SAC 102 INTRODUCTION TO AGRICULTURAL CHEMISTRY 2 + 1

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CHEMISTRY OF FRUITS AND VEGETABLES

Generally, the fruits and vegetables are made up of the following constituents. H_2O, CHO, fat and lipids, proteins, Amino acids, vitamins, minerals, viz.,P, K, Ca, Mg, Fe, organic acids, pectins, pectic enzymes, tannins, pigments, odorous compounds.

Water

It is the major constituent i.e. 75-95% in fresh fruits and vegetable. It is also present in leaves, stalk (or) stem and ranges from 70-80%. As the plants attain maturity, the water content gets reduced. The moisture content varies at the stage of crop growth, variety of crop, irrigation schedule and harvesting time.

CHO

They are sugars (or) polyhydroxy aldehyde (or) ketones. Fruits will have generally monosaccharide. The pentoses will be more in apple, guava, lime, grapes.

Disaccharide in non-reducing sugars such as sucrose, lactose and maltose

Triasccharide - Ramnose

Polysaccharide – Starch.

The sweetness of the fruit is decided by the type and quantity of sugars present in the fruit. It varies for e.g.

Sucrose	**– 100%**
Glucose	**– 75%**
Fructose	**- 173%**
Maltose	**- 72%**
Lactose	**- 16%**

Total sugars in riped fruits (in %)

Apple	**6 –17**	**Guava**	**3-10**
Banana	**11-12**	**Grapes**	**2-19**
Mango	**14**	**Pineapples**	**8-18**
Orange	**4-12**	**Lime and lemon**	**1-14**
Papaya	**9**	**Tomato**	**2-4**

Reducing and non-reducing sugars in fruits (%)

Fruit	**Reducing**	**non-reducing**
Apple	**6-11**	**1-7**
Mango	**3-5**	**7-8**
Papaya	**7**	**<1**
Orange	**3-6**	**2-5**
Lime	**1-3**	**<1**

Types of sugars in fruits (%)

Fruits	**Glucose**	**Fructose**	**Sucrose**
Apple	**1.6**	**6.1**	**3.6**
Banana	**5.8**	**7.0**	**-**
Grapes	**8.0**	**8.0**	**-**
Orange	**2.4**	**2.4**	**5.0**
Lime	**<1**	**<1**	**<1**
Pineapple	**2.3**	**1.4**	**8.0**
Tomato	**1.6**	**1.2**	**-**
Pomegranate	**5.5**	**6.1**	**-**

Classification of CHO: Sugars

Monosaccharide – e.g. Glucose and Fructose. In some cases it is equal, glucose is > fructose and in some cases fructose is > Glucose. Sometimes arabinose will also be higher.

Disaccharides –e.g. Sucrose – more in sugarcane

Sugar derivatives contain the sugar acids and the polyhydroxy alcohols.

Sugar acids:

i. Saccharic acid

ii. Mucic acid

iii. Gelacturonic acid

iv. Gluconic acid

v. Glucoronic acid

Polyhydroxy alcohol

i. Sorbitol

ii. Glycerol.

II. Structural CHO

It contains many polysaccharides such as the galacton and Arabinon. They are the polysaccharides (i.e. homo and hetero) are the cellulose, hemicellulose and the gumes. Arabinose, xylon.

III. Pectic substances are groups of compounds comprising pectin, protopectin and pectic acid.

IV. Protopectin

Organic acids are the important constituents responsible for the taste and flavour of the fruits.

Different types are:

I. Aliphatic volatile acids.

i. Formic acid

ii. Acetic acid

iii. Butyric acid

II. Aliphatic mono carboxylic acids

i. Alcoholic acids

Glycolic acid

Lactic acid

Glyceric acid

2. Aldehydric acid

Glyoxalic acid

3. Ketonic acid

Pynuric acid

Oxaloacetic acid

III. Aliphatic dicarboxylic acid

1. Oxalic acid – present in banana
2. Succinic acid – all fruits
3. Maleic acid – apple, grapes
4. Fumaric acid – green apples
5. Tartaric acid – Tamarind, grapes

iv. Tricarboxylic acid

Citric acid

Isocitric acid

Cisaconitic acid

v. Aromatic acid

Benzoic acid

Salicylic acid

Coumaric acid

Quinic acid

Skimic acid

V. Amino acids:

All the fruits : Glutanic acid, Aspartic acid

Apple : Aspartic, glutamic, β alanine

Banana : Aspartic, glutamic, hystidine

Tomato : Glutamic, Tryptophan

VI. Protein content in different fruits (%)

Generally it is very low in fruits. It varies with species of crop, season, cultural practices followed by the influence of environmental factors.

Apple	0.2	Mango	<1
Banana	1.1	Pineapple	<1
Grapes	1.3		
Tomato	1.2		
Guava	0.8		
Avocado	2.1		
Dates	2.2		

VII. Enzymes

Role: It helps in ripening

Pectinase → act on pectin and covert them into methyl alcohol and poly galacturonic acid.

Cellulase → act on cellulose and convert them into methyl alcohol and simple proteins. This reaction is responsible for softening while ripening.

Amylases → act on starch, maltose and convert then into simple sugars

Phosphorylases → act on starch and maltose and convert them into phosphorylated sugars.

Invertase → Inversion of sugar

Lipases → act on fats.

Peroxidases → Involves in the oxidation and reduction

Phenolases → Acts on phenolic compounds

Proteases → act on proteins.

VIII. Fruit lipid

Fruit lipid contains very high amount of fat. e.g. Butter fruit – Avocado → 60% fat. Besides this, soybean contains 16%, potato 5%, Lipids gets converted to protein as oligoproteins.

IX. Volatile compounds

Characteristic odour of any fruits is due to the volatile compounds.. They will less than 100 ppm in concentration but they are esters, alcohols, aldehydes and ketones. Presence of these compounds will give characteristic smell.

Apple – Ethyl 2 methyl butyrate

Grapes – Methyl anthranilate

Banana – Amyl acetate and isopentyl acetate

Grape fruit – Terpenes

Lemon – Hydrocarbon containing isoprene

Orange – limonine

X. Fruit phenolic compounds

These are responsible for colour, flavour and taste. These phenolic compounds give both desirable and undesirable qualities. The fruit phenolic compounds include flavonoids and the cinnamic acids. The major flavonoids are the anthocyanins, the leucoanthocyanins, the flavonols, flavones. The presence of these phenolic compounds in fruits gives an astringent taste.

XI. Fruit pigment

Pigments give colour such as carotenoids, chlorophylls, anthocyanin and anthoxanthin. The yellow, orange and red colour of the mango, papaya, tomato, carrot, peach, apricot and red pepper is mainly due to the presence of carotenoids. Carotenoids contain hydroxy groups called as Xanthophylls. This is the specific colour of yellow maize, papaya, mandarin orange. Carotenoids are water insoluble but some are fat soluble. Flavonoids are widely distributed in plants and are water solublr and they consist anthocyanin which gives red, blue, purple colour to the fruits. Anthoxanthins are responsible for yellow colouration.

XII. Vitamin

Yellow coloured fruits generally contain vitamin A. e.g. Papaya, Mango. Vitamin C- Citrus fruits and high in west Indian cherries. Guava – 200 mg/100 g, Banana – 10-30 mg/100 g, Melon fruits - 23-35 mg/100 g, Orange – 50 mg, Apple – 2-10 mg, Tomato – 25 mg, West Indian cherry – 500 – 1000 mg/100 g.

Besides A and C some fruit contains β-carotein → the precursor of vitamin A. Some fruit contains Nicotinic acid, folic acid and thiamine.

Mango – Vitamin A-total soluble solids – 20-26%.

Pulp ratio – 60%, reducing sugars – 9.8%, Non. Reducing sugars –7.4%

Carotenoids – 1675-11,536 mg/100 g

Among mangoes, Alfonso contains more carotenoids.

Vitamin A – 10-36%, Acidity – 0.15 – 29%

Different stages of maturity

Juvenile stage – up to 21 days – only cellulose materials are present.

Adolescent stage – 21-49 days – development of aroma takes place and CHO content gets increased.

Climactaric stage – Climataric fruits, respiration takes place even after the harvest. e.g. Mango, Papaya, Banana.

Non-climataric – Respiration will be less after harvest. eg. Apple, grapes, Date.

Climataric stage – 49-77 days. In this the sucrose content gets accumulated.

Finally the Senescence stage – more than 77 days decrease in glucose and sucrose content.

Banana

Total soluble salts– 17-21%, total sugars – 16-25%, acidity – 0.1-0.2%

Stages:

Inflorescence stage – up to 130 days, young inflorescence contains N up to 80% and important amino acids are alanine and arginine. After 130 days the amino acids content gets reduced. 75% of soluble N is Aspergin, glutamin, hystidine. Dry matter production takes palace in 80-100 days period. Dry matter will be around 25%. Starch gets accumulated after 100th day. Hydrolysis of starch is taking place up to 130 days and after that gets converted to glucose, fructose and sucrose. Generally the acidity gets reduced as the fruits get ripened. Insoluble pectin gets decreased after 100 days. Then the soluble pectin gets decreased. As the fruit gets ripened, chlorophyll gets disappeared and the yellow pigment dominates.

Apple : TSS -> 16-17%, glucose 1.7%, Fructose –6.1%, Sucrose – 3.6%
Among amino acids dominant ones are Aspargin, Aspartic acid, Glutamic acids and B-alanine. Protein content is very low 0.2%. Important organic acids present are maleic acid, however the green apple contains more of fumaric acid. Sugars - more glucose and fructose are present.

PAPAYA :

Solo variety – More of vitamin A. More cheap and more nutritious. It is poor man's apple.

Immature papaya fruit will have more of milky latex which has papain very much used in pharmaceutical industries and also used by hotels for making meat softer. It is also used in tanning industry – juice, pulp. It has contain Fe-17 mg/100 g, Ca – 0.5/100 g, carotein 666 mg/100 g, vitamin 57 mg/100g.

Papaya seed contains one toxic principle called carpin. It contains some aromatic compounds such as Ethyl butyrate and ethyl acetate, methyl butyrate and methyl acetate.

Guava

It contains more moisture 76-88%, acidity 0.2-0.6% CHO – 8.1 –14.5%, Vitamin C 38-300 mg/100 g, carotein – in unriped fruit –150 mg/100g in case of riped fruit – 480 mg/100 g. Fat content – 0.2%, fruit fiber – 0.7%, volatile compounds – butyl and ethyl alcohols and Protein 0.6-2%

In premature stage – contain more fructose and glucose upto 5% and later stages it gets reduced to 0.2%.

Grapes

Grape is a non-climataric fruit that is why harvesting is done when the berries are fully riped.

Paneer, musket, seedless, Thomson, Anab E sahi

CHO = glucose and fructose ranges 200 g/l of Juice.

In unriped fruit the glucose content is less than 8.5%. It contains the pentoses (Arabinose and xylose). The organic acid present in grapes is maleic acid which influences the taste and flavour. Industrial use of grapes:- used in wine industry, juice industry, dried grapes.

Anthocyanin and Tannins are responsible for specific colour such as red vine and white vine. The compounds which give aroma for grapes and wines are Terpenes and Terpenols. The berry of the fruit contains more of free terpenols and bound state of terpenols.

Following are the signs for ripening of fruit :

1. Formation of the waxy layer on the skin of berries

2. They become soft

3. Slight change in colour and browning of cluster stem

4. Berries are easily detached from the stem on pulling.

5. Seeds are loosely attached with the pulp and also become brown in colour.

6. On taste berries are sweet.

7. Juice of berries becomes thick and the refractometer reading shows 18-20.

8. Grapes are harvested by cutting.

9. Yield of grapes varies much due to variety, system of training or pruning, climatic condition, soil type, age of wines and also the cultural practices. A well maintained grape vine is productive for number of years.

Citrus: vitamin C

i. It is non-climataric especially the sweet oranges fail to ripen after they are harvested. When the fruits approach maturity, the skin colour changes from dark to light green then to yellowish. However, the colour change is not reliable criteria; the ripening is decided with TSS, acidity content, TSS-acidity ratio. TSS-acidity ratio is important factor. It gives an idea about the quality of juice and flavour. Fruits should be harvested before they attain over maturity. Sugar content: 0.9 – 3.4%.

The yield varies with the climatic conditions, soil types, varieties and age of plant, pests and diseases, management practices.

Amino acid: Aspartic – glutamic.

Sapota

Cricket ball, PKM, Co

It's climataric fruit which will ripe even after the harvest. The maturity of sapota is judged by following points.

1. **The fruit changes to dull orange (or) potato colour.**
2. **On scratching the fruit it shows a yellow streak but it will be green if the fruit is not matured.**
3. **The skin becomes smooth, free from brown scales.**
4. **The content of the milky latex is reduced then it becomes watery.**
5. **Spine like stigma, at the tip of the fruit drops off, when it attains maturity.**

6. Harvesting is done by twisting the fruit.

7. Up to 30 years gives yield 2000-3000 fruits from a ripened tree.

8. Quality and yield is decided by climate, soil type, cultural practices, age and variety.

Pomegranate

It is non climataric. It starts bearing fruits from 4th year and cultivated upto 30 years.

Pomegranate fruit development and maturity shows the CO_2 evolution from the fruit has been low and non climataric peak (or) measurable ethylene was detected during the maturities. The pomegranate fruit is ready for harvest in 5-7 months. Matured fruits will be yellowish in colour and turns pink and finally red in colour. On tapping it gives a metallic sound, and then it is fully ripened. Yield goes up to 30 years.

CHEMISTRY OF VEGETABLES

Importance of vegetables

i. They play a major role in human nutrition. They acts as a substitute for nutrients

ii. They are important for neutralizing acidity during digestion. They also serve as roughage in human nutrition and thus help in proper digestion

iii. Important source of minerals like Ca, P, Fe, Mg

iv. Important source of vitamins A and C

v. The green and yellow vegetables like carrot, turnip, beans contains appreciable quantities of vitamin A. Dried seeds of beans and peas and legumes contain proteins. Besides vitamin C, the vegetables also have the thiamine, niacin and folic acid. The tomatoes and potatoes contains fairly high amount of vitamin C. The factors that affect the composition of vegetables

i. Genetic variations

ii. Fertilizer and mature application

iii. Soil condition

iv. Climate

v. Cultural

vi. Stage of maturity

vii. Changes that takes place during processing

viii. Changes that takes place during storage

Daily requirement of vegetables for human consumption: 300 g/day person

Crude fiber content:

Cauliflower	**0.74 –1.74**
Chillies and Capsicum	**17.0 – 18%**
Potato and cucumber	**0.2 - 0.67%**
Bhendi	**7.0 - 18%**

CHO:

Tomato	**3-5%**
Carrot	**3-7%**
Cauliflower	**1-4%**
Brinjal	**5-6%**
Cucumber	**2-3%**
Radish	**1-2%**

Reducing sugars:

Tomato	**1-4%**
Potato	**0.2-2.1%**
Brinjal	**0.6-2.0%**
Onion	**2-3%**
Cauliflower	**2.2-4%**

Crude protein:

Peas	**6-8%**
Brinjal	**0.6-2.2%**
Tomato	**0.8-2.7%**

Cauliflower	**1.6-2.9%**
Radish	**0.73-1.3%**

Ascorbic acid content (mg/100g):

Peas	**30-104**
Cauliflower	**48-98**
Bhendi	**9-16**
Tomato	**25-100**
Onion	**6-10**

β - carotene (mg/100g):

Carrot	**0.4-8.5**
Cucumber	**9-25**
Tomato	**1.25-1.61**

Acidity:

Tomato	**0.5-1.6%**

Pungency:

Brinjal – Glycoalkaloid is pungent material – 0.5-5 mg/100 g

Chillies – Capsaicin is pungent material – 0.15-0.95%

Onion – Allyldisulphide 13-62 mg/100g

Colouring matter:

Anthocyanin pigment – Brinjal – Violet colour – 0.07-0.75 iu/100 g

Oleoresin – in chillies – 30 – 112 iu /100 g

Capxanthin, Zea cryptoxanthin, β - carotene

Tomato – lycopene red colour	**2-5 mg/100 g**
Starch in potato	**6-10%**
Peas	**3-12%**
Sweet potato – pectic substances	**4-7%**

Alcohol insoluble solids:

Potato	**15-17%**

Phenolic compounds:

Potato	**16-24 mg/100g**
Onion	**1-3**
Brinjal	**44-138**
Carrot	**44-86**

Change of colour in fruits is due to

Polyphenol oxidase which is responsible for the change of colour to brown (or) discoloration of the harvested fruits.

In brinjal 2-46 units of protein of Polyphenol oxidase is present In chillies 210-2430 of protein very high.

Ash content:

Carrot	**0.22-0.81%**
Brinjal	**0.38-0.6%**

Brinjal : ***Solanum melongena***

It is a good source Ca, P, Fe, Vit B. It consists of 14-19% protein with very high biological values and digestibility coefficient. However, proteins are very low in lysine, Tryptophan, methionine and isoleusine.

Sugars present in brinjal are glucose, fructose and sucrose. It contains vitamin C ranging from 4-12 mg/100 g. It goes as high as 24 mg/100 g. The pigment of brinjal is anthocyanin – otherwise called as nasunin. It also contains the other pigment, lycoxanthin. The bitter principles present in leaves of brinjal are solasodins which is an alkaloid. The edible portion of fruit contains 11% of pectin. It also contains some phenolic compounds such as chlorogenic and neochlorogenic acid.

Enzymes present are polyphenolases which are capable of oxidizing anthocyanin pigment and others are capable of oxidizing chlorogenic acid present in brinjal.

Potato – Solanum tuberosum

Starch content is as high as 65-80% on dry weight basis. Important sugars present are glucose, fructose and sucrose. The non-starch material polysaccharide of the tuber includes cellulose, hemicellulose and pectic substances – 1.8-3.3% on dry weight basis. Pectic substances contain anhydrogalacturonic acid. It also contains polysaccharides like Ramnose, xylose and galactose. The pectic substance includes cold water soluble and hot water soluble and ammonium citrate and ammonium oxalate soluble fractions.

The N content varies from 1.2-2.0% on dry weight basis of the total N, half is present on the form of protein and the N consist free amino acids, oxides, and nitrogenous bases. The important protein of potato is globulin, then this globulin consists two fractions of protein namely tuberin and another is globulin II. The tuberin constitutes 76% of the total protein and globulin II is 1.4% only. The other proteins such as albumin, glutenin and prolamine amounts about 4%, 5% and 1.8% respectively.

The biological value of potato protein is 68% and this protein has low amount of S containing amino acids but however they are rich in lysine. The enzymes present in potato are Phosphorylases and α and β amylases, phosphatases. The vitamins present in potato are vitamin A and vitamin c in larger amounts but in smaller amounts it also contains riboflavin, thiamine and nicotinic acid. Fat content is very low 0.1% on fresh weight basis organic acids present are citric and maleic acid. Among the phenolic compounds the chlorogenic acid and also the tyrosine are common substances present in potato. Tannins, quinones are present in potato skin and they give the particular colour to the potato skin. e.g.,Kuprijothi – variety. Important alkaloid in potato is solanine → Steroidal Glycoalkaloid. It contains so many fractionsα, β and r solanine and also α, β and r choconine. But all these alkaloids get last during boiling. Volatile

compounds present in potato are amyl alcohol, it also includes, H2S, acetaldehyde, methanol, acetone, ethanol, dim ethyl Sulphides.

Bhendi:

These bhendi fruits are very rich in pectin and mucilage compounds. The fruits are rich in Ca and Fe. It also contains a flavanoid compound. Fruits are rich in vitamin A, C and also contains thiamine and riboflavin to some extent also niacin. The seed cake contains large quantity of protein and used as animal feed. Bhendi flower contains flavanol pigments are Goss pectin and Quercetin. It's rich in fiber content.

Tomato

It is an important vegetable grown in Tamil Nadu, Andhra Pradesh, Karnataka. PKM. is important variety. Colors are due to presence of lycopene. It also contains alkaloid → Tomatine. It will be 130-150 mg/100 g. Tomato is commonly called as poor mans apple

It contains	**H_2O**	**94%**
	Protein	**1%**
	Fiber	**0.6%**
	Fat	**0.3%**
	CHO	**4%**

It has minerals viz., Na – 3 mg, Mg – 11 mg, Cu – 0.1 mg, Cl – 51 mg
K – 268 mg ,S – 11 mg, Mn – 0.19 mg, Ca – 11 mg, Fe – 0.6 mg,
P – 27 mg

Vitamins:

Vitamin A	**1100 (IU)**
Vitamin B	**0.2 mg**
Vitamin C	**23 mg**
Vitamin E	**0.27 mg**

Nicotinic acid	**0.6 mg**

It also contains biotin, maleic acid, citric acid, oxalic acid, sugar content – 1.85 – 4.27%, Acidity – 4.2-10.2 mg/100 ml. Ascorbic acid 21-22.5 mg/100 g. It is also a chief source (or) alternative source for citrus fruits in case of vitamin C. It is commonly used as salad vegetable. Tomato Soup, Ketchup, pickles etc.

Cole crops:

Crops grown in hilly areas and needs cool temperature

Cabbage – Brassica oleracea var. capitata

Chemical compounds: for 100 g of fresh cabbage

Water		**92.1 g/100 g of fresh cabbage.**
Protein		**1.4 g**
Total fat		**2 g**
Total CHO		**5.7 g**
Fiber		**1.5 g**
Vitamin A		**70 IU**
Vitamin B, and B2		**0.04 mg**
Vitamin B6		**0.11 mg**
Vitamin C		**46 mg**
Minerals	**P**	**28 mg**
	Ca	**46 mg**
	K	**227 mg**
	Na	**30 mg**

Cauliflower:

Composition / 100 g of cauliflower

Water	**91.75 g**	**Vitamin A**	**40 IU**
Energy	**31 cal**	**Ascorbic acid**	**70 mg**
Protein	**2.4 g**	**Thiamine**	**0.2 mg**
Ca	**22 mg**	**Riboflavin**	**0.1 mg**

Niacin 0.57 mg

Cauliflower was cut into pieces and dried and stored and used in off seasons.

Radish:

Nutritive value / 100 g of modified roots

Moisture	**94.4%**	**Fiber**	**0.8 g**	**Fe**	**0.4 mg**
Protein	**0.7 g**	**CHO**	**3.48 g**	**Na**	**33 mg**
Fat	**0.1 g**	**Ca**	**50 mg**	**K**	**138 mg**
Minerals	**0.6 g**	**P**	**22 mg**		
Vitamin A	**5.1 IU**	**Oxalic acid**	**9 mg**		
Riboflavin	**0.02 mg**	**Calories**	**17 units**		
Vitamin C	**15 mg**				

Radish leaves: chemical composition

Water	**89.1%**	**Fat**	**0.6%**	**Fe**	**0.8 mg**	**Ca**	**0.31%**
Protein	**3.9%**	**P**	**0.06%**	**CHO**	**4.1%**	**Vitamin A**	**81 IU**
Riboflavin	**2.7 mg**	**Vitamin B**	**21 mg**	**Vitamin E**		**21 mg**	
Nictoinic acid	**2.4 mg**						

Moringa:

Oil extracted from dried moringa seeds will have high lubrication value. Besides the leaf protein it also contains many amino acids. Amino acids are expressed in terms of mg/100 g of N.

Chemical compounds of Moringa (composition/100 g)

Particulars	Drumstick	Leaves
Moisture (%)	87	76
Protein (g)	2.5	7.6
Fat (g)	0.1	0.7
CHO (g)	3.7	12.5

Energy K. cal	**26**	**92**
Ca + Mg (mg)	**30**	**440**
P (mg)	**100**	**70**
Fe (mg)	**5.3**	**7**
Carotene (mg)	**110**	**6780**
Thiamine (mg)	**0.05**	**0.06**
Riboflavin (mg)	**0.07**	**0.05**
Niacin (mg)	**0.2**	**0.8**

Amino acids:

Arginine	**6**	**Leusine**	**9.3**
Hystidine	**2.1**	**Isoleusine**	**6.3**
Glycine	**4.3**	**Valine**	**7.1**
Tryptophan	**1.9**	**Phenylalanine**	**6.4**
Methionine	**2**	**Threonine**	**4.9**

Uses: **Both drumstick and leaves are used for cooking**

Seed oil:

More valuable As lubricant → Watches, Aero plane parts and aromatic industries

Seed: Sedimentation/ coagulating agent. Purification of water (Pollution)

Seed contains following compounds

Moisture	**4**
Oxide protein	**38.4**
Fatty acid	**34.7%**
NFE	**16.4%**
Fiber	**3.5%**
Mineral matter	**3.2%**

Vitamins in vegetables

Vegetable	Vitamin A (IU)	Thiamine	Riboflavin	Nicotinic acid	Vitamin C
Brinjal	124	0.04	0.2	0.04	12
Tomato	320	0.07	0.1	0.4	31
Radish	5	0.06	0.02	0.5	15
Bhendi	88	0.07	0.1	0.6	31
Beans	221	0.08	0.06	0.3	11
Cabbage, cauliflower and carrot	2000	0.1-0.5	0.01-0.1	0.4 – 1.0	1-124
Turnip (greens)	9540	trace	trace	Trace	130

Minerals in vegetables

P – 0.3-0.7%, K = 1-4%, S-0.4%, Ca – 0.5-2%, Mg – 0.1-0.5%, Fe, Mn, Cu, Zn – 50-500 ppm

SPICES AND CONDIMENTS

Commonly used are ginger, turmeric, cardamom, coriander, chillies, pepper, clove, nutmeg, cinnamon, vanilla, cumin seeds.

Pungency is given by alkaloids such as S- compounds called allyltrisulphide – It is present in Onion, Garlic contains – Allyl sulphide

Ginger

It is a modified underground stem. It is commonly used as a spicy material. It contains stain volatile oils, pungent compounds, proteins, cellulose, starch, sugars, minerals and resin compounds.

Starch content varies from 40-60% in a rhizome on dry weight basis. It contains non-volatile pungent oil called as gingerol and this gingerol is obtained by the solvent extraction.

This gingerol is composed of a series of homologous compounds and these are all the condensation products called as gingerone which contains

the straight chain aldehydes. In ginger the aroma and flavour are determined by the presence of volatile oils. The main volatile compound is sesquiterpene hydrocarbon. It also contains the monoterpene hydrocarbons. It also contains the oxygenated monoterpenes. The particular odour of ginger is due to these hydrocarbons. It also contains gingiberene which is commonly present in turmeric.

Colouring pigment in turmeric is curcumin.

Desmethoxy curcumin	**24%**
Bixethoxy curcumin	**15%**

Coriander

It acts as flavour, increasing taste, a medicinal value material; dried and ripe seed of coriander contains most steam volatile oils, protein cellulose, pentasons, tannins, calcium oxalate and also other mineral.

Fiber 23-36%, CHO 20%, Fatty oils 16-28%,

Protein 11-17%.

Among the fatty acids, the saponifiable fractions of fatty acids amounts for 90%, among this, the important acid is oxtadecinoic acid.

The major constituent of spicy oil is coriandrol. It is an optically active form of monoterpene alcohol which is called as linalal.

Pepper

Pepper berries contains the steam volatile oil, fixed fatty oils, alkaloids, resins, proteins, cellulose, pentasons, starch and the minerals.

Maximum oil content of dried pepper is 3.8%, this value will be always more for the black pepper than white pepper. The pungent of black pepper is due to alkaloid called as "Piperin". Piperin content ranges from 4-10%.

The fatty oil presence varies from 2-9%, piperin contains almost 95% of total pungent alkaloid present in the pepper. The aroma and the flavour are due to stem volatile oil which comprises more of monoterpene

hydrocarbons. The pepper contains spicy oil called deoresin. The oleoresin is nothing but a spicy oil containing aromatic and pigments. It contains natural antioxidant which enhances the keeping quality.

Composition of pepper: oleoresin Volatile oil content – 15-25 ml/100g, Refractive index at 20°C – 1.45790 – 14890.

The total N content is around 55%, in the form of piperin.

Uses

It reduces fat accumulation in blood veins.

Chillies

It's used as both vegetable and spices. The chilli fruits contain fixed fatty oil, steam volatile oils, pigments, the pungent principles, resins, proteins, cellulose, pentasons, and the minerals. Chilli fruits contains significant amount of quantity of vitamins B, C, E and A → Carotene, when it is present is fresh vegetable. Vitamin C – 340 mg/100 g is fairly high. Pungency is due to "Capsaicin". The Colouring matter of ripened fruit are due to the presence of "Capsanthin". Then the Zeasanthin, glutenin, cryposanthin, α and β-carotene, the dry chillies also contains xanthophylls, the fixed oil in the chilli fruit varies from 9-20%. Then it will have low volatile oil content which ranges 1-2%.

Comp of spices and condiments (%)

Name	Oleoresin	Vol. acid	Active principle (%)
Pepper	10-12	19-35	Piperin 40-60
Chillies	12-16	-	Capsaicin 1-4
Ginger	15-7	25-38	Gingerol 20-30
Turmeric	6-7	18-25	Curcumin 30-47
Cardamom	-	4-5	-
Cinnamon	-	-	Cinnamic aldehyde
Clove	-	70-90	Eugerol
Cumin	-	2.5-4.5	Cumaldehyde
Fenugreek	-	0.2	Trigonelline, Choline

Coriander	**-**	**0.5-2.0**	**Coriandrinol**
Vanilla	**-**	**1.2-2.5**	**Vanillin**
Onion	**-**	**-**	**Allyl disulphide**
Garlic	**-**	**-**	**Allylsulphide, Allyl trisulphide**

Narcotics and Beverages

Narcotics → Substances that produces drowsiness

Crop – Tobacco

i. Chewing type

ii. Flue red Virginia tobacco.

Plant parts → leaves, stems and roots

Alkaloids present in Nicotine are Nicotine, Nor-Nicotine, Anabasin.

Smoking qualities of Virginia tobacco regimes, following contents

Nicotine 0.5-1.7

Sugar 0.8-0.9

K 3-4%

Cl 0.25-0.29%

The smoking qualities are also assessed by the following ratio of contents

ratio of total N

ratio of Soluble N

ratio of total ash

ratio of water soluble ash

Beverages

2 types

i. Used for chewing: eg. Betel vine, Areca nut, Cocoa

2. Used for drinks: e.g. Tea, Coffee

Betel vine

Oxygenated compounds in betel vine

1. Methyl chevicol 0.81%

2. Terphenol 0.76%

3. Cincole 0.68%

4. Anethole 0.63%

Betel vine → the pleasant aromatic flavour is due to the presence of Terpene compounds. Oil content in leaves varies from 0.11 – 0.15, phenol content in leaf – 2.5-8.4%.

Arecanut

Alkaloids : 1. Arecoline (0.12-0.14%)

2. Arecaidine

3. Arecolidine

4. Guvacine

Cocoa

It has highest fat content: 56-58%. It also contains free fatty acids <1% and some chocolate flavour.

Coffee

Colour – due to presence of chlorogenic acid. Alkaloids → Caffeine, Trigonelline.

Ingredients	Green coffee	Roasted coffee
Moisture	10-12	-
CHO	60	53
Reducing sugar	1	-
Sucrose	7	-
Pectin	2	-
Hemicellulose	15	13

Fiber	**20**	**22**
Oils	**13**	**15**
Protein	**1.2**	**1.2-1.3**
Ash	**4**	**4**
Chlorogenic acid	**7**	**4.5**
Trigonelline	**1**	**1**
Caffeine	**1**	**1.2**

Colour of coffee sometimes changes to bluish green and this is due to the presence of oxidative product of chlorogenic acid. The aroma of coffee is due to the presence of sulphur compounds and also due to pyrazines.

Tea

The tender leaves are used. There are two types of tea, green dust and green powder. The major constituent of tea is

Thiamine → It is glutamyl ethyl amyl.

Tea also contains caffeine → 2.5-4.5%, Tannins – 2.4%

Amino acid – 2.1%. Amadora → Combination of amino acids and sugars in green leaves. Taste of tea flavour is due to presence of catechins.

There are 3 different types of catechins

i. L. epicatechins

ii. L. gallo catechins

iii. Gallyl esters of L. epicatechins.

Flavour of tea is due to presence of pyrazine, furones, pyrroles, 2, 4 hepta dianol.

Composition of different parts of tea plants

1. Bud 4.9% pectin

2. 1st leaf 6% pectin

3. 2nd leaf 4.7% pectin

4. Stalk of plant 7% pectic acid

Nutritional composition

Zinc	**22-63 ppm**
Cu	**22-25 ppm**
Fe	**40-180 ppm**
Pb	**1 ppm**

ESSENTIAL OILS

These are complex mixtures of the odorous and the steam volatile compounds deposited by the plant in the sub cuticular spaces of glandular hairs and also in the cell organelles.

These essential oils are present mainly in spices and medicinal plants.

Compounds of essential oils are Monoterpene and Sesquiterpene

It also contains mixtures of aldehyde, ketones, esters, phenyl terpenes, and camphor and benzene derivatives.

Essential oils are classified as alcohol groups, → e.g. geraniol.

Aldehyde	**e.g. citrol.**
Ethers	**e.g. Anethole**
Hydrocarbons	**e.g. pinine**
Ketones	**e.g. Piperitene**
Phenols	**e.g. Eugenol.**

Advantage

Presence of Essential oils enhances hygienic conditions. It will not allow rancidity. Free from bacteria, and other catalytic enzymes. It do not impart colour to the product and free from tannins. It is stable.

Uses:

Mainly used in the preparation of cosmetics for giving fragrance.

Examples for essential oils

1. Rose oil	**Geraniol**	**68-81%**
	Citronellol	**26-35%**

2. Jasmine oil

Esters of benzyl acetate	**32-74%**
Linalol	**30-45%**
Methyl anthranilate	**0.4-3.5%**
Indole anthranilate	**1.7-2.7%**

Geranium oil :

Oil	**0.15%**	
Geraniol	**56.7%**	**unsaturated terpenols**

($C_{10}H_{18}O_7$)

Lemon grass oil :

Oil	**0.28-0.5%**
Citrol	**85-95% ($F_{10}H_{16}O$)**

Palmrosa oil :

Free geraniol	**80%**
Combined geraniol	**15%**

Export: Geranium, Lemon grass, Palmrosa oil.

Patchouli oil

Oil	**1.3%**

Citronella oil

Eucalyptus oil	**Hilly region**
Cinchona oil	**Nilgiris**

Medicinal and aromatic plants:

Pharmaceutically and economically important

1. Solanum sp:

Solasodine and solanine 2% (prevents diarrhoea)

2. Cassia absus –

Chaksine iodine

3. *Vinca rosea*

Leaf alkaloid:	**Vinblastine**
	Vinceristine
Root alkaloid:	**Ajmalicine**
	Serpentine

Pyrethrum: Chrysanthemum sp.

Flower contains: Pyrethrin I, Pyrethrin II and Pyrethrolone

All are being used as insecticide and biopesticides

Chimona ledge Riana **: Quinine – Antimalarial.**

Datura innoxia **Hyercyanine**

Aloe barbadensis **Aloin compound**

Artemesia annua **Artemisinin, Santonin**

Daisuorea delloides **Tuber**

Daiscorea floribunda **Diogenin, codinine**

Digitalis lanata **Acetyl oligonin**

Glycyrhiza glabra **Gly cirrhizin**

Papaver somniferum **Codinine, morphine – drug called opium → Large, number of alkaloids have been isolated such as norprotein, narceine, papaverine etc.**

Rauvolfia serpentine **Serpentine, Rescinamone, Ajamline**

Onion and garlic also posses medicinal properties they contain lackrymatory factors responsible for tears in eyes.

Allyldisulphide – onion

Allyl sulphide – garlic

CHEMISTRY OF FORAGE CROPS

Chemical compounds and nutritional properties of forage crops

Legume Forages, cereal Forages, Tree Forages, Grasses

Legume Forages: **Lucerne, Berseem, Cowpea**

Cereal Forages: **Sorghum, Maize, Cumbu, Rice, Ragi, wheat**

Grasses: Guinea grasses cumbu Napier, Buffalo grasses, Dinanath, Kolukattai, Hariyali.

Tree Forages: **Agathi, Desmanthus, Subabul, Velimasal**

Composition of forage crops:

Moisture – green Fodder - 70-75%, Dry fodder → 1/10th of its weight, CHO → Nitrogen free extract → Soluble portions of CHO also contains some organic acids, very easily digestible materials, it also has crude fiber, mainly present as cellulose, hemicellulose and lignin (35-75% → Digestible capacity).

Forage protein – 80-90% forms crude protein

Generally, Grass protein is inferior in quality wise to that of legume protein. Forage contains 3-25% crude protein.

CO.2 fodder grass contains crude protein 8.92%, Crude fat 1.76%, Total ash 14.0%, Ca 0.59%, P 0.29%, Mg 0.38%, K 1.86%.

Fats → Energy source and mainly used for maintaining health of animals.

Minerals → Depend upon fertility status of soil in which it is grown. Mainly Ca, Mg, K were required in larger quantity whereas micronutrients such as B, Cu, Fe, Mn, Zinc, Mo, Na, Co, Cl also needed in comparatively lesser amount. Almost all the forage crops contain all these elements.

Growth factors

Enzymes, hormones, vitamin B – complex C, E and K are present in Forage crops and vary in amount.

Toxic substances

Oestrogens, coumarins, saponins, Alkaloids, cyanogenitic glycosides, nitrates, oxalic acids, selenium, mimosine

Nutritional factors

Factors that determine quality aspects of forage crops.

True Digestible Nutrition (TDN)

$$\text{Protein Digestible Nutrition (PDN)} = \frac{\text{Digestible Portion of crude fiber}}{\text{Crude fiber x 2.25}}$$

$$\text{Nutritive ratio (NR)} = \frac{\text{Digestible CHO + Digestible ether extract x 2.25}}{\text{Digestible crude protein}} \quad \text{or}$$

$$NR = \frac{DC + DE \times 2.25}{DCP}$$

Metabolic energy = Heat in the food – Heat last through urine and other materials.

$$\text{Protein quality} = \frac{\text{(\%) digestible crude protein + (\%) digestible true protein}}{2.25}$$

Biological value of proteins → It is the amount of nitrogen in dietand amount of N in excreta of an adult animal are measured and the percentage of N retained by the animal from the quantity of N absorbed from the diet.

Nutrition content for forage crop

Cumbu Napier hybrid grass

Digestibility	**- 50%**
Ca	**- 0.8%**
Fe	**- 250 ppm**
Mn	**- 150 ppm**
Cu	**- 15 ppm**

General composition of green Forage

Sorghum, Cumbu, maize, Ragi, Varagu and Other green grasses.

Crude protein	**– 5.2-10.6%**
Crude Fiber	**– 28-37 %**
Ca	**- 0.9%**
P	**- 0.5%**

Nutritional content in the straw

Crude protein	**- 2-8%**
P	**- 0.5%**
Ca	**- 0.9%**

Crude fiber goes as high as 60%

Nutritional Content in (Silage → preservations of green Forages and some additives such as molasses are added to increase it's nutritive value).

Crude protein	**- 3-8%**
Crude fiber	**- 24-44%**
Ca	**- 0.4%**
P	**- 0.5%**

Nutritional content of leguminous Forage crops

Cowpea, Lucerne, Berseem

Dry matter	**11-20%**
Moisture	**80%**
Crude protein	**12-24%**

Cellulose	**21-33%**
Non digestive protein	**37-57%**
Hemicellulose	**7-21%**
Lignin	**4-10%**
Silica	**1-2% (Induces more resistance in plants)**
Ash	**10-13%**
Soluble CHO	**60-85%**
Crude fiber	**35-75%**

Toxic principles

Oestrogens

These are phenolic compounds which causes infertility in animals.

Coumarins → These are phenolic compounds mainly present in legumes, its presence causes reduction in palatability of forage corps. It causes bleeding in animals, causes anticoagulation.

Saponins → they occurs mainly as glycosides when these undergo hydrolysis, they releases sapogenins. Commonly present in Lucerne and Jowar. Its presence causes excess salivation. Causes vomiting, diarrhoea, damages liver and kidney systems.

Alkaloids → Alkaloid content exceeds 0.5 mg/kg then it will become toxic to animals.

Typtomine in grasses → grazing animals in let loose cases

Perololine – grazing animals

Pyrolizidine → Seen in all livestocks

Cyanogenic glucosides – HCN

Secondary metabolites which release the cyanides, nitrites, isothiocyanates → Mainly present in young sorghum and ratoon sorghum crop. HCN react with haemoglobin in blood to form methanoglobulin which causes reduction in O_2 content.So O_2 content intake is affected causing death.

Alkaloids affect liver, kidneys and lungs.

Nitrate nitrogen will become more toxic in the animal stomach (Rumen) is reduced to nitrite which also interfere with the O2 intake in the blood. It will never become toxic when they exceed 0.3-4% but it creates the accumulators of nitrates.

On hydrolysis of this cyanogenic glycosides they yield to molecules of glycosides, and one each of benzaldehyde and hydrocyanic acid. This hydrocyanic acids gives problems for animals. Hydrocyanic acid present in sorghum is Dhurrin.

Oxalic acid → Calcium oxalate, Na oxalate, K oxalates will interfere with Ca metabolism. When Ca metabolism gets affected, this oxalate gets accumulated in the kidney and also affects brain tissues. Above 3% of concentration it will become toxic to animals. Generally the oxalates are present in grasses.

Xelenine →In Ray little quantity of 4 ppm causes toxicity to animals. Commonly present in Lucerne. Leads to abnormal growth of muscle, in animals. Its toxicity is detoxified in the presence of sulphur compounds.

Mimosine → It is an amino acid present in tree fodder such as Lucerne. When leaf is fed alone in more amount causes 50% toxicity. Problem causes due to its presence is less of hairs, causes excessive salivation, stunted growth, leads to formation of goiter.

Post – harvest changes in Horticultural and Agricultural produces

There are 2 different types of reactions are taking place.

1. Constructive	**2. Destructive**
Synthesis takes place	**Degradation takes place**
Maintenance of mitochondria	**Destruction of chloroplast**
Formation of carotenoid	**Breakdown of chlorophyll**
Anthocyanin – colour	
Inter conversion of sugars	**Stand hydrolysis**
Synthesis of starch → Glucose, fructose and sucrose	
TCA cycle	**Destruction of acid**
Formation of flavour and	**Oxidation of substrate**
Volatile compounds – Taste	
Formation of amino acids	**Solubilization of pectins**
Building blocks of protein	
Formation of ethylene pathway	**Ethylene induces cell wall softening**
Takes place generally before harvest	**takes place after harvest**

Post harvest – General changes

- **Moisture loss**
- **Weight loss**
- **Lesser enzymatic activity**
- **Catabolism – destruction – things gets lost**
- **Alterations in proximate and ultimate constituents**
- **Changes in nutritive values**
- **Changes in texture, taste, flavour, aroma**
- **Changes in pH value**
- **Changes in consumer acceptability**

Moisture

Moisture content should be loss 10-15% when the seeds are stored after harvest, there will be accumulation of metabolites such as ammonium, HCN, essential oil and degradation of acetones.

Loss of amino acid

Decrease in quality, above 40% of harvested products in world is lost through post harvest deteriorates. Tomato, banana, Mango etc. Many of the chemical changes with occur to induce changes in flavour, taste, texture, odour, after harvest. It will not be in the case of grains. So the grins can be stored. In grains moisture content will always be less and also in preserved fruits cereals, seed legumes are stored for a long time when the moisture to at optimum level. But there will be changes taking place at the time of germination. Because these grains are biological products, that's why they germinate and respire. Accumulation of metabolites leads to dormancy in seeds. Dormancy is an crop factor and once when the dormancy to broken, seed will germinate because of decomposition of the seed. Low viability the vigor of seeds is due to the production of volatile compounds such as methanol. With glucose metabolism, we can manipulate the seed deterioration quality.

Post harvest changes in Horticultural crops

3 important processes taking place

1. Transpiration

2. Respiration

3. Ethylene production

Transpiration

It leads to loss of water, 65-95% loss. There's loss in moisture which leads to shrinking, withering of tissues of the plant parts that leads to loss in weight.

Respiration

Broadly classified as climateric and non climateric fruits. Climatric fruits respire more in non-climatric fruits -> less respiration. cli. fruits → Ex. Mango, Papaya, Apple, tomato, banana. Non – climatric fruits → Ex. orange, Grapes, pomegranate (Fruits are allowed to ripe in tree itself).

Respiration is the enzymatic oxidation of sugars leads to the production of CO_2, H_2O and Energy that leads to catabolic activities. Because of this response aroma, taste and lowering of the self – life. In non – climatric fruits, keeping quality will be more.

Ethylene production

Ethylene production leads (or) induced changes in permeability of the mitochondria in the membranes. It will enhance more ATP movement through its permeability. The respiration activity also increased due to production of ethylene compounds.

Three different stages – controlled by enzymatic activities

1. Unriped stage 2. Riped stage 3. Over ripening stage

The ripening is highly influenced by pectin compounds.

Pectin → protopectin unripe –protopectin Pectin Ripe – pectin Pectic Proteins

RNA High Low Low

Synthesis

Ethylene synthesis Low High High

During ripening of fruits starch is converted into glucose, fructose, sucrose. Because of transpiration and respiration, the moisture content gets altered, loss in wt, ultimate change in proximate and ultimate compounds,

reduction in ascorbic acid content total soluble solids gets increased and acidity gets decreased, sweetness gets increased.

CHO + O_2 → CO_2 + H_2O + energy

In the case of immature plants parts there's more TCA cycle activities whereas the case of matured plants parts more of hexose monophosphate pathways is increased. Citric acid, tartaric acid in grapes gets changed to lactic acid and CO2 and biodegration of fruit juice leads to formation of soluble sugars. It gives to lactic acid and converted to acetic acid – citric acid succinic acid.

Lactic acetic citric – succinic acid.

Starch converted to ethanol and acetyl COA.

Glucose → Succinate → Fumerate → Acrylase → Ethylene + CO_2

Because of transpiration and respn there will be some alternately in the flavour, aroma, taste and enzymatic activities. Besides over ripening leads to decrease of nutritive values and finally the consumer acceptability.

Changes due to enzymatic activity especially due to Hydrolases enzymes

1. Carbohydrates → act on CHO, starch and sugar fractions
2. Pectinases – Pectic compounds – mainly involved in ripening of fruits.
3. Proteases 0 Amino acids.
4. Chlorophyllases enzymes chlorophyll – colour changes

Chlorophyll + H_2O chlorophyllases phytol + chlorophytol phytol is due photo chemical oxidations whereas the chlorophyll is due to storage and senescence (process of being old).

Degradation of green colour. Because of degradation leads to change of carotenoids and carotenoids becomes unstable and converted to anthocyanin due to influence of light and O_2 and gives red colour due to lycopene in anthocyanin.

Softening of tissues and textural changes

Its due to enzymes called ethylene methyl esterase, polygalacto uronase, protopectinases.

Flavour production → If once produced the acidity gets decreased and sweetness gets increased. Tannins, phenols, flavonoids gets increased because of flavored products.

Changes in CHO

Starch hydrolysis takes place leading to simple sugars. Such as glucose, fructose and sucrose.

Changes in lipids

Because of rancidity of fats, the lipid changes.

Protein synthesis

Because of protein synthesis, highly influenced by proteases, proteolytic enzymes. Due to this linoleic acid gets decrease and palmitic, linolenic acid gets decreased.

Vitamins

Vitamins content gets decreased; org. acid content also get decrease quality gets decreased.

Changes in pH

It can be prevented.

1. By keeping the produce in refrigerators (or) cold condition.

2. Lowering O_2 decrease and increase CO_2 content in storage

3. By using 2, 4- dinitrophenol

4. By using ethylene inhibitors

5. By using sugar inhibitors such as benzimidozole.

6. Spraying of 0.5% $CaCl_2$.

7. Storing in perforated polythene bags

8. Use of antioxidants (Tocopherol)

POST HARVEST CHANGES IN SUGARCANE

Non-reducing sugar become reducing sugar by inversion. Harvesting at right time reduces the sugar loss. There should not be any delay in harvesting once it attains maturity.

After harvest, it should be immediately transported for the factory for crushing. The juice also should not be kept unused. Age of sugarcane 10-12 months and the juice is processed immediately.

Changes

1. Conversion of sucrose to glucose and fructose – inversion (Invertase acted upon this).

2. Sucrose should be retained for maximum output

3. Reduction in sugar output varies 5% - 150% if the canes are not crushed within 4 day after harvest.

Depending upon situation the reduction even goes as high as upto 50%.

If the harvest is delayed after 9 days of its maturity, loss of sugar will be 37%.

Sugar recovery also reduced by 11% (for opt. and 9 days)

In the case of sugarcane juice, besides inversion, microbial degradation leads to more acidity of juice and more viscosity will be there and the sugar crystal formation is effected and finally the quality gets deteriorated.

Enzymes involved are acid invertase and neutral invertase which are involved in inversion processes. In the case of early maturing cane varieties the sugar gets accumulated it attains maturity and there will be sudden (or)

till drastic reduction because of the soluble active invertase enzymes therefore sugar recovery gets reduced.

The sucrose gets translocated and gets accumulated in the sheath of cane will become index for identifying the maturity stage. If it is not harvested at right time, the change of pH also influences the recovery of sugar etc, it should be prevented.

If you want to avoid sugar loss
Harvest at right time
immediate transport
Crushing at right time
Should be immediately bundled and kept under shade (or) should be sprayed with water do increase the humidity and chemicals such as sodium meta silicate 20-30 moles / l of water.
Topping of sugarcane based on net sugar recovery.
Red rot (or) sett rot of sugarcane will immediately spread if not harvested at right time.
Green and dry leaf ratio also influences the sucrose content reducing sugars will be low at early growing stage but towards the end of growth stage the sucrose content will gel increase and attains peak (or) maximum at right maturity stage and after that the sucrose content gets reduced if not harvested at right time.

There will be decrease in N, P and ash content and increased in K, Ca content with increase in sucrose content at maturity stage.

Post harvest changes in oil seed crops

i. Ground nut, 2. Castor, 3. Sunflower 4. Gingelly, 5. Mustard

The case of oil seed the synthesis of lipids starts at the early mid stage of the seed development. Most of the accumulated starch is the storage protein and the lipids.

In case of groundnut, the crude fat and crude protein content gets increase with the decrease in free fatty acids and free amino acids at the time of maturity. The sugars and the starch content also the activity of hydrolytic enzymes gets decreased at the time of germination of oil seeds. At the time of germination, the favorable environment with water and temperature the seed started germinating and at the time of germination the starch content rapidly gets mobilized and the endosperm becomes completely liquefied. The cell walls of are get dissolved. The cytoplasm and protein deposits also get dissolved in those things are made available for the germinating seed and growing seedling. The elongation of radical and plumule are made.

Chemistry of pesticides

Pesticides

Definition

The comprehensive term "pesticides" relates to compounds used for the control of pests of all descriptions including plant and those directly hazardous to the health of man and animals.

The term pesticide also embraces compounds for the control of rodents, slugs, snails and household and stored product pests.

Pesticides

These are chemicals designed to combat the attack of various pests on agricultural and horticultural crops.

They fall into three major classes

Insecticides

Fungicides

Weedicides (weed killers)

A pesticide is described as a chemical (or) biological agent that eliminates (or0 dissuades the pest life for the benefit of man.

The pesticides are generally classified into various groups based on pest organism against which the compounds are used, their chemical nature, mode of action and mode of entry.

1. Insecticides

Compounds used to control various insects / pests attacking field crops, farm animals, stored products and human being eg. Endosulfan, Malathion, Carbaryl, carbofuran and synthetic pyrethroids.

2. Rodenticide

The chemicals that are exclusively used to control various rats e.g. zinc phosphide, warfarin, thallium sulphate, alpha-naphthol Thoreau and bromodialone.

3. Acaricides

These are chemicals used to control mites feeding on various crops and animals. Some insecticides are found to kill the mites that are said to have acaricidal activity. The term acaricide is applicable to agents capable of killing the eggs of mites also e.g. Dicofol, tetradifon, chlorofenzon, chlorophenoltuon, azinphos (methyl), binapacryl and sulphur.

4. Avicides

These are chemicals used to repel birds like quails, baya, house sparrow, crows, parakeets and pigeons which often become pests of field and orchard crops. eg. TMTD (Tetra methyl thiuram disulfide), Anthraquinone. Most of the insecticides are highly toxic to birds.

5. Molluscicides

These are chemicals used to kill the snails and slugs in agriculture and public health service. Eg. Metaldehyde, Nitrosamide, copper sulphate, pentachlorophenoate and Trifenmorph.

6. Nematicides

These are chemicals used exclusively for the control of nematodes. They are classified as fumigant and non – fumigant nematicides.

The fumigant groups of compounds are injected into the soil mainly as per plan application eg. D.D. (Dichloropropane Dichloropropene), DBCP (Nemagon) (dibromochloropropane), ethylenedibromide.

The non fumigent nematicides are suitable for post planting treatment eg. aldicarb, fensultothion, carbofuran mocap, phorate, thioxazim, disulfoton and Vc 13.

Some organophorous insecticides like parathion, Malathion phosphamidon, diazinon, Dimethoate also possess nematicidal properties. Oxamyl is a nematicide which can be sprayed to control foliar nematodes.

7. Fungicides

The term fungicide means any agent capable of killing fungi.

Chemicals which inhibit, inactivate (or) destroy the ability of fungi to grow and reproduce are referred as fungicides. Fungicides are exclusively used to control plant diseases caused by fungi.

Eg. Copper oxychloride, bordeaun mixture, sulphur, dithiocarbamates like manoczeb, thiram, zineb and propineb, pthalamides like captan, captatol and folpet, organophosphorous compounds like edipheriphos and systemics like carbendazim.

8. Bactericides

These are exclusively used to control the diseases causes by plant pathogenic bacteria. E.g. Streptomycin sulphate and aurecomycin.

9. Herbicides

These chemicals are used to control the weeds and undesirable plants in crop and plantations. These are again classified as pre-emergence and post emergence herbicides, eg. 2, 4-D butachlor, benthiocarb, pendimethalin, atrazine, fluchloralin, anilophos and paraquat.

10. Chemosterilants

Chemicals which deprive insect species of their ability to reproduce are known as chemosterilants.

Such chemicals when administrated orally to the insect (or) by contact with them produce irreversible sterility without affecting their mating behavior.

They are classified into a. alkylating agents.

b. Antimrysboliyrd c. Miscellaneous eg. Tepa, Amithopterin. hempa and hemel. However, they are seldom used in practice due to their hazardous nature.

Pheromones → chemicals with attract the insect and secreted by external entries by an animal (or) insect and produce the specific response in a receiving individual on the particular species mainly for mating synthetic hormones are available for attracting the opposite sex.

Repellants

Chemicals which cause insects to move away from the source are referred as repellants.

Pesticide – Classification

Insecticides	Fungicides	Herbicides
1. Organochlorine	1. Control of diseases	1. Selective
2. Organo phosphorus	2. Seed disinfectants	2 Non-selective
3. Carbonates		
4. Synthetic pyrethroids		

Herbicides are also classified based on methods of use and their effect on plant as follows.

a. Contact herbicides

b. Systematic herbicides

c. Herbicides acting on root system of plants (or) germination seeds.

Fungicides

Suphur compounds Copper compounds Mercurial compounds Others

1. Inorganic

2. Org

1. Inorganic

2. Organic

1. Quinones

2. Organotin

3. Antibiotics

4. Heterocyclic N compounds

Insecticides

Inorganic

1. **Arsenic trioxide**
2. **Arsenic pent oxide**
3. **Arsenate's**
4. **Fluorine insecticides**

Organic

Natural org insecticides

Synthetic org. insecticides

Natural organic I

1. **Nicotine**
2. **Not – nicotine**
3. **Anabasine**
4. **Pyrethrum**
5. **Rotenone**
6. **Allethrin**

Synthetic organ I

1. **Organo chlorine compounds**
2. **Organo phosphorus compounds**
3. **Carbamates**
4. **Synthetic pyrethroids**
5. **Miscellaneous**

Insecticides are classified based on

1. **Mode of entry**
2. **Mode of action**
3. **Chemical nature**

1. Mode of entry

- **a. stomach poison**
- **b. Contact poison**
- **c. Fumigant**
- **d. Systematic poison**

a. Stomach poison

The insecticide applied on the leaves and other part of the plant when infested act in the digestive system of the insect and bring about the kill.

These chemicals penetrate the intestinal membrane and cause deranged metabolism. The stomach poison should be palatable for the pest species and be able so bring about the kill quickly.

Most chlorinated hydrocarbons and organo phosphorus compounds act as stomach poison.

A bacterial toxin of Bacillus thurngiensis belongs to this group.

b. Contact poison

The toxicant which brings about the death of the pest species.

By means of contact with the wan monolayer and getting adsorbed on the surface of the cuticle of the body, and also penetrates into the body through the vulnerable sites viz., membranes, bases of sefae and tracheal system on its body is said to be a contact poison.

All suitable insecticides like chlorinated hydrocarbons, many organophosphates, carbamates and synthetic pyrethroids act as contact insecticides.

c. Fumigant

Most of the fumigants are respiratory poisons and act in gaseous phase. All lands of insects can be controlled irrespective of their feeding habits. Eg. Hydrogen cyanide, aluminium phosphide, EDB and insecticides like DDVP, lindane phorate have got fumigant action. Fumigants enter through the spiracles.

D. Systemic poisons

These chemicals when applied to plant (or) soil are absorbed by foliage (or0 roots are translocated through vascular system into the plant and any insect particularly that sucking form feeding will get poisoned and killed and such forms are called as systematic insecticides. Eg. Methyl elemeton, belimethoate, phosphamidon, phorate, carbofuran and aldicarb.

2. Mode of action

a. Physical poisons

b. Protoplasmic poisons

c. Respiratory poison

d. Nerve poison.

a. Physical poison

Toxicant which brings about the kill insects by exerting a physical effect is a physical poison. Heavy oils, tar oil etc cause the insects particularly scale insects to die of asphyxiation i.e. exclusion of air.

Inert dusts effect a loss of body moisture by lacerating the epicuticle due to their abrasiveness as in aluminum oxide (or) absorb moisture from the body due to their hygroscopic nature as in charcoal.

b. Protoplasmic poison

A toxicant responsible for precipitation of protein especially destruction of cellular protoplasm of midgut epithelium is said to be a protoplasmic poison.

e.g. Heavy metals like Hg, Cu, Fatty acid, Formaldehyde, ethylene oxide, flwrine and arsene compounds.

c. Respiratory poison

A chemical which blocks cellular respirations as with the fumigants hydrogen cyanide, eartron monoxide etc. is said to be a respiratory poison. They inhibit the enzyme activity.

d. Nerve poison

A chemical associated with its solubility in tissue lipid and functions actively by interfering with nervous system like inhibiting acetyl choline esterase, altering impulse transmission and causing death is called as nerve poison.

e.g. Organophosphate, carbomate, Organochlorine (DDT, Lindane), botanicals like pyrethrum, Nicotine, synthetic pyrethroids etc.

3. Chemical nature

a. Inorganics

b. Organics

- i. Hydrocarbon oils
- ii. Animal origin
- iii. Organic compounds of plant origin
- iv. Synthetic org. compounds

1. Ditritrophenol
2. Organothiocyanates
3. Chlorinated hydrocarbons
4. Organophosphorous compounds
5. Carbonates
6. Synthetic pyrethroids
7. Microbial toxicant
8. Nuclear polyhedrosis viruses (NPV)

a. Inorganics

Comprise compounds of mineral origin and elemental sulphur. These are chemicals used during prewar periods.

eg. Arsenic compounds (Lead arsenate, calcium arsenate), Fluorine compounds (Sodium fluoride, sodium fluoaluminate, sodium flusilicate), sulphur, lime, barium carbonate, thallium sulphate and zinc phasphosole. However except sulphur and zinc phosphide others are not in use.

b. Organics

1. Hydro carbon oils

Mineral oils – petroleum oils – coal tar oils fussil fuels. Geosole oil, anthracene, oil in its natural stage itself will become toxic to plants and used as solvents, diluents.

2. Animal origin

Oils from animal beings Ex.: Marine annelids.

Lumbrianerias heteropoda, lumbrianaris braviciara are found to possess insecticidal properties. Insecticide derived from LH and LB are called Nereistoxin. Common name for animal origin P is cartap.

3. Plant origin

Toxicants derived from plants and used for control of insects. Eg. Pyrethrum, rotenone, derris, Nicotine ryania, Acorus, Neem.

4. Synthetic org. compounds

Very commonly and frequently used insecticides to control pests. It has broad subgroups in it (refer front page).

a. These dinitrophenols are derivatives of 4, 6-dinitro 2 alkyl phenols of these salt and esters are used as insecticides. They act as stomach and contact poison also affect the ovicidal effect of eggs. The commonly used dinitrophenols DNOC-Dinitro organic compounds, Dinocap-acaricide (mites),

BINAPACRYL – commonly called morocide. It is not systemic acaricide and controls the spider mites very effectively.

B. Organothiocyanates → These are org compounds possessing iso thiocyanates. They are known to possess insecticidal property very quick knock down effect. The group common one is lord – controls aphids, thrips, red spider mites. Contact insecticide – thanite.

C. Chlorinated hydro carbons → (Other wise called Organochlorine)

They are potent nerve poisons which will have very quick known down effects and very high residual toxicity. It undergoes slow degradation.

Chlorinated hydrocarbons	Organophosphorus
DDT	
BHC	

Chlordane, Aldrin, Dieldrin, Hepta chlor, Toxaphene, Endrin, Endosulfin.

These are phytotoxins to some of cucurbitaceae plants which are highly susceptible. They are very very toxic to fishes.

d. Organophosphorus (OP)

Commonly acts as nerve poison, inhibit choline esterase poisoning due to OP compounds generally causes chloinergic symptoms. In insects it

causes the hyperactivity. Tremors consulsion (fits), paralysis. All these things finally leads to death.

Dichlorous, phosphamidon, Monocrotophos, Dicrotophos, chlorofenvinphos, methyl parathion, fenthion, fentrothion, chloropyriphos, methyl demeton, quinolphos, malation, phasalone, phorate, profenphos.

Carbamates

These carbamates are the esters of carbamic acid, these mainly acts as nerve poison chemicals. it inhibits chloiesterase which inturn causes cc medicated synaptic transmission. Through nerves.

Eg. Carbaryl
Carbofuran
Aldicarp
Oxamyl
Methamyl

Synthetic pyrethroids

These will have very good knock down effects and relatively less toxic to higher org. (or) animals over usage of insecticides is SP develops resistance in insects.

eg. Cypermethrin
Decamethrin
Permethrin
Ethofen pox (trebon)

Microbial toxicants

Bacillus thuringiensis Bacterial toxins, act as stomach poison, causing death, causes gut infection, very effective against lepidopteron insects.

Nuclear polyhedrosis viruses (NPV)

Larva infected by virus is made to mingle with other larva and after the death of this entire larva they are washed in water and sprayed on crops.