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Review Article

A Critical Appraisal on Digestive System (Avastha Paka) of *Ayurveda* in the Modern Physiological Perspective

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Abstract

In *Ayurveda*, *ahara* (food), *swapna* (sleep) and *brahmacharya* (celibacy) are considered as *tryo-upasthambhas* or sub-supporting pillars of life. Food is critical for the sustenance of life; it is the first of the three, followed by sleep and *brahmacharya*. Foods are any substances containing nutrients, such as carbohydrate, proteins and fats that can be ingested by a living organism and metabolized into energy and bodily tissues. Digestion is the process of breakdown of complex form of food into simplest monomers through enzymatic process in gastrointestinal tract. In *Ayurveda*, conversion of hetrogenous *panchbhautic ahara* (complex food) into its basic homogenous *panchmahabhuta* (simplest monomers) is directed by the synchronization of three sets of *agni; jathragni*, *dhatwagni* and *bhutagni*. The process of digestion, metabolism and assimilation is mainly accomplished by *agni*. The site of *jathragni* is *grahani* or *pakvamashaya* better known as *pittadhara kala*. *Samana vayu*, *Pachaka pitta* and *kledaka kapha* helps in digestion. *Samana vayu* which is present near the vicinity of *agni* stimulate the *pachakagni* for the digestion and separation of food. *Kledaka* kapha is present in the stomach which softens the food materials. *Ayurvedic* classics explains the whole process of digestion that starts with the intake of food, takes place in three stages called as *Avastha paka*, these are *Madhur avastha paka*, *Amla avastha paka* and *katu avastha paka*. Few works have been mentioned on conceptual features of *avastha paka* in relation to modern physiology. In this article correlation of the physiological concept of *avastha paka* with modern medical science has been stated. For this study, the basic materials have been collected from the *Ayurvedic* classics with the available commentaries, as well as Text books of modern medical science better understanding of the concept and its comparison with contemporary science.

Keywords: *Avastha paka, madhur avastha paka, amla avastha paka, katu avastha paka,* digestion.

INTRODUCTION

Ahara (diet) plays an important role in maintaining a good energy level among human beings. The purpose of *Ayurved* science is to maintain the health of the healthy and cure disease of diseased.

In Ayurveda health is a state where dosha, agni, dhatus, waste products, all physiological functions should be in homeostatic state and soul, sense organ and mind should be in a state of total wellbeing [1]

Ahara (diet) plays an important role in maintaining the health of a person, *Acharya charak* has stated that the food taken in right quantity certainly provides strength, complexion, happiness and longevity to the person without disturbing the normalcy [2]. Individual should consume the right quantity of food that helps to maintain proper digestive power. The amount of food consumed depends on the properties of food materials, *gurutava* (heaviness) and *laghutava* (lightness) of food stuff. *Acharya Vagbhata* has mentioned half of the stomach is to be filled with food and one fourth with water. The rest of the stomach is to be left empty for the activity of *doshas* to aid normal physiology of digestion [3]. *Acharya charak* has advised several dietary regimens to remain healthy. It is related to the types and quantity of food to be consumed. One should divide the total capacity of his stomach into three parts – one third portion of the space should be allocated to solid food articles, one third for the liquid food substances and the remaining one third should be left for the movement of *vata, pitta* and *kapha*[4]. *Acharyas* has advised several regimes to keep in mind related to food habit and everyone should follow these basic thumb-rules during dietary intake to maintain health. This doesn't cause any adverse effect

arising out of improper amount of diet. Food taken in right quantity at right time (*kalabhojanam*) is also important. Intake of food in excess quantity (*Atimatrasana)* causes indigestion or *ama* formation whereas intake of food according to power of digestion (*yatha agnya abhyavahara*) promotes digestion (agni *sandhukshnanam*). Intake of food at right time (*kalabhojana*) promotes health (*arogyakaranam*). Intake of heavy food items (*guru bhojana*) causes indigestion or late digestion (*durvipaka*). Intake of food once in *ahoratra* (*ekashanbhojana*) brings about to easy digestion and assimilation (*sukha parinama karanam*). Fasting or abstinence from food (*anashana*) tends to reduces longevity (*ayusho hrasakaranan*). Under eating or intake of food in reduced quantity (*pramitashanam*) tend to reduce a person's weight or causes emaciation (*karshaniyanam*). Intake of meal before the digestion of previous meal (*ajirna adhyashana*) induces the assimilation disorder or causes impairment of *grahani* (*grahani dushana*). Intake of irregular meal (*vishamashana*) causes irregularity in digestive power (*agnivaishamyakaranam*). Intake of food having mutually antagonostic property (*viruddha viryashana*) leads to eight censurable diseases (*nindita vyadhikaranam*). Regular intake of diet having all tastes (*sarvarasa abhyasa*) promotes strength (*balakaranam*). Regular intake of food having only one taste (*eka rasabhyas*) causes weakness (*daurbalyakaranam*) [5]. This consumed foodstuff passes through a sequence of biochemical process in human gastrointestinal tract to make it a usable source of energy is called digestion. This process allows the food to interact with various secretions, enzymes, emulsifying agents, acids or alkaline substances thereby facilitating the breakdown of complex molecules into simpler molecules under optimum pH [6]. Similarly, according to classical literature of *Ayurvedic* science, *Jatharagni* lies in the gastrointestinal tract. It initiates the process of digestion by conversing food into nutrient fluid (*ahara rasa*). In the process of conversion of *ahara* into nutrient fluid, food undergoes three stages of digestion namely; *madhura*, *amla* and *katu awastha paka* and three biological substances *kapha*, *pitta* and *vata* are produced respectively.

The foods that have all the six tastes and of with different properties is consumed, it undergoes the first stage of digestion known as *madhura avastha paka* during which *kapha* is produced which is thin and foamy in nature[7]. *Madhura* means sweet, carbohydrate splitting salivary amylase is the first enzyme to start digestion of carbohydrate in gastrointestinal tract (GIT). The name *madhura* is appropriate for this stage. Salivary juice and mucus secreted from the surface mucus cells and mucus neck cells in the stomach serve many protective functions. Therefore, these may be included under froth like *kapha.*

Afterwards, the food undergo digestion in its partially digested form chyme moving downwards to small intestine from the *amashaya* (stomach) stimulates the production and secretion of various digestive enzymes along with *accha pitta* (bile).

Several proteolytic, lipolytic and amylolytic enzymes are secreted. On functional understanding *pachaka pitta* may be correlated with digestive enzymes [8]. The end products of digestion are formed in the form of peptone, proteoses, fatty acids and glycerol. These are derivatives of alcohol, aldehyde and carboxylic acid. This may be considered as the *amla avastha paka.* It occurs in *pachymanasaya* i.e., proximal part of the small intestine (duodenum and jejunum). When the *pakva* part (the non-absorbable remnant part after the absorption of the nutrients), reaches the *pakvashaya.* There it gets further digested and absorption of water and other nutrients due to the presence of *agni* in that region and the drying effect of *agni* converts it into a solid mass. There also occurs the production of tremendous amount of different types of gases (*vata*) which is *katu* (pungent) in smell called as *katu avastha paka.*

PROCESS OF DIGESTION

The alimentary tract provides a continuous supply of water, electrolytes, vitamins and nutrients. This requires:

- *Prana vayu* helps in ingestion of food into the esophagus and *samana vata* facilitates the peristaltic movement in alimentary tract.
- Secretion of digestive juices and digestion of food can be compared with the action of *samana vayu* and *jathragni. Samana vayu* intensifies the action of *jathragni* and *pachak pitta.*
- Absorption of water, various electrolytes, vitamins and digestive end products which can be compared with the *vivechan* action of *samana vata*[9].
- Circulation of blood through the gastrointestinal organs to carry away the absorbed substances, this process is facilitated by the action of *samana vayu* which takes the nutrient fluid (*Ahara rasa)* to the heart and brought to the systemic circulation by the action of *vyana vayu.*
- The process of excretion of waste product out of the body is felicitated by *apana vayu.*

Avastha-paka

Jatharagni paka, i.e., gastrointestinal digestion of food has been described under *Avasthapaka* or the change in the state or form of food substance in the *Amashaya*, *Pachyamaanaasaya* and *Pakwasaya* in the course of digestive process. Two phases of this *paka*, the *prapaka* and *vipaka* have been envisaged. The term "*Prapaka*" has been defined by the commentator *Chakrapani Dutta* as *Pratham paka* or the first change. The term "*Vipaka*" is defined as the final transformed state of the food that has undergone its interaction with jatharagni. *Prathampaka* is again subjected to further

changes under the influence of *Jatharagni*[10]. This is a process, in which biochemical & physical transformation takes place in three stages of food digestion in gastro-intestinal tract. During the process of digestion, *madhur*, *amla* & *katu* become dominant in different phases of digestion. On this basis, digestion has been classified into three phases i.e. *Madhura avastha paka*, *amla avastha paka and katu avastha paka*[11].

i) Madhura avastha-paka

As soon as the food consisting of various compositions of either *panchbhautic* type, or of four types of food (*peya*, *lehya*, *bhakshya* and *bhojya*) or of two types of *veerya*, or of with various qualities or six *rasas* is taken, *madhur* (sweetness) is manifested during the first stage of *avastha-paka* resulting in the production of thin & frothy *kapha*. This aspect of digestion takes place in *amashaya* is comprehended by *madhur bhava. Madhura awastha paka* is accomplished by the combined action of *kledaka kapha*, *samana vayu*, *agni* and pH of stomach. *Ayurveda* is a science based on the functional understanding of physical, physiological and psychological functions. Based on the functional understanding, it appears that the digestion of carbohydrate type of food starts in the buccal cavity by salivary secretions as the carbohydrates are sugar like substances they are meant for the production of *kapha* in first stage. The presence of food in the oral cavity starts secretion of saliva and mucus. The principal salivary glands are parotid, submandibular and sublingual glands. The parotid glands secrete mainly serous type of secretion, whereas the submandibular and sublingual glands secrete both serous secretion and mucus. Saliva contains α-amylase (ptyalin), water and bicarbonate ions. Saliva has pH 6.0 to 7.0 which is favorable for the digestive action of the ptyalin. The process of digestion especially of carbohydrates starts at oral cavity. Ptyalin does 5% of the carbohydrate digestion during the churning movement till the food swallowed. Saliva present in the mouth does *pachana* and *kledana* of carbohydrate types of food. After this process, *prana vayu* and *samana vayu* helps in the deglutition of chewed food to the stomach (*amashaya)*[12]. Starch digestion continues in the stomach for as long as for one hour before the chewed food mixes with gastric secretions. The chewed food in the stomach has a stimulatory effect on the gastrin cells of the pyloric gland to cause release of gastrin to be transported to the ECL cells of the stomach. The ECL cells than causing release of histamine. The histamine then acts quickly to stimulate the secretion of hydrochloric acid. This stimulation keeps on increasing and causes vigorous mixing of food with acidic secretion and pH of the stomach food content start to decreasing below 4.0. Activity of salivary amylase is then blocked by the acid of gastric secretion [13]. Mixing of food in the stomach with gastric secretions form a semi fluid mixture called chyme. Chyme resembles the formation of *phenbhut (*semi fluid mixtures) production of *kapha*. Nevertheless, on average, 30-40% of the starches will have been hydrolyzed mainly to form maltose until the food and its accompanying saliva mixes completely with the acidic secretions. Carbohydrates are almost totally converted into maltose, sucrose and lactose before passing beyond the duodenum and upper jejunum. These glucose polymers are sweet in nature, so this stage of digestion is called as *madhur avastha pak.*

Amla Avastha-Paka

Major portion of *ahaar* undergo the process of *madhur avastha paka* in the *amasaya* only. After this process, food reaches to *pachmanasaya* in the form of chyme. The complete digestion of remaining food (carbohydrate) occurs in the *pachmansaya* by the action of pancreatic amylase/α-amylase within 15-30 minutes. So, some portion of *madhur awastha paka* also undergo in *pachmanasaya*, though the chief site of *madhur avastha pak* is *amasaya* and partially in *pachmanasya*.

The *Madhur Avasthapaka* is seen to be brought to partial end by the secretion of hydrochloric acid (HCl) by the parietal cells of the stomach. Activity of salivary amylase is blocked by the acid of the gastric secretions, when pH of the medium falls below 4.0. *Acharya Charaka* has stated that during *amla avastha pak*, the food remains in *vidagdha* (partial digested form) form in the *pachmanasaya. Amlabhava develops* due to action of acidic medium of the chyme (pH 2-3) results in sourness. Commencement of *amlabhava* takes place during this phase. Complete digestion of partially digested food occurs during this phase.

Pachak pitta, *agni* is secreted in the form of various pancreatic digestive enzymes, functions collectively at *grahni*. According to *Acharya Charaka*, *grahani* is located above the umbilical region & it is the seat of *agni. Grahani* holds the undigested food on which agni acts and vigorously digest the food and *samana vayu* helps in absorption of *sara bhag* and remaining undigested food is propelled forward by the peristaltic movement [13]. *Acharya Sushruta* has stated that *grahni* is situated between *amashya* & *pakvashya*, also called as *pachyamanashya*. Internally, it is covered with a special type of membrane named as *Pittadhara-kala* & it is the seat of *agni*. Various secretions are secreted from different *ashaya* like pancreas, intestine & liver. I-cells of duodenum and jejunum secrete cholecystokinin which increases pancreatic enzyme secretion to contract gall bladder and relax sphincter of oddi to release bile (*achchha pitta*). *Achchha pitta* plays an important role to bring pH at optimum level so that various enzymatic secretions of small intestine (*agni*) acts on partially digested food. As a result end products like peptone, proteoses, fatty acids and glycerol is formed, thereafter food becomes *vidagdha* & retaining the properties of *amla rasa* so, it called as *amlavastha*. After digestion, the *ahararasa* is absorbed through the *pittadharakala* (mucosal membrane of duodenum and

jejunum) & remaining *apakva* food is expelled into *pakvashaya* with the help of *samana vayu*.

In parlance to the modern physiology, pepsinogen secreted from the peptic cells of the gastric glands of the stomach. It becomes activated to form pepsin after coming in contact with HCL. Pepsin becomes activated around average pH of 2.0-3.0 and inactive at a pH above 5. This activated pepsin cause partial digestion of protein in the stomach to form acidic chyme. Pepsin does only 10-20% of total protein digestion. Most protein digestion occurs in *pachmanasya* (duodenum and jejunum) under the influence of proteolytic enzymes from pancreatic secretions. The acidified chyme enters into the duodenum (*Grahni)* acts as a stimulus to secretion of various digestive enzymes and juices. This stimulus is shown to be responsible for the secretion of bile and pancreatic juices to the duodenum for further digestion of partially digested chyme. It would seem that the *Vidagdha Ahara* (partly digested food) present in the *pachhmanasaya* activates the secretion of *achcha pitta.* The concept of *Accha Pitta* includes the bile and pancreatic secretions which together have been shown to be responsible for digestion of fats, proteins and carbohydrates. In the parlance of modern physiology, the steps involved in digestion of proteins and fats occurs during *amla avastha pak*. In stomach, enzyme pepsin (active at pH 2-3) does only 10-20% of protein digestion. Pepsin converts the protein to proteoses, peptones and a few polypeptides. Most of protein digestion occurs in small intestine under the influence of proteolytic enzymes from pancreatic secretions, viz., chymotrypsin, trypsin, carboxypolypeptidase, elastases. Only a small percentage of protein gets digested all the way to their constituent amino acids. Mostly protein remains as dipeptides and polypeptides. The last stage of protein digestion by peptidases in the enterocytes that lines small intestine leads to formation of amino acids. Finally, most of large polypeptides are digested to dipeptides, tripeptides and single amino acids [15]. Emulsification of fat occurs in the duodenum under the influence of bile. Bile contains large quantity of bile salts as well as the phospholipids which is extremely important for emulsification of fat. Most of the triglycerides of the diet are split by pancreatic lipase into free fatty acids and two monoglycerides [16].

iii) Katu avastha-paka

The third *avasthapka*, digested food materials reaches to *pakvashaya*. Residual products of the food undergo fermentation by the intestinal bacteria. This stimulates the production of *vayu*. When the digested food stuff pass from *pachya-manashaya* to *pakvashaya*, then *shoshymanasya* i.e., being dry up by absorption of water content. Thereafter, the waste products i.e., feces take a bolus form, because of drying effect of Agni. The term *Pari pindita Pakwasya* means bolus from of fecal matter. The term *Vayusyat Katubhavatah* describes the production of odoriferous products and pungent gases[17].

In the parlance of modern physiology, maximum process of digestion and absorption is completed in small intestine. As the contents reach the large intestine, absorption of remaining water and electrolytes get started. The large intestine can absorb maximum of 5-8 liters of fluids and electrolytes per day. Bacterial action occurs in *pakvashaya* (colon). They are capable of digesting small amount of cellulose, in this way providing a few calories of extra nutrition for the body. Other substances formed as a result of bacterial activity are vitamin K, vit B_{12}, thiamine, riboflavin and various gases that contribute to flatus in the colon, specially Carbon dioxide, hydrogen and methane. The odor of fecal matter is due to the presence of odoriferous (*katu bhava)* products include indole, sketole, mercaptans and hydrogen sulphide.

The foregoing modern contribution is seen not only to confirm but also amplify the ancient *Ayurvedic* version of events that take place in the large intestine and the formation of feces with production of pungent *Vayu*. Gases can enter the gastrointestinal tract from three ways: (1) inhaled air, (2) gases formed in the gut by bacterial action, or (3) gases that diffuse from the blood into the gastrointestinal tract. The amount of gases forming in the large intestine everyday averages 7 to 10 liters (*vayusyaat*). Only about 0.6 liter expelled through the anus usually. The remainder is normally absorbed into the blood through the intestinal mucosa and expelled through the lung. In the large intestine, bacterial action generates most of the gases, including especially carbon dioxide, methane, and hydrogen. Some of the food items are known to cause greater expulsion of flatus through the anus than others—beans, cabbage, onion, cauliflower, corn, and vinegar. These foods provide a suitable medium for gas-forming bacteria, especially unabsorbed fermentable types of carbohydrates. For instance, beans contain an indigestible carbohydrate that passes down to the colon and becomes a suitable food for colonic bacteria. Irritation of large intestine causes excess expulsion of gases, which promotes rapid peristaltic expulsion of gases through the anus before they can be absorbed [18].

DISCUSSION

Avasthapaka refers to series of changes which *Ahara dravyas* (food) undergo in the *Kostha* (alimentary tract). *Agni* is the only chemical agency responsible for *Ahara Pachana* (digestion) in the *kostha*. In the first stage of digestion (*Madhura Avasthapaka*), the food in *amashaya* attains *Madhura bhava* by action of salivary amylase on starch, digestion of carbohydrates occur into simpler forms of glucose rendering it fit for absorption. Mixing of food in the stomach with gastric secretions form a semi fluid

mixture called chyme. Chyme resembles the formation of *phenbhut (*semi fluid mixtures) production of *kapha.*

In the second stage (*Amla Avasthapaka*), the *Ahara* is stated to undergo vigorous digestion in *pachhmanasaya*. *Amlabhava develops* due to action of acidic medium of the chyme (pH 2-3) results in sourness. In parallel to modern physiology, vigorously digestion and absorption of partially digested food takes place in the *pachymanasaya.*

In the third phase (*Katu Avasthapaka*), the absorption of water and electrolytes occurs in the large intestine. Usually 5-8 liters of water and electrolytes get absorbed per day from the *pakwasaya*. The term *Pari pindita Pakwasya* means, the bolus from of fecal matter after maximum water absorption. The term *Vayusyat Katubhavatah* describes the production of odoriferous products and pungent gases like carbon dioxide, methane, and hydrogen.

CONCLUSION

Ayurveda science is one of the best gifts of the sages of ancient India to mankind. Food is basic support to life just as oxygen which is essential for life. *Agni* is usually employed for digestion and metabolism of food and rendering if fit for utilization of the body. In *Ayurved* the process of digestion has been classified into three phases i.e. *Madhura avastha paka, amla avastha paka and katu avastha paka.* These stages of *avastha paka* can be compared with contemporary modern physiology. The first stage of *avastha-paka*, digestion of carbohydrate type of food by salivary amylase continues in the *amasaya* till the pH became 4. Mixing of food in the stomach with gastric secretions form a semi fluid mixture called chyme. Chyme resembles the formation of *phenbhut (*semi fluid mixtures) production of *kapha.* During *amla avastha pak*, the food remains in *vidagdha* (partial digested form) form in the *pachmanasaya. Amlabhava develops* due to the secretion of extremely acidic HCL (pH o.8) in the stomach. The acidic chyme enters into the *pachmanasya* (pH 2-3) results in sourness. Commencement of *amlabhava* takes place during this phase. At the same time gall bladder starts to empty *achha pitta* (bile) when the fatty food reaches into the *pachmanasya.* Vigorous digestion and absorption of partially digested food occurs during this phase. The third *avasthapka*, digested food material reaches to *pakvashaya*. Residual products of the food undergo fermentation by the intestinal bacteria. This stimulates the production of about 7-10 liters of gases every day. *Pari pindita Pakwasya* means, the bolus from of fecal matter after maximum water absorption. The term *Vayusyat Katubhavatah* describes the production of odoriferous products and pungent gases. Hence, the concept of *Aaharapaka/avastha paka* in *Ayurvedic sciences* signifies its relevance with modern physiology of digestion and metabolism in the present scenario.

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