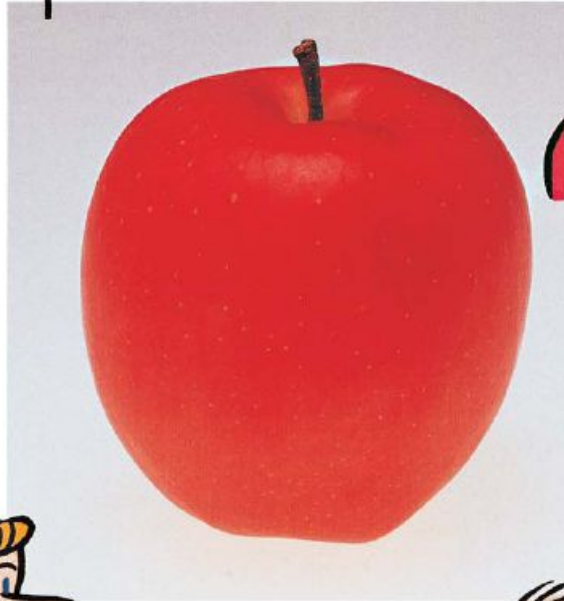
- *Anthocyanins* are the most important in red apples
- *Anthocyanins* are formed via 1. sugar path and 2. path of PAL enzyme activity
- Many factors can affect coloring process:
  - *Light* is required for anthocyanin accumulation
  - *Low temperature* increases anthocyanin synthesis
  - *High nitrogen* availability and uptake delay the maturation process and also delay the synthesis of anthocyanin
  - *Ethylene exposure* stimulates PAL enzyme and anthocyanins accumulation

What color is this apple ?



Red!

Hmmm.  
Burning red.



I'd say  
crimson.



Bright Red.



# Color - analysis

## Tool

- Colorimeter Minolta

## How?

- Apple should be scanned by a colorimeter around its diameter a couple of times,
- Results presented by units:  
L = lightness  
a = chromaticity coordinate between red and green  
b = chromaticity coordinate between blue and yellow





- $L^* = 43.31$
- $a^* = 47.63$
- $b^* = 14.12$

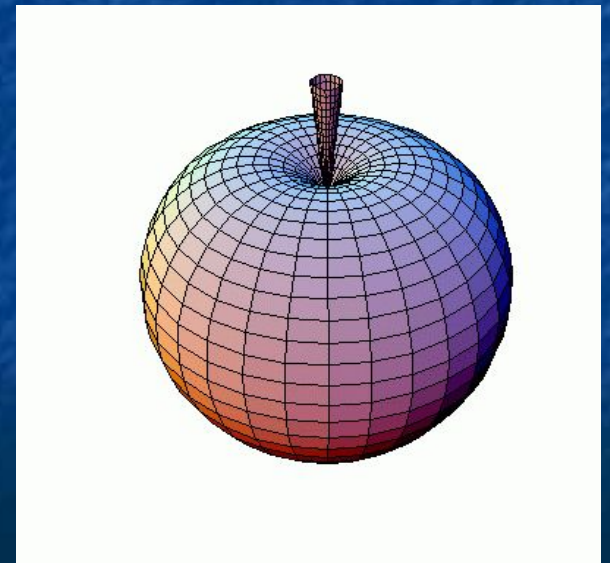
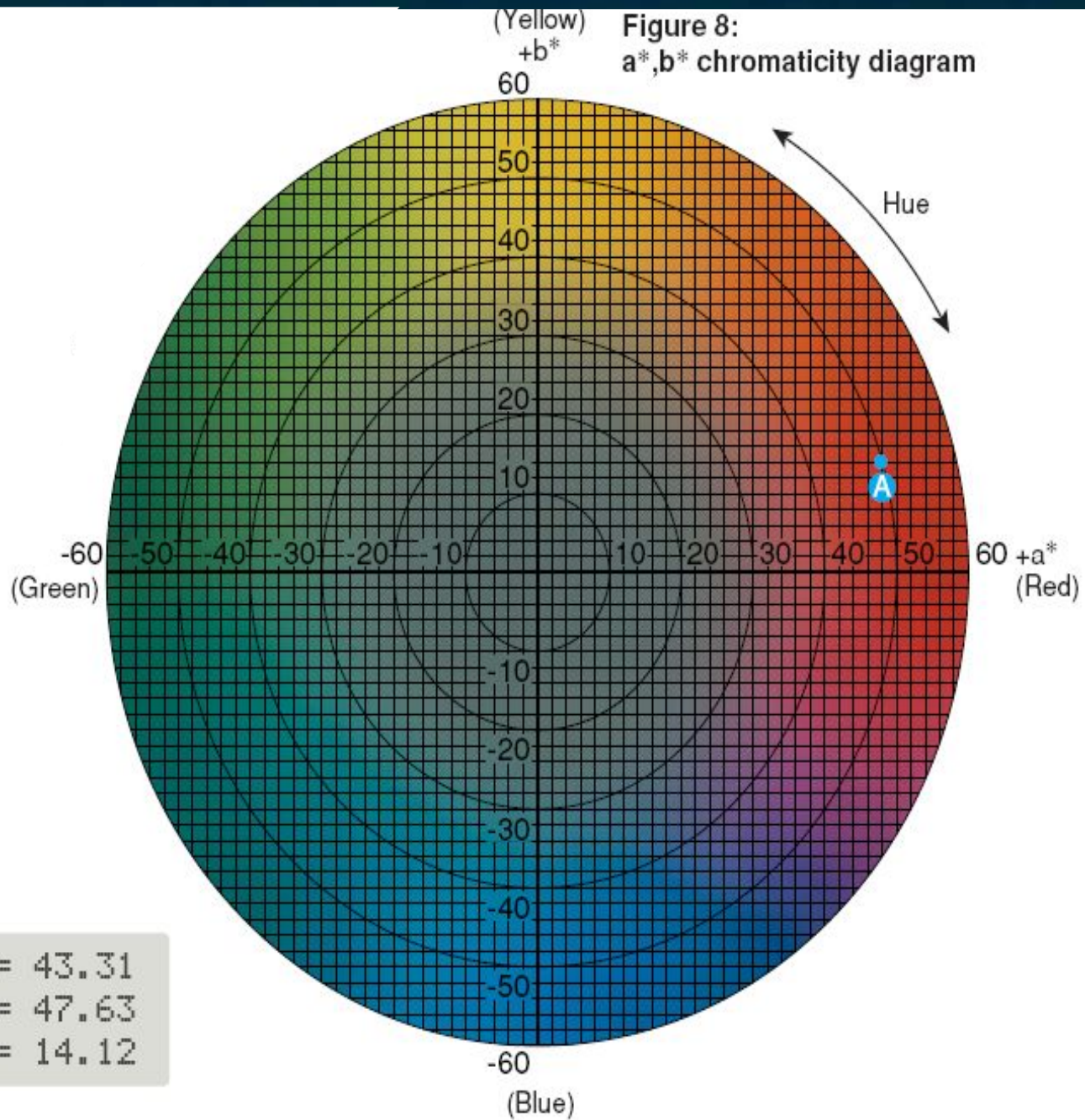


Figure 8:  
a\*,b\* chromaticity diagram



L\*= 43.31  
a\*= 47.63  
b\*= 14.12

## Quality parameters:

- Size and shape
- Skin color
- Firmness/texture
- Starch / sugar (soluble solids content)
- Titratable acidity
- Volatile compounds / aroma / odour
- Taste
- Flavour (taste and odour)

## Firmness/texture

- texture comprises those properties of a product that can be appraised visually or by touch
- textural properties may also be assessed by muscle sense in the mouth so human perception of texture is determined by the way that fruits flesh breaks down during chewing

*Texture* is a quality factor, which include:

1. Firmness
2. Crispness
3. Juiciness
4. Mealiness

## Firmness/texture

- texture is a creation of composition of cells and their structure, therefore the turgor of cells is important in fleshy products
- texture depends on maturity stage and storage conditons:
  - Advanced maturity: apples becoming soft, beans/peas become fibrous and hard
  - Chilling storage: potatoes hardcore – center of potatoes becoming woody and inedible



# Firmness/texture

*Texture* is a quality factor, which include:

1. Firmness
2. Crispness
3. Juiciness
4. Mealiness

- *Firmness* is a resistance to deformation by applied force
- *Firmness* is the most used to describe texture, sometimes it is only one quality parameter (New Zealand-kiwifruits)
  
- *Mealiness* in sensory profiling is described by: softness, dryness, flouriness, granularity
- *Mealiness* is mostly perceived as unpleasant by consumers (exception older people generation)

# Firmness/texture - analysis

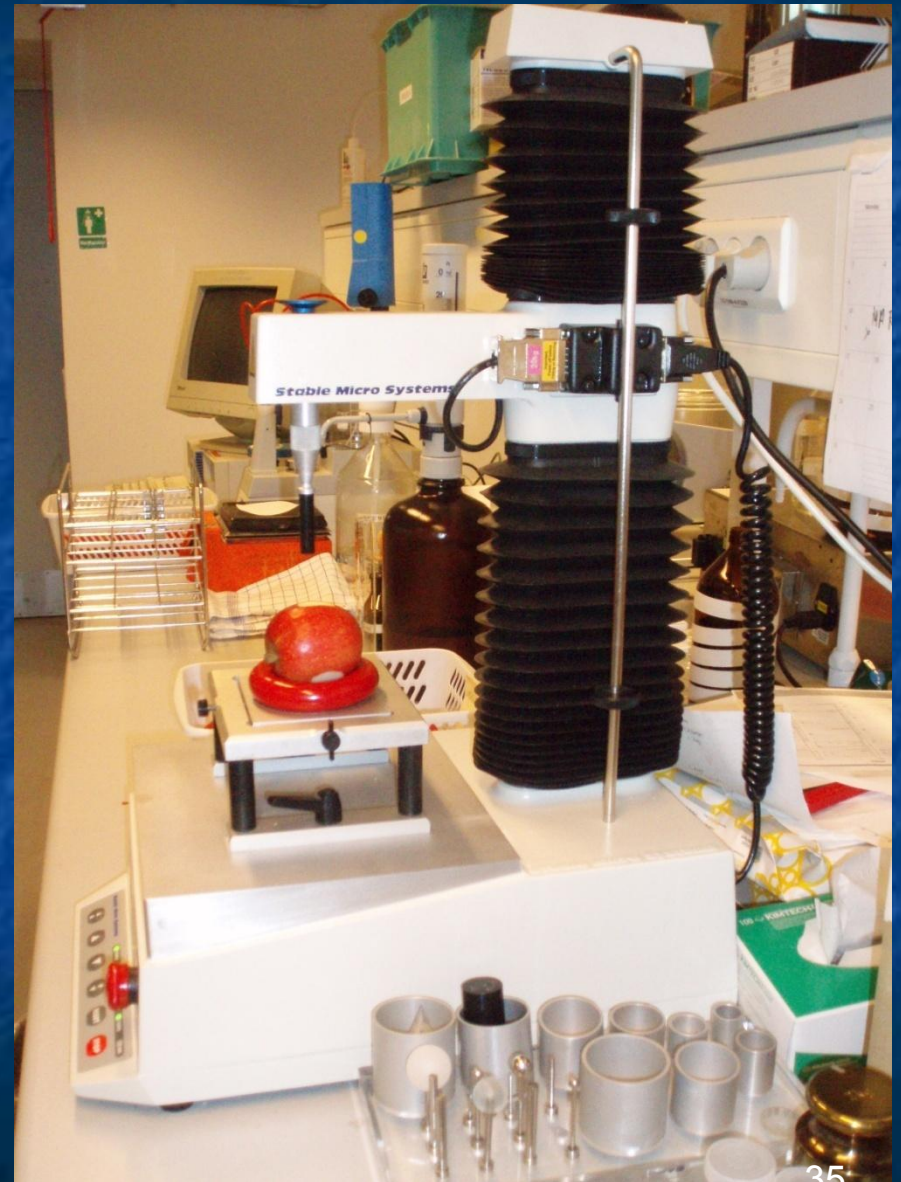
## Tool

- firmness can be measured by **penetrometer**, a simple pressure gauge also by Texture Analyser TA

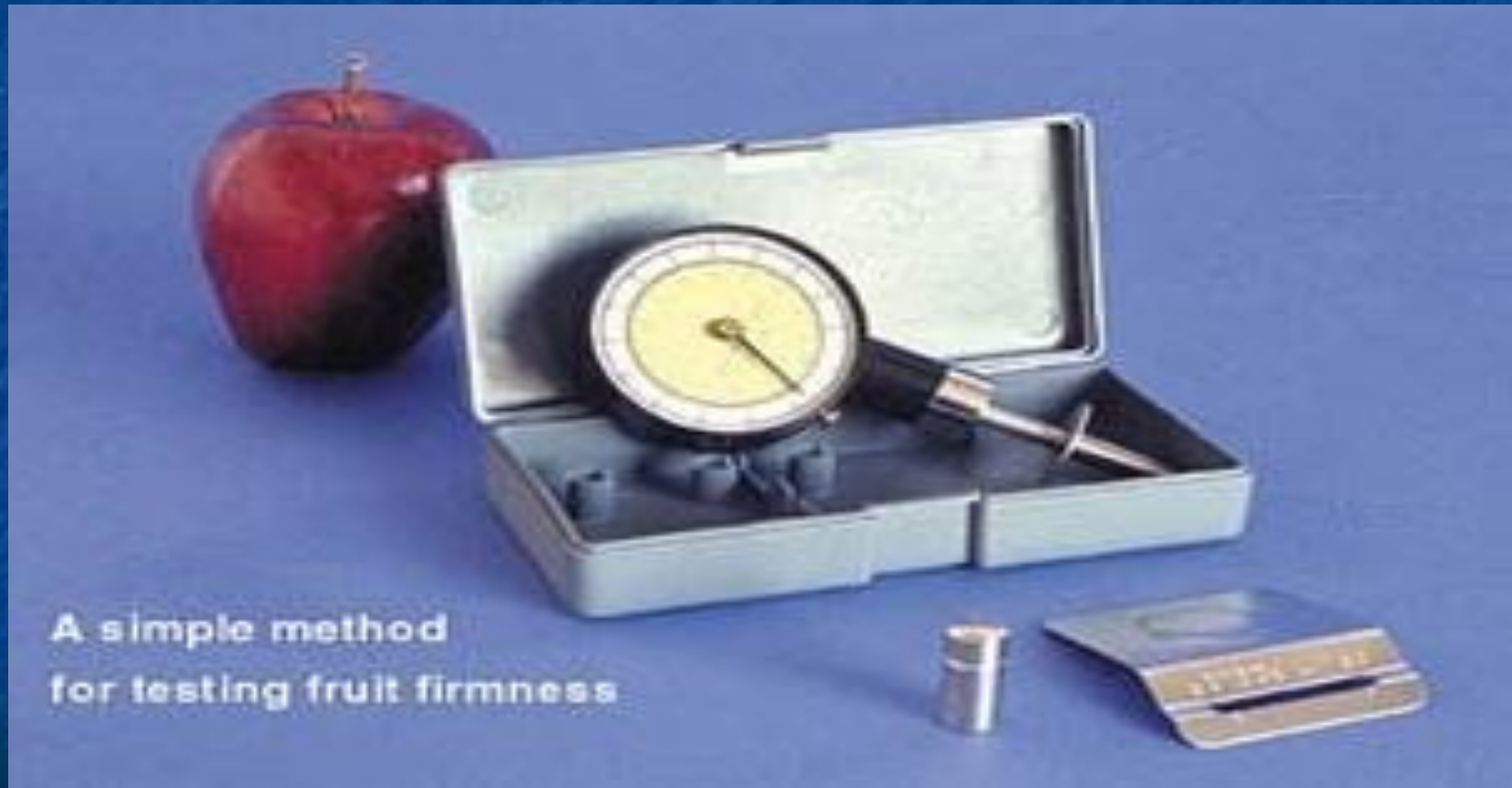
## How to do it?

- approximately 10 apples should be analysed
- a piece of peel is taken off at the widest diameter of each apple (both opposite sides)
- the pin of the penetrometer should be gently thrust into this area
- the device shows the resistance measured
- the process is repeated on both apple sides
- the value should be an average from two measurements.

# Texture Analyser



# Firmness-exercise



A simple method  
for testing fruit firmness

## Quality parameters:

- Size and shape
- Skin color
- Firmness/texture
- Starch / sugar (soluble solids content)
- Titratable acidity
- Volatile compounds / aroma / odour
- Taste
- Flavour (taste and odour)

# Starch

- Starch is composed of two glucose polymers amylose and amylopectin,
- During ripening process starch breaks down and converts into sugar, into the complex sugar *sucrose* and the reducing sugars *glucose* and *fructose*
- The less starch the riper the fruit,
- There is a relationship between starch loss and ethylene production
- Sugars released during starch breakdown are utilized for respiratory metabolism
- Sugar is an important measurement of internal quality because the taste of the fruit is primarily dependent on the sugar and acidity content
- many factors can influence the sugar content of ripening fruit: exposure to the sun and shade, irrigation, rootstock, fertilization, weather conditions etc



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# Sugar - analysis

## Tool

- To determine the amount of total sugar in the fruit **the hand refractometer/refractometer** can be used

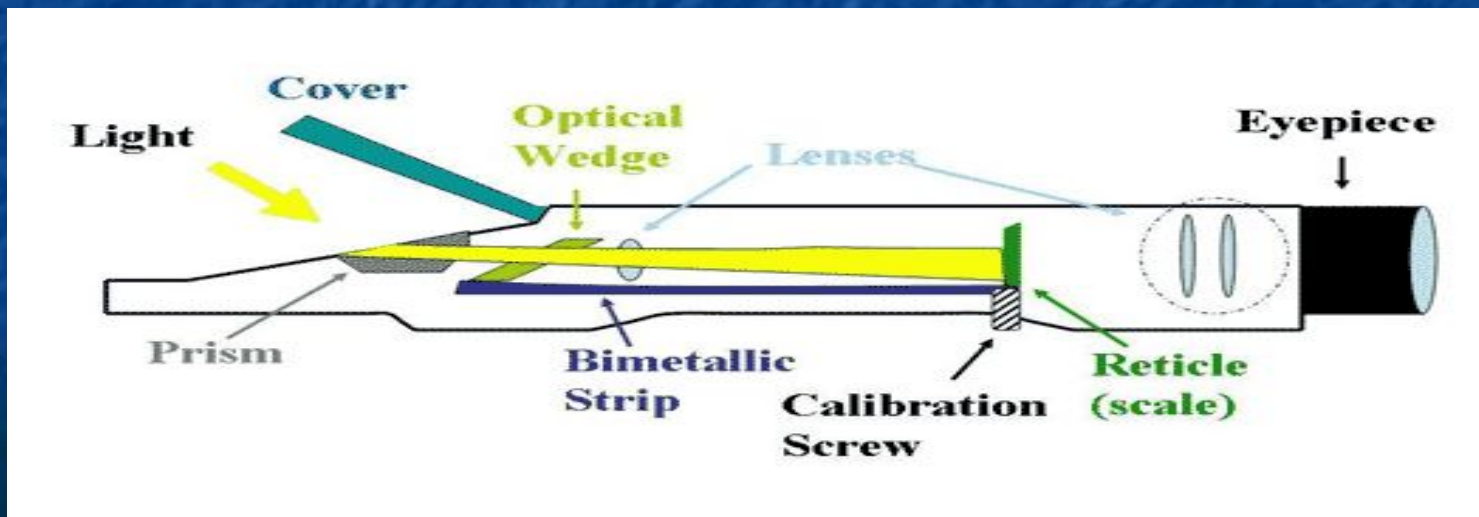
## How?

- press the juice from apple
- put a small drop of the juice into the glass part of refractometer
- repeat action several times in order to achieve a workable average
- Sugar content is usually expressed by %Brix degrees (the relative "sugar weight" of a sample compared to distilled water)





# Sugar -analysis



# Sugar - analysis



Refractometer without any sample



Properly calibrated refractometer



Sample of some real grapes - time to make wine

## Quality parameters:

- Size and shape
- Skin color
- Firmness/texture
- Starch / sugar (soluble solids content)
- *Titrateable acidity*
- Volatile compounds / aroma / odour
- Taste
- Flavour (taste and odour)

# Titratable acidity

- is a measurement of quality which gives clues as to determining the harvest date (brix:acid ratio)
- there are many organic acids, but generally two/one are mainly in the fruit:

**Table 4-3. Organic Acids in Apple, Pear, Grape, Banana, and Strawberry**

	<i>Apple</i>	<i>Pear</i>	<i>Grape</i>	<i>Banana</i>	<i>Strawberry</i>
Glycolic	+	+	+	+	tr
Lactic	+	+	+	+	
Glyceric	+	+	+	+	tr
Pyruvic	+		+	+	
Glyoxylic	+		+	+	
Oxalic	+		+	+	
Succinic	+	+	+	+	+
Fumaric	+		+		
Malic	++	++	++	++	+
Tartaric			++		
Citramalic	+	+		+	
Citric	+	+	+	+	+++
Isocitric	+		+		
Cis-aconitic			+		
Oxaloacetic	+		+	+	
$\alpha$ -Oxoglutaric	+	+	+	+	
Galacturonic	+	+	+		
Glucuronic	+		+		
Caffeic	+		+		
Chlorogenic	+	+	+		
p-Coumarylquinic	+				
Quinic	+	+	+	+	+
Shikimic	+	+	+	+	tr

# Titratable acidity

- ❑ organic acids are utilized as respiratory substrates and as carbon skeleton for synthesis of the new compounds during ripening (respiration, create aroma compounds...etc)
- ❑ acidity decreases with increasing ripeness
- ❑ the acidity can vary greatly from year to year, influenced mainly by weather conditions

# Titratable acidity - analysis

## Tool

- To determine the acidity level in the fruit **titration method** is used

## How?

- press the juice from apple
- measure 1ml of juice, add some water
- start titration with NaOH (sodium hydrate)
- acidity is expressed in malic acid g/l



## Quality parameters:

- Size and shape
- Skin color
- Firmness/texture
- Starch / sugar (soluble solids content)
- Titratable acidity
- Taste
- Volatile compounds / aroma / odour
- Flavour (taste and odour)

# Taste

- Consumers try to correlate visual parameters with taste (round, shiny, red apple has to taste good) – unfortunately we can assess taste only after purchase of the product
- Taste is perceived by specialized taste buds on the tongue
- There are many tastes but most appear to primarily represent combinations of 4 sensations :
  1. Sweet
  2. Sour
  3. Bitter
  4. Salt



# Taste

- Sweetness and sourness are predominant
- Taste changes as the ratio of sugar and organic acids changes
- Sweetness comes from amount and type of sugar in fruits (fructose>sucrose>glucose)
- Sourness comes from amount and type of organic acids

# Taste - exercise



## Quality parameters:

- Size and shape
- Skin color
- Firmness/texture
- Starch / sugar (soluble solids content)
- Titratable acidity
- Taste
- Volatile compounds / aroma / odour
- Flavour (taste and odour)

# Apple Aroma

- Over 300 volatile compounds have been measured in apples
- The change in production of volatile compounds by apple fruit is closely linked to ripening process so also to ethylene
- The types of apple aroma compounds produced typically belong to one of several groups, mostly esters, aldehydes, alcohols, ketons (others in smaller amounts)

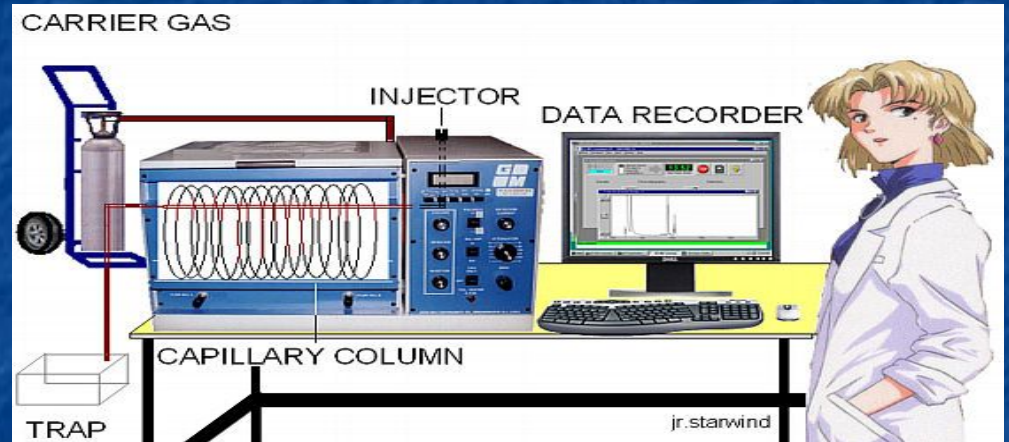
Compound	Sensory description	Cultivar	Reference
<b>Aldehydes</b>			
acetaldehyde	green/sharp	Golden Delicious	Rizzolo et al. (1989)
<i>trans</i> -2-hexenal	green/sharp overall intensity	Golden Delicious McIntosh	Rizzolo et al. (1989) Panasiuk et al. (1980)
hexanal	green apple harmonious, fruity green/sharp, earthy overall intensity good, green apple grass like	Delicious many Golden Delicious McIntosh Delicious many	Flath et al. (1969) Duerr (1979) Rizzolo et al. (1989) Panasiuk et al. (1980) Flath et al. (1969) Duerr (1979)
<b>Alcohols</b>			
butan-1-ol	overall flavour, aroma, sweet aroma	Royal Gala, Golden Delicious	Young et al. (1996); Rizzolo et al. (1989)
hexan-1-ol	earthy, unpleasant	Golden Delicious	Rizzolo et al. (1989)
<i>trans</i> -2-hexanol	harmonious, fruity	many	Duerr (1979)
<b>Esters</b>			
butyl acetate	red apple aroma Cox-like aroma harmonious nail polish	Royal Gala Cox's Orange Pippin many Gala	Young et al. (1996) Williams & Knee (1977) Duerr (1979) Plotto (1998)
pentyl acetate	banana like apple, fruity Gala	Cox's Orange Pippin Golden Delicious Gala	Williams & Knee (1977) Rizzolo et al. (1989) Plotto (1998)
hexyl acetate	red apple aroma characteristic apple Cox-like aroma ripe Golden Delicious sweet fruity, apple Gala, ripe, pear	Royal Gala  Cox's Orange Pippin Golden Delicious	Young et al. (1996)  Williams & Knee (1977) Rizzolo et al. (1989)
2 methyl butyl acetate	Gala, ripe, pear overall aroma, characteristic apple solvent	Royal Gala  Gala	Plotto (1998) Young et al. (1996) Plotto (1998)
ethyl butanoate	banana like fruity, estery harmonious, fruity	Cox's Orange Pippin Golden Delicious many	Williams & Knee (1977) Rizzolo et al. (1989) Deurr (1979)
ethyl-2-methyl butanoate	fruity apple like sweet strawberry	Golden Delicious Delicious Gala	Rizzolo et al. (1989) Flath et al. (1967) Plotto (1998)
4-methoxyallyl benzene	spicy, aniseed	many	Williams et al. (1977)
methyl-2-methyl butanoate	sweet fruity	Gala	Plotto (1998)
propyl-2-methyl butanoate	very sweet, strawberry	Gala	Plotto (1998)
butyl-2-methyl butanoate	fruity, apple	Gala	Plotto (1998)
hexyl-2-methyl butanoate	apple, grapefruit	Gala	Plotto (1998)
butyl hexanoate	green apple	Gala	Plotto (1998)
hexyl propanoate	apple	Gala	Plotto (1998)
butyl butanoate	rotten apple, cheesy	Gala	Plotto (1998)
butyl propanoate	fruity, apple	Gala	Plotto (1998)
hexyl butanoate	apple	Gala	Plotto (1998)
hexyl hexanoate	apple	Gala	Plotto (1998)

## Apple aroma

- In pre-climacteric apples, aldehydes and alcohols are the largest quantitative groups of volatile produced, but after ripening begins ester production increases and becomes the largest quantitative group in many cultivars
- *The most important is the treshold of each compound not a quantity of compound! !*
- treshold = ability to percive the odour

# Aroma/Odor - analysis

## GC-MS



# Aroma/Odor - analysis

## Olfactory GC





# Aroma - exercise

## Quality parameters:

- Size and shape
- Skin color
- Firmness/texture
- Starch / sugar (soluble solids content)
- Titratable acidity
- Volatile compounds / aroma / odour
- Taste
- **Flavour** (taste and odour)

# Flavour

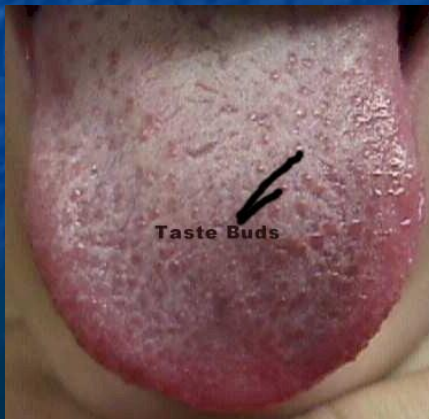
TASTE + ODOUR



PERCEIVED BY BUDS IN  
THE TONGUE



PERCEIVED BY OLFACTORY  
RECEPTORS IN THE NOSE



# Flavour

TASTE + ODOUR



PERCEIVED BY BUDS IN  
THE TONGUE



PERCEIVED BY OLFACTORY  
RECEPTORS IN THE NOSE

"...This wine tastes so nice, because of its fruity and spicy notes..."

The sentence refers to pleasant odor sensed, when taste can be describe only by 4 sensations: sweet, salty, sour and bitter.



popart.com

# Exercise 3

- 10.03.2009
- Lab on the 4th floor (at my office T459)
- Each group = different time

# Exercise 3

## Group 1 (opponent to group ...) at 15.15

Aslan, Ozlem  
Østergaard, Anne  
Betzer, Cathrine

## Group 2 (opponent to group ...) at 11.00

Zidova, Petra  
Dedenroth, Stine Elise  
Yilmaz, Tuba

## Group 3 (opponent to group ...) at 15.00

Demir, Kevser Burcu  
Weinreich, Christine Frigaard  
Desta, Zeratsion Abera

## Group 4 (opponent to group ...) at 14.00

Thach, Tine  
Dobrynin, Aleksey  
Stalmach, Joanna

## Group 5 (opponent to group ...) at 14.30

Gardin, Jeanne  
Shahid, Aleena  
Gruca, Marta  
Helene

## Group 6 (opponent to group ...) at 13.00

Sarica, Gülsen  
Hansen, Majbrit  
Rodriguez Algaba, Julian

## Group 7 (opponent to group ...) at 13.30

Jacobsen, Stine Kramer  
Orhan, Damla  
Kemezys, Andrius

## Group 8 (opponent to group ...) at 11.30

Mutlu, Ayse Ceren  
Kjeldgaard, Karina Juhlert  
Mlynek, Janus Cronquist  
Mengistu, Fekadu Gebretensay

# Exercise 3 - delivery

- 13.03.2009
- Tåstrup 8-01
- Oral presentation of the exercise results (10+10min)
- Groups examine each other



# Exercise 3 - delivery

- Oral presentation includes:
  - ❖ Objective introduction (why?, what are the differences? Is it important?)
  - ❖ Methods and material presentation
  - ❖ Results
  - ❖ Discussion (expected or surprising results...etc) - references
- Opponent groups ask questions and examine other team on their knowledge