

# Physiology of digestion

## Lecture-III

### Intestinal digestion

The semi digested acidic content of stomach, or chyme, are intermittently introduced into the duodenum through the pyloric valve during onward process of digestion. The pancreatic duct and bile duct open into duodenum just very close to pylorus. The high alkaline content of pancreatic and biliary secretions neutralizes the acid content of chyme and changes the material to alkaline side which is necessary for the activity of the enzymes present in the pancreatic and intestinal juice. Important secretions from the small intestine are-

1. The bile
2. Pancreatic juice
3. Intestinal juice or succus entericus

### The bile

Bile is an alkaline and viscous fluid having pH 8-8.6 having yellowish green in colour. The bile is secreted continually by the liver at a rate 0.5 to 1 lit. per day. The gall bladder attached to the hepatic duct acts as a reservoir of the bile. During digestion the gall bladder contracts and supply bile rapidly to the small intestine via common bile duct. The secretions also get mixed with the bile in common biliary duct just before their entry in the duodenum.

### Secretions of bile

Hormonal mechanism is initiated due to contraction of gall bladder and relaxation of its sphincter. Intestine in response to the presence of food specially meat and fats secrete a hormone called Cholecystokinin (CCK). This hormone stimulates the gall bladder to increase the rate of flow of bile into the duodenum.

### Composition and function of bile

The gall bladder bile is more concentrated than the hepatic bile. In the gall bladder water is absorbed and mucous is added.

Constituents of gall bladder bile

Water-constitute 86% of the bile

Mineral salts- Includes Cl, CO<sub>3</sub> and phosphate of Na, K, Ca and NaHCO<sub>3</sub>.

Bile salts- In the human bile there are two types of bile salts are present

- i. Sodium taurocholate
- ii. Sodium glycocholate

These are active in emulsification of fats.

- Emulsification: it is the breakdown of large fat globules into a suspension of fine droplets 1µm in diameter
- Bile salts have ability to lower the surface tension of water.
- The presence of bile in the small intestine is also necessary for the absorption of fat- soluble vitamins A, D, E, K.
- After transit through the small intestine, about 90% of the bile salts are actively absorbed in the ileum and carried to the liver via portal blood. From the liver they are excreted back to the intestine. This process of continued re utilization of bile salt is called “entero-hepatic circulation” of bile salts.

Bile pigments: These are waste products of haemoglobin breakdown of damaged or dead erythrocyte in the liver. Bilirubin and biliverdin are the important bile pigments. They are excreted along with bile.

These bile salts have no functional importance.

Mucous: It acts as buffer and a lubricant.

In addition to the above functions bile also helps as an excretory vehicle for drugs, toxins, various inorganic substances such as copper, zinc and mercury.

It gives colour and deodorizes the faeces

### **Pancreatic juice**

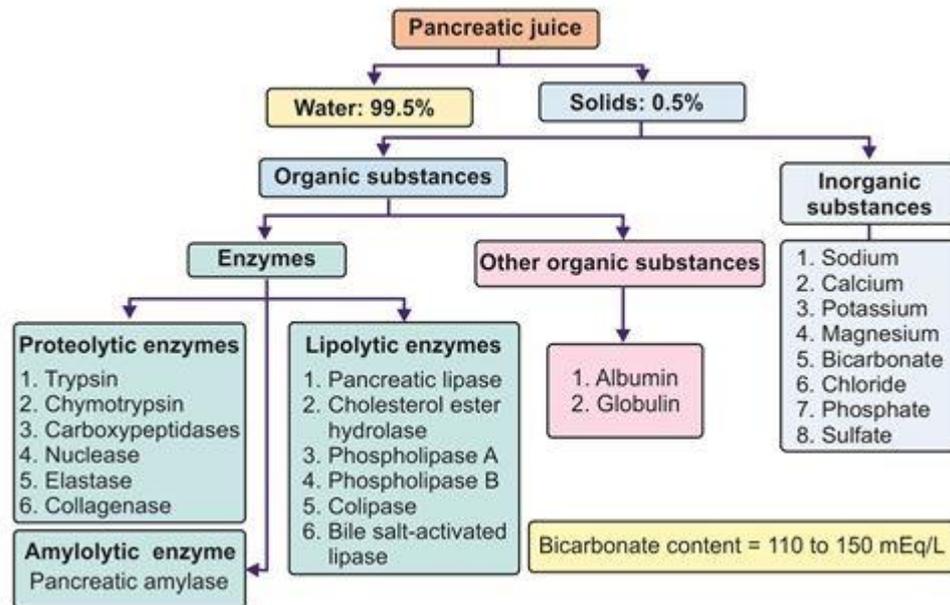
Pancreatic juice is released by means of hormonal stimulation.

As a result of HCl, fats, Proteins, carbohydrate and partially digested food the duodenum and upper jejunum secretes hormones.

The active hormonal component formed by duodenum are

1. Secretin -stimulates the secretion of watery fluid high in carbonate and low in enzymes.
2. Pancreozymin – stimulates the production of viscous fluid low in bicarbonate but rich in enzymes.
3. Both these are secreted by the pancreas.

Composition and function of Pancreatic juice: -



Pancreatic juice enters the duodenum at the hepatopancreatic ampulla. Pancreatic juice is alkaline (pH 8) because it contains significant quantities of bicarbonate ions, which are alkaline in solution.

When acid stomach contents enter the duodenum, they are mixed with pancreatic juice and bile and the pH is raised to between 6 and 8. This is the pH at which the pancreatic enzymes, amylase, and lipase, act most effectively.

**Digestion of proteins.** Trypsinogen and chymotrypsinogen are inactive enzyme precursors activated by enterokinase (enteropeptidase), an enzyme in the microvilli, which converts them into the active proteolytic enzymes trypsin and chymotrypsin. These enzymes convert polypeptides to tripeptides, dipeptides, and amino acids.

**Digestion of carbohydrates.** Pancreatic amylase converts all digestible polysaccharides (starches) not acted upon by salivary amylase to disaccharides.

**Digestion of fats.** Lipase converts fats into fatty acids and glycerol. To aid the action of lipase, bile salts emulsify fats.

### Intestinal juice or succus Entericus

The Intestinal juice is secreted by the specialised glands situated between the villi of the intestinal mucosa. It is alkaline in nature, pH -8.0. This is the digestive juice which completes the digestion of carbohydrate, fats and protein.

Stimulation and Intestinal secretion

On entering the small intestine chyme stimulates the mucous membrane to secrete the hormone enterocrinin

which induces the flow of intestinal juice from intestinal glands.

The intestinal juice consists of:

Water

Mineral salts: Cl, HCO<sub>3</sub>, PO<sub>4</sub> of Na, K, Ca and Mg

Mucous

Enzymes

The important enzymes and their functions are as follows:

1. Enterokinase+Inactive Trypsinogen-----→ trypsin (active)
2. Amino peptidases +Smaller peptides-----→Dipeptides
3. Dipeptidases +Dipeptides -----→ Monopeptides (amino acids)
4. Invertase (Sucrase)+ Sucrose -----→Glucose +Fructose
5. Maltase Maltose -----→ Glucose
6. Lactase +lactose -----→ Glucose + Galactose
7. Lipase + remaining Emulsified fats -----→ Fatty acids and glycerol
8. Phospholipase + Phospholipids-----→ Glycerol, fatty acids
9. Phosphatase + Organic Phosphate -----→ Free Phosphate
10. Polynucleotidase + Nucleic acid -----→ Nucleotides
11. Nucleosidases + Purine or Pyrimidine nucleosides -----→ Purine or Pyrimidine bases+ pentose Phosphate

### The Major Products of Digestion

Finally, as a result of digestion at various level the food constituents are broken down into simple assimilable form- the end products of digestion are

For Carbohydrate---Monosaccharides

Protein ----- Amino acids

Triacyl glycerol ----- Fatty acids and glycerol

**TABLE 20.1. SUMMARY OF CHEMICAL DIGESTION OF FOOD**

<i>Chemical Digestion of Proteins</i>	<i>Chemistry Digestion of Carbohydrates</i>	<i>Chemical Digestion of Fats</i>
<b>PROTEIN FOOD</b>	<b>POLYSACCHARIDES</b>	<b>FAT</b>
↓ ← PEPSIN (Gastric Juice) ↓	← PTYLIN (Saliva) ↓ ← AMYLASE (Pancreatic Juice) ↓	← BILE SALTS (Bile) ↓
↓ PROTEOSES AND PEPTONES ↓	↓ DISACCHARIDES (SUGARS) ↓	↓ EMULSIFIED FATS ↓
↓ TRYPsin AND CHYMOTRYPsin (Pancreatic Juice) ↓	↓ MALTase, LACTase SUCRase (Intestinal Juice) ↓	↓ LIPase (Pancreatic and Intestinal Juice) ↓
↓ TRI-AND DIPEPTIDES ↓		↓ FATTY ACIDS AND GLYCEROL
↓ PEPTIDASES (Intestina! Juice) ↓		
↓ AMINO ACIDS MONOPEPTIDES)	↓ MONOSACCHARIDES (GLUCOSE, FRUCTOSE, GALACTOSE)	