Advanced Crop Quality
Lecture-4

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Carbohydrates

Carbohydrates are:

- **Almost all are derived from aldehyde or ketones**
- A major source of energy.
- They have in their molecules mainly C, H and O
- Also called saccharides, which means "sugars."
- **C,H,O elements are the main elements in carbohydrate compounds, and the ratio of H:O elements in them is 2:1 in water. This means that carbohydrates are produced from the union of carbon with water. Therefore, the molecular formula $(CH_2O)n$ was given, where n is the number of carbon atoms. It is at least 3 and can increase to several thousand carbon atoms.**

How are Carbohydrates Made?

For the process of photosynthesis, carbon dioxide and sunlight have to be present. Also, the plant must have water. Only then can the plant photosynthesize and produce glucose and oxygen from carbon dioxide, water and sunlight. The equation of photosynthesis is as follows:

$$6\,CO_2 + 6\,H_2O \longrightarrow C_6H_{12}O_6 + 6\,O_2\uparrow$$

Carbon dioxide + Water ---> Glucose + Oxygen

- **The glucose produced is then stored in the leaves as starch.**

Functions of Carbohydrates

1 - Source of energy for living beings, e.g. glucose

2 - Storage form of energy, each gram of carbohydrates provides us with about four calories.

3 - Carbohydrates are also combined with nitrogen to form non-essential amino acids.

4 - Carbohydrates make up part of the cellulose, giving plants strength and structure.

5 - Constituent of nucleic acids RNA and DNA, e.g. ribose and deoxyribose sugar .

Classification Of Carbohydrates

The carbohydrates are divided into three major classes depending upon whether or not they undergo hydrolysis, and if they do, on the number of products formed.

1- Monosaccharides

The monosaccharides are polyhydroxy aldehydes or polyhydroxy ketones which cannot be decomposed by hydrolysis to give simpler carbohydrates. Examples are glucose and fructose, both of which have molecular formula, $C_6H_{12}O_6$.into groups according to the number of individual simple sugar units.

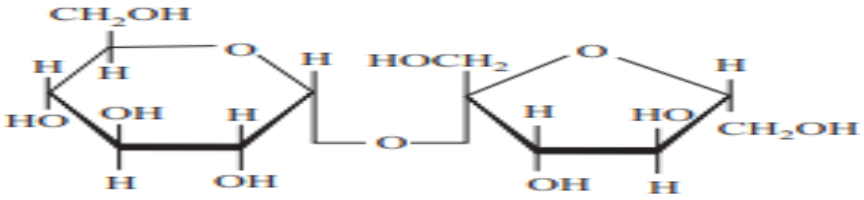
- Although there are monosaccharides with different numbers of carbon atoms (3-9), The hexacarbonate (hexoses) are the most common monosaccharides in animals and plants. Among them, glucose and fructose are of particular importance.
- **Glucose** is of special importance for plants as it is the basis of starch and cellulose, and the chemical formula for glucose and **fructose** is ($C_6H_{12}O_6$).
- The **pentose** sugars are less available, $C_5H_{10}O_5$. These sugars enter into the formation of complex carbohydrates found in the cell walls and plant pigments.
- **Ribose** enters the nuclear ribose and the end of the acid. Ribulose is an intermediate sugar in photosynthesis..

2- Oligosaccharides

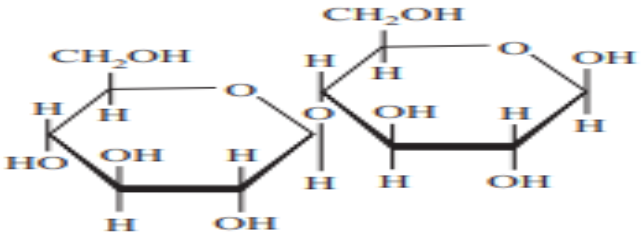
(Disaccharides)

When two monosaccharides are combined together with elimination of a water molecule it is called disaccharide. Monosaccharides are combined by glycosidic bond. Examples are sucrose and maltose, both of which have molecular formula, $C_{12}H_{22}O_{11}$.

Disaccharide	Description	Component monosaccharides
Sucrose	common table sugar	glucose α1→2 fructose
Maltose	product of starch hydrolysis	glucose α1→4 glucose
Trehalose	found in fungi	glucose α1→1 glucose
Lactose	main sugar in milk	galactose β1→4 glucose
Melibiose	found in legumes	galactose β1→6 glucose



Sucrose



Lactose

3-Polysaccharides

- The polysaccahrides are carbohydrates of high molecular weight which yield many monosaccharide molecules on hydrolysis. Examples are **starch and cellulose**, both of which have molecular formula, $(C_6H_{10}O_5)_n$.
- Foe example ,the starch that is stored in seeds and tubers, cellulose, which makes up most plant cell walls, and plant glues.
- The most polysaccahrides in the plant consist of hexa- and pent-carbon sugars, which form cellulose and starch, which are the most abundant glucose molecules in the plant. The polysaccharides are not sweet in taste or soluble in water.

4-Derived Sugars

- They are the sugars that are derived from monosaccharides such as:
- A- Amino Sugars
- B - Glycosides
- C - Deoxy Sugars

The most important carbohydrate compounds for plants are

starch & cellulose

HOMOPOLYSACCHARIDES

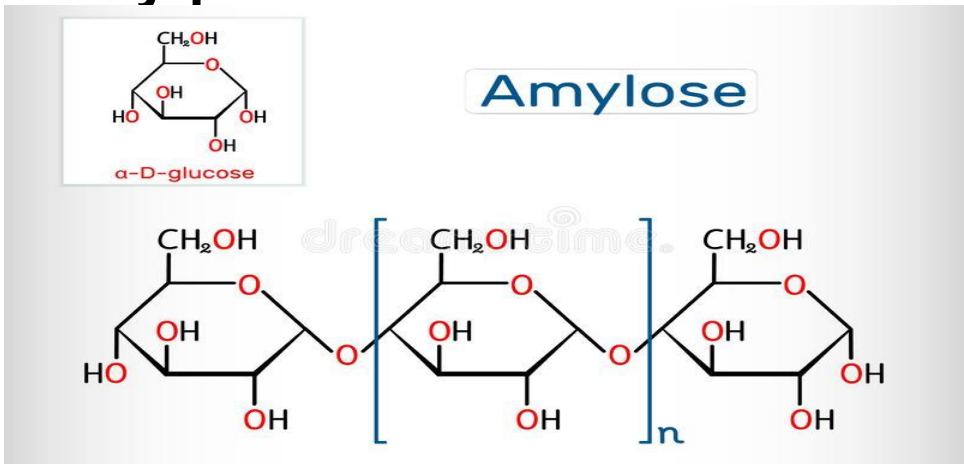
Starch: **It is one of the most important carbohydrates in grains. It is considered one of the reserve carbohydrates stored in some plants such as potatoes and legume seeds.**

- **Starch appears as granules that have shape and size.**
- **Starch granules are not dissolved in cold water because there is an outer membrane surrounding their components, and for the purpose of dissolving them, The outer shell of the granules is broken and the temperature of the water is raised by heating, and this membrane decomposes, the components that dissolve in the water are released, forming a thick gelatin solution.**
- **This process is called Gelatinization .**
- **starch is decomposed using mineral acids or enzymes (hydrolysis).**

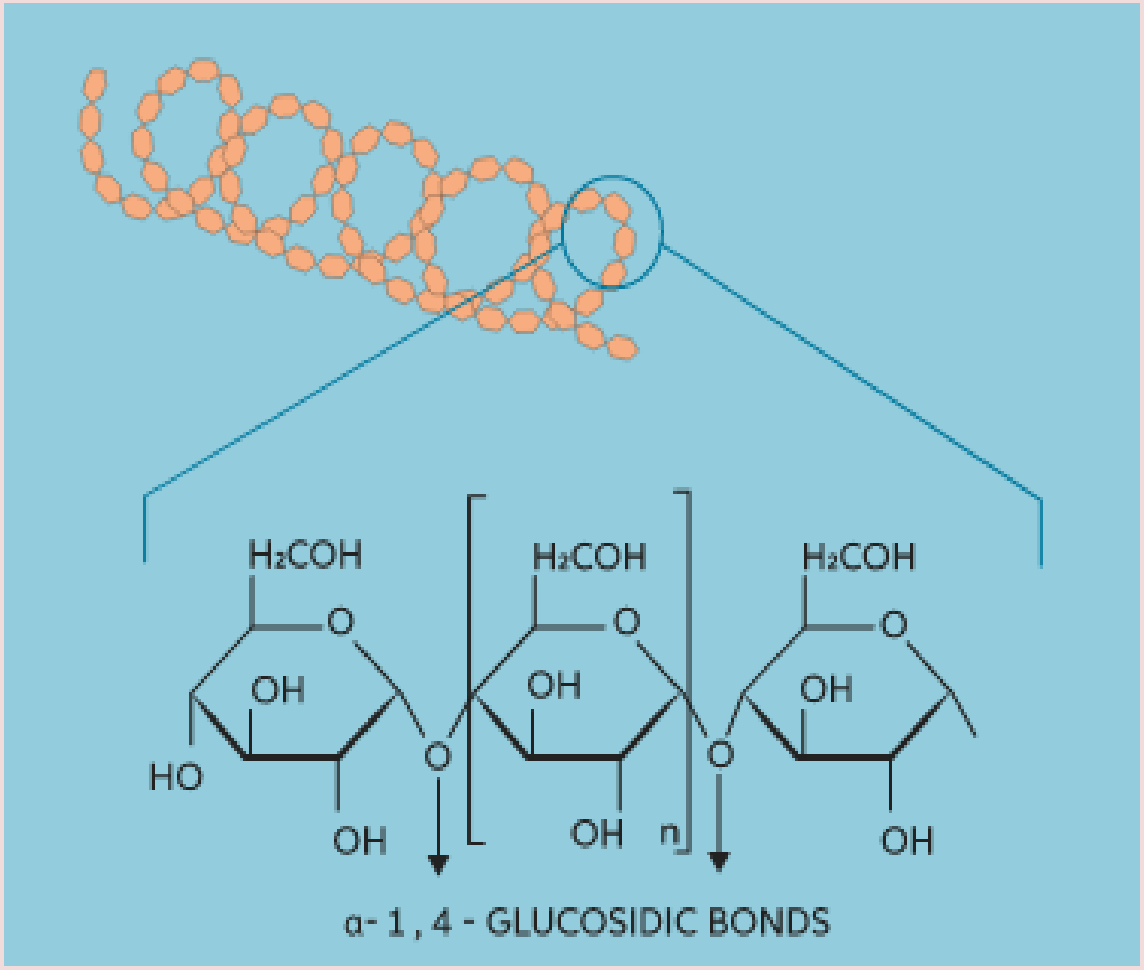
Starch is composed of two constituents.
1- amylose

starch contain $10-20\%$ amylose

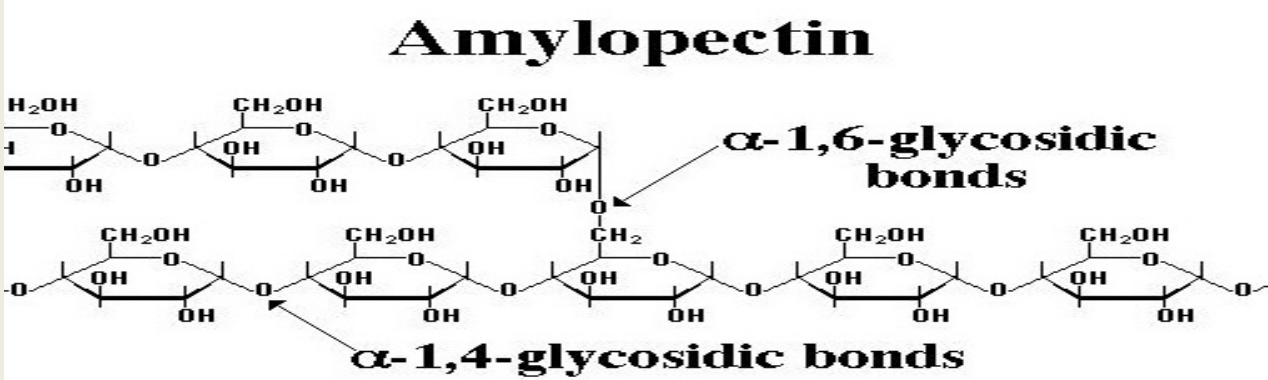
- **It is soluble in water**
- **structure is straight chains of sugar units linked by α - 1-4 - glycoside bonds.**
- **One amylose molecule contains about $250-300$ unbranched glucose molecules.**
- **Polymer unit $200-2{,}000$**
- **Give blue color with iodine.**
- **it is used as a food coating for many processed foods because it does not absorb moisture.**



- Amylose is decomposed by the enzyme α - Amylase, producing a mixture of glucose and maltose
- Amylose ⟶ (Glucose + Maltose) ⟶ Glucose



2- Amylopectin



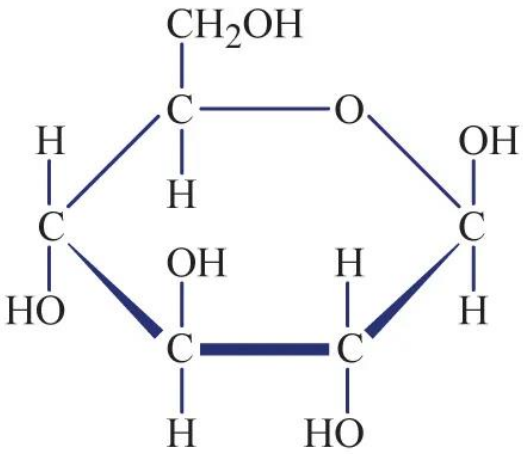
- starch contain 80% Amylopectin
- it is not soluble in water.
- It contains side chains in addition to straight chains.
- Its units are linked with the side bonds with α - 1-6 Glycoside bonds.
- The number of glucose in each branch about 12 units and branching occurs every 25-30 units.
- Polymer unit Up to 2,000,000
- Give purple color with iodine.
- Amylopectin is more viscous when hydrated and is useful for making thickening food compounds.

Amylopectin is decomposed by two enzymes:

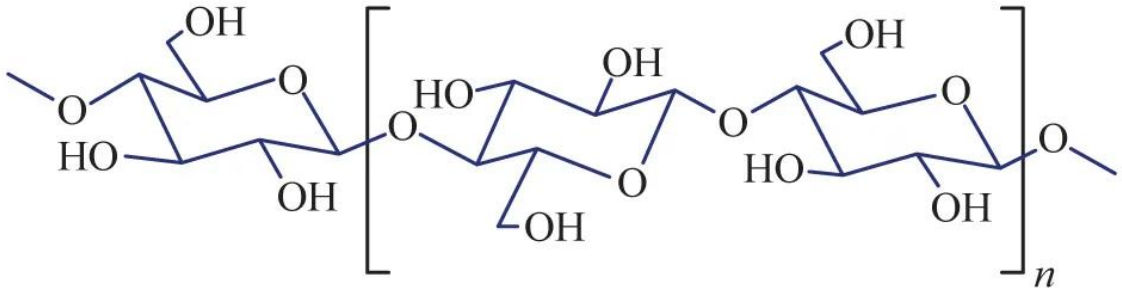
- **The first enzyme** α - Amylase, which breaks the bonds of α - 1-4 glycoside
- **The second enzyme Isomaltase** breaks the bonds of Glycoside α - 1-6 - at the branch point.

Cellulose

- Cellulose is the major structural material of plants.
- Cellulose is a fibrous material that is insoluble in water.
- It is a polymer of glucose units linked together by glycosidic bonds.
- it is the main component of the thick cell wall.



glucose



cellulose

Effect of environmental factors on sucrose accumulation in sugar cane

- Sugar cane is C4 plants (highly efficient in the use of solar energy).
- vegetative part is the economic part.
- Most of the world's sugarcane is grown in subtropical and tropical areas.
- It was found that the areas in which the highest sugar production are located between the longitude of 18° north to 18° south of the equator.
- Many publications showed the advantage of moderate levels of water stress and reduced temperatures for sucrose accumulation.
- Temperature, photoperiod &Moisture.

-Any site outside this range(18° north to 18° south of the equator) changes the photoperiod, which is not appropriate, as it leads to early flowering in the cane, which is undesirable due to the

losses of sugars, so the proportion of sucrose in the stems of cane decreases and the proportion of fiber increases.

-It was also found that drought conditions encourage slow growth, which increases the accumulation of sugars.

-Studies have shown that the quality of juice is linked to a decrease in moisture content in the cane stalks, because the high moisture content encourages plants towards vegetative growth, consuming large amounts of sugars in the formation of new growths.

- Several studies showed a significant negative correlation between the percentage of sucrose in cane, the number of green leaves, the total area and the dry weight of the leaves.
- Temperature is the main determinant of cane planting in tropical and subtropical regions.
- The low temperature is one of the most important and most effective factors in encouraging the plant towards maturity, as it leads to a reduction in the amount of absorbed elements and thus slow vegetative growth, which helps in the accumulation of sucrose.

- Increasing the amount of nitrogen fertilizer above the plant's need leads to the continuation of vegetative growth, delaying the process of transporting and accumulating sugar, and increasing monosaccharides, which negatively affects the crystallization of sucrose.
- Increasing fertilization leads to an increase in the water content, which increases the percentage of impurities in the juice and increases the lodging of plants , and thus affects the harvest process

sugarcane :measuring commercial quality

- **There are a number of measurements that contribute to assessing the quality of sugarcane:**

- pol (sucrose) percent in juice;
- brix (total soluble solids) percent in juice.
- pol (sucrose) percent in cane.
- brix per cent in cane.
- fibre per cent.
- commercial cane sugar (CCS).
- purity.

- The process of determining sugarcane quality requires several measurements. The diagram below summarises the process.

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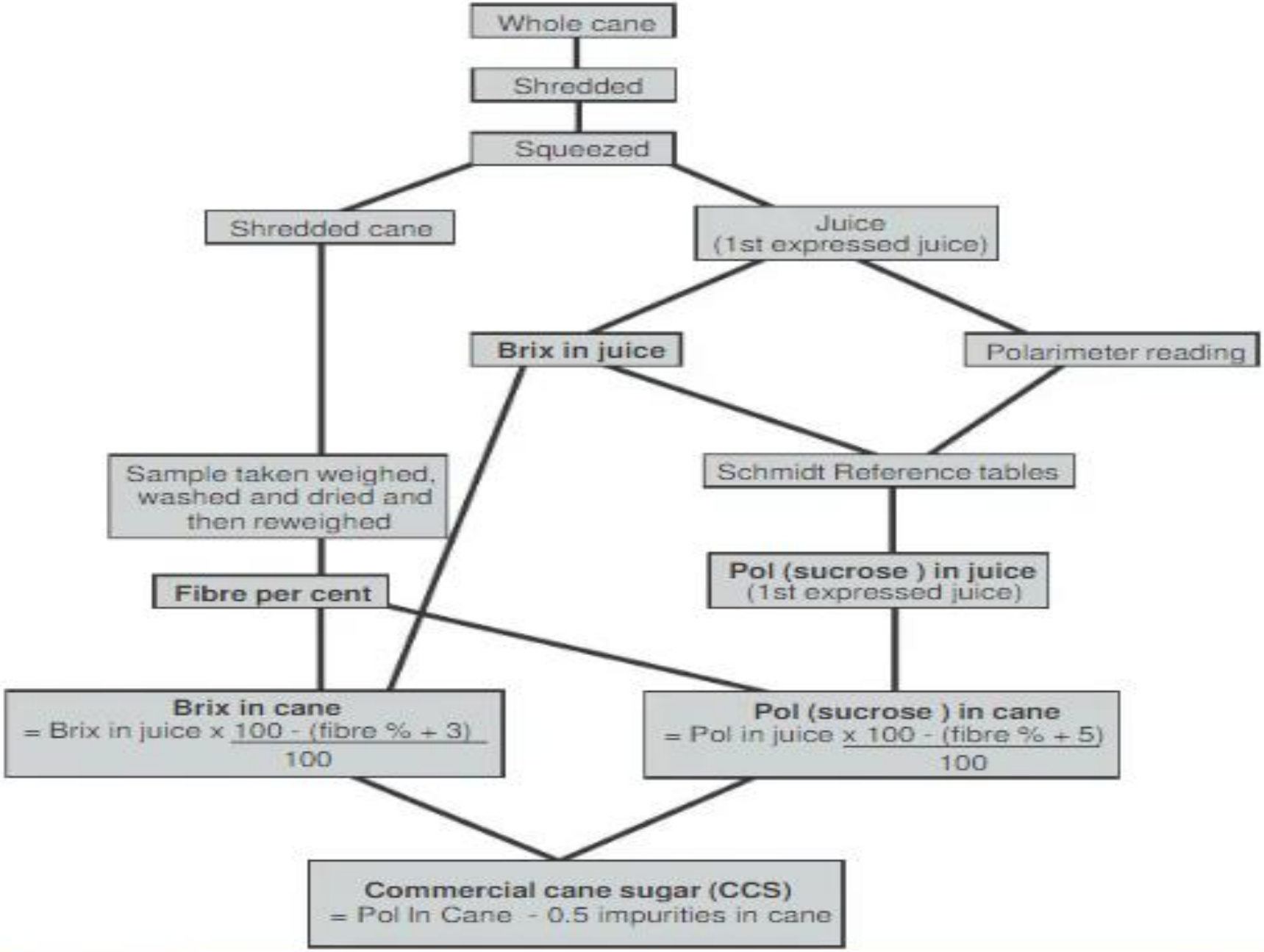

Pol (Sucrose) percent in juice

Pol (Sucrose) percent in juice:

-It is the percentage of sucrose contained in 100 cm^3 of juice and is measured by a **Polarimeter**.

Brix (Sucrose) percent in juice:

-It is the percentage of dissolved solids in 100 cm^3 of juice, and its value is extracted using a **Refractometer**.

Table 1.1 Extract of the reference tables for converting Polarimeter and brix readings to a per cent sucrose in juice.

Polarimeter reading	Brix							
	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5
71	17.16	17.13	17.09	17.05	17.02	16.99	16.95	16.92
72	17.41	17.37	17.33	17.30	17.26	17.23	17.19	17.16
73	17.65	17.61	17.58	17.54	17.50	17.47	17.43	17.40
74	17.89	17.85	17.82	17.78	17.74	17.71	17.67	17.63
75	18.13	18.09	18.06	18.02	17.98	17.95	17.91	17.87
76	18.37	18.34	18.30	18.26	18.22	18.19	18.15	18.11
77	18.61	18.58	18.54	18.50	18.46	18.66	18.39	18.35

Fibre in cane

Method for Determining Fibre Percentage at the Sugar Mill

Over a period of 24 hours samples are collected immediately after the cane has passed through the shredder. These samples are combined, and a 500 gram sub sample taken.

A.Sub sample is put through a cutter grinder.

B.The ground sample is then placed into a fibre machine where it is washed to remove brix (soluble solids) and fine dirt.

C. The sample is then dried using hot air and weighed .

The final weight divided by the initial weight provides a fibre percentage.

Example: Original weight of 500 grams, final weight of 75 grams.

Fibre percentage = (final weight / original weight) x 100

= (75 / 500) x 100 = 15%

= 15 %

Brix percent in cane

Brix in cane = brix in juice x (100 – (% fibre + 3))/100

Therefore with brix in juice of 21.0 and fibre of 15% it is possible to calculate brix in cane.

Brix in cane = 21.0 x (100 – (15 + 3))/100

= 17.22

Pol (sucrose) percent in cane

Pol in cane = pol in juice x (100 – (% fibre + 5)/100

Therefore with our brix reading of 21.0, the pol in juice calculated to be 17.95 and fibre of 15% it is possible to calculate pol in cane.

Pol in cane = 17.98% x (100 – (15 + 5))/100

= 14.38%

Impurities in cane

Impurities in cane = brix in cane – pol in cane

=17.22- 14.38= 2.84

(CCS) Commercial cane sugar

- Commercial cane sugar (CCS) is calculated knowing both: brix in cane and pol in cane.
- CCS provides an estimate of the percentage of recoverable sucrose from cane.
- CCS = pol in cane – 0.5 impurities in cane

Therefore from the example;

CCS = 14.38 - (0.5 x 2.84)

= 12.96


Thank you
for your
attention