SEASONAL VARIATIONS IN THE AMOUNT AND ACIDITY OF GASTRIC JUICE SECRETED IN DOGS AND IN MAN

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As work carried out in the laboratory of K.M. Bykov [1] and V.V. Koval'skii [7] has shown, seasonal variation of physiological and biochemical processes is one of the ancient methods by which the animal adapted itself to changing environmental conditions.

Clinicians frequently encounter the important phenomenon that seasonal variation of physiological functions (and other kinds of biological rhythm) have their counterpart in pathological processes [8, 11].

Seasonal variation of gastric juice secretion in man and in animals has not been sufficiently studied. Reference must be made to T.I. Danilova's investigation [4], where a reduction was found in the amount and acidity of gastric juice secreted by dogs kept in sunlight.

A.F. Glagoleva [3] has pointed out that the digestibility of food in dogs and rabbits was reduced in summer and increased in winter.

A reduction in the amount of gastric juice secreted, and in its acidity, in healthy human subjects in summer, and an increase in winter, has been found by N.E. Kuznetsov [9], and by Risse [18] in experiments on himself. Similar results have been obtained by Richter [19] when investigating the acidity of the gastric juice at different seasons in patients with gastric ulcer.

On account of the small number of observations which have extended over a period of one or two seasons (Danilova, Kuznetsov), and in view of the great theoretical and practical importance of the possibility of finding a correlation between variations in secretion and exacerbations of various gastric conditions, we have made a study of the seasonal variations in the secretion, and the acidity of gastric juice in dogs and in healthy human subjects.

METHOD

For this purpose a group of 10 healthy human subjects was chosen, and observations were made on them over a period of 2 years; experiments on 3 dogs were carried out for periods of 7-31 months.

Measurements were made of gastric secretion in healthy human subjects in the morning, using a fine stomach tube. After introducing the tube into the stomach, the contents were emptied once over a period of 1-3 minutes with the subject first standing, then sitting, then lying. In this way, the total volume of the gastric contents was measured, and then the free and the total acid was measured.

The secretion was studied using Érman's alcoholic test meal. Sixty minutes after the meal, if possible, the whole of the stomach contents were drawn off, the volume measured, and the stomach again emptied at 15-minute intervals for the next 45 minutes. In this way, measurements could be made both on the secretion occurring directly after the meal, and on the subsequent portions.

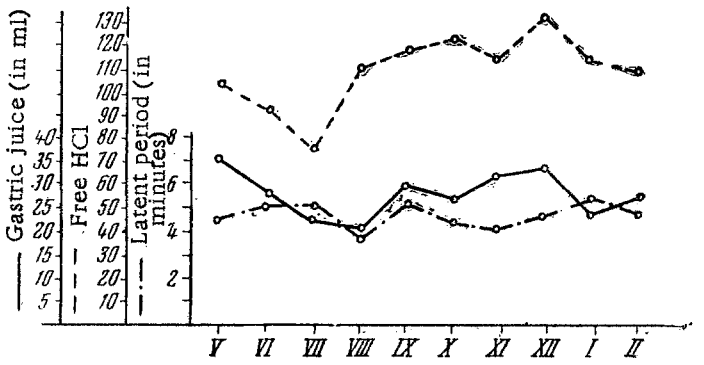

Fig. 3. Variations in the secretion of gastric juice in response to meat in the dog Grey, according to the month.

The digestive power of the juice with respect to meat and to bread was greater in August than in the winter months, and much greater than in the spring months.

It can be seen from Table 3 and from Figure 3 that in this dog there was a variation in the amount of secretion with an increase in spring (May), autumn (November), and winter (December) and a reduction in summer, particularly in August.

In general, the acidity varied in the same way as did the amount secreted, reaching a minimum value in summer (in July) and a maximum level in autumn (in October) and in winter (in December).

The digestive power of the juice increased in summer, particularly in July, November, and December, and decreased in September and in February.

The latent period was shortest in August, and comparatively long in winter (January) and in autumn (September).

Typically, in both human subjects and in dogs, the seasonal variations of secretion were more clearly marked than were the changes in acidity.

These results confirm those obtained by Danilova, Kuznetsov, Risse and Richter.

According to the published findings, seasonal changes in the animal organism are brought about by the effect of both exogenous and endogenous factors.

Without considering the problems of how gastric secretion is influenced by the endocrine glands, whose function is known to change according to the seasons, or of how it may be affected by diet, particularly by the vitamins, we will consider only the effect on secretion of one of the more important of the exogenous factors, the meteorological factor, which varies greatly according to the season and which must necessarily react on the functioning of the organism and of the different organs.

There have been many clinical observations and experimental studies which bear on the problem of the effect of the separate meteorological factors on the emptying and on the secretion of the stomach.

Here we must note the work carried out in I.P. Razenkov's laboratory [14], which demonstrated the inhibitory effect of high environmental temperatures and low barometric pressure on gastric juice secretion in dogs and in man. The effect of temperature was later confirmed by S. Galieva [2] and by S.A. Mogilevskaya [12] in experiments on dogs. Müller and Hölscher [17] also demonstrated the inhibitory effect of both generalized and local heating on gastric juice secretion and on acidity.

Of the clinical studies, attention must be drawn to the investigations of V.I. Predtechenskii [13], I.A. Kassirskii [6], P. Isaev [5], and R.O. Faitel'berg and others [15], who showed that an inhibitory action was exerted on gastric juice secretion in healthy and sick human subjects by general and artificial heating, and by a warm climate. A.A. Kirstner and others [10] found that a similar action was exerted by infrared radiation. Bögendörfer and Sell [16] showed that cooling had a stimulating effect on gastric secretion.

In dogs, the secretion was studied using a Pavlov pouch and natural food stimuli consisting of meat (200 g) and bread (300 g).

The experiment was usually carried out twice in one week: once with meat, and again with bread. The rules worked out in Pavlov's laboratory were observed. The amount of juice secreted was measured at 30-minute intervals over the first 4 hours.

During the whole of the investigation, particular attention was paid to maintaining an unchanged feeding routine and to maintaining the health of the animals. They were kept in separate cages, and both in winter and in summer they were regularly taken for walks out of doors. The daily food ration consisted of 200 g of meat, 350 g of meal, 400 g of bread, and 400 g of vegetables. When no meat was given, the equivalent weight of protein was supplied as milk. During the experiment, the weight of the animals remained within normal limits.

RESULTS

Changes in the amount secreted and in the acidity of the gastric juice both when fasting and after a test meal supplied to healthy human subjects at different times of year are shown in Table 1 (the average values for the amount of secretion are expressed in milliliters, and the acidity is shown in titration units; the secretion in response to the meal is taken over a period of 1 hour 45 minutes).

TABLE 1

Seasonal Variations in the Amount of Secretion and in the Acidity of Gastric Juice in Healthy Human Subjects when Fasting, and after a Test Alcoholic Meal

Season	Fasting		After test meal	
	Secretion (in ml)	Free HCl (in titration units)	Secretion (in ml)	Free HCl (in titration units)
Autumn	33.3	12.4	100.0	41.6
Winter	32.0	6.1	87.5	39.5
Spring	13.5	13.5	83.0	36.7
Summer	23.7	11.1	69.2	30.3

It can be seen from Table 1 that in healthy humans, both after fasting and after a test meal, considerable seasonal variations in secretion and in acidity occur, the amount secreted in autumn being increased, while there is a reduction in winter and in summer, the minimum value being obtained in spring; after a test meal, the maximal secretion is also found in autumn, the value in winter and in spring being reduced.

The acidity (free acid and total acid) was greatest in autumn and spring, and least in winter, while after a test meal the maximum acidity was found in autumn, and the minimum in summer.

In Tables 2 and 3, and in Figs. 1, 2, and 3, the results are given of experiments on secretion in dogs (Storm, Happy and Grey).

It can be seen from Table 2 that in Storm the secretion of gastric juice in response to meat varied considerably over a period of 3 years, and that there was an increase in each autumn and spring, and a reduction in summer. The greatest difference between the autumn maximum and the summer minimum occurred in 1951, and amounted on average to 6.9 ml (42.8%). The difference between the spring increase and summer reduction was somewhat smaller, but occurred constantly every year. The change of secretion in winter was not such a characteristic feature (see Table 2).

In Fig. 1, it can be seen that the autumnal increase in gastric secretion was most frequent in September (1952, 1953) and least frequent in October (1951). In the winter months, the secretion was increased only on one occasion (in February of 1952). In spring, the increase was most often found in May. The reduction of secretion was found every year in August, and then in January 1952 and 1954, and in February 1953, 1954.

TABLE 2

Seasonal Variations in the Secretion of Gastric Juice in Response to Meat in Storm

Season	Amount of gastric juice											
	To meat						To bread					
	Number of experiments	Amount (in ml)	Acidity (in titration units)		Latent period (in minutes)	Digestive power of juice (in mm)	Number of experiments	Amount of juice (in ml)	Acidity (in titration units)		Latent period (in minutes)	Digestive power of juice (in mm)
			Free HCl	Total acid					Free HCl	Total acid		
Summer, August 1951	6	9.2	58	75	4.9	5.6	5	5.9	37	55	7.4	5.5
Autumm, 1951	10	16.1	93	113	5.8	4.2	4	8.6	43	62	7.4	4.3
Winter 1951/52	15	14.8	97	113	6.8	4.2	4	9.5	84	105	6.2	6.5
Spring, 1952	13	14.2	90	112	6.2	4.9	11	11.6	77	98	6.6	4.7
Summer, 1952	11	11.4	99	118	5.5	5.7	4	6.3	69	88	7.5	7.0
Autumn, 1952	9	12.3	84	104	6.7	3.8	4	6.9	65	80	9.6	8.0
Winter, 1952/53	–	–	–	–	–	–	–	–	–	–	–	–
Spring, 1953	9	12.8	93	109	4.5	4.1	3	7.2	99	115	5.0	5.5
Summer, 1953	14	10.8	93	108	4.0	4.7	1	5.5	58	80	4.5	6.0
Autumn, 1953	13	14.9	98	128	5.2	5.5	1	7.3	100	120	5.0	6.0
Winter, 1953/54	10	9.7	78	99	5.5	5.5	2	6.6	65	92	5.5	5.5
Spring, 1954	8	14.3	112	130	5.3	4.7	2	8.2	100	124	4.5	5.9
Summer, July 1954	4	8.5	104	119	4.0	5.0	2	3.0	67	101	6.5	6.1

The acidity of the gastric juice secreted in response to meat showed less typical seasonal variations than did the amount secreted, if we are to judge from the data in Table 2; in Fig. 1, it can be seen that there is an increase in the amount of free HCl, and this occurs in September or November and in May and June of each year, there being a reduction in August, October and in January.

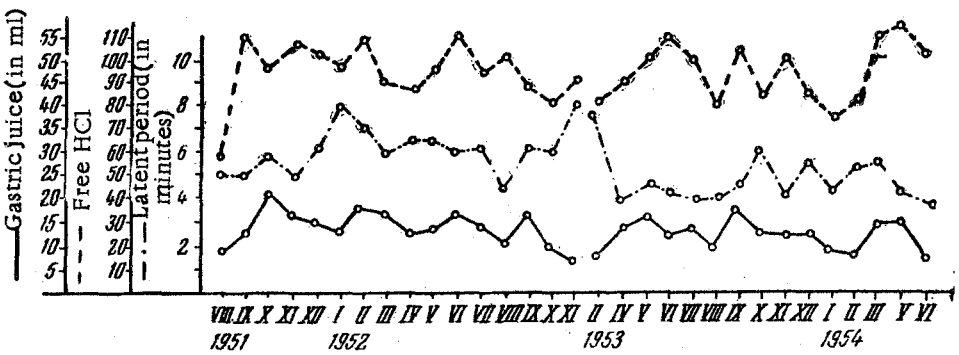

Fig. 1. Changes in the secretion of gastric juice in the dog Storm in response to meat, in the different months.

Usually, the digestive power of the gastric juice increased in summer, and was reduced in autumn and in spring, i.e., the change was in the opposite direction to that of the amount secreted.

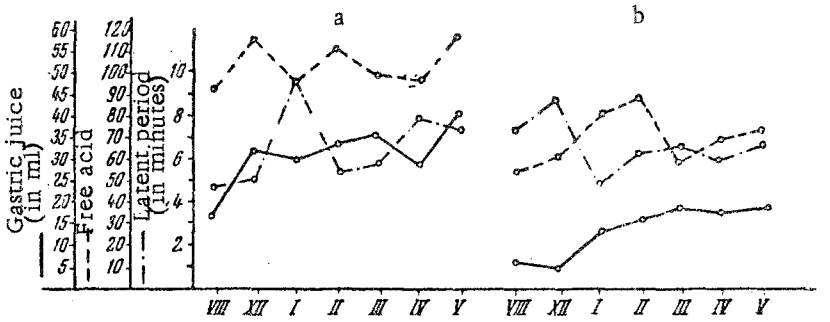

Fig. 2. Changes in the secretion of gastric juice to meat (a) and to bread (b) in Happy, in the different months.

The latent period of the secretion was consistently reduce in summer (in August) and increased in winter, an alteration which indicates a change of excitability of the secretory apparatus at these periods.

Seasonal variations in the secretion to bread were, in general, similar to those found for meat, but with a few exceptions. The amount secreted was maximal in spring and in autumn; a minimum value occurred in summer. The acidity was most frequently increased in winter and depressed in summer. The digestive power increased in summer and in autumn, and was reduced in spring, during the period of maximum secretion. The latent period was extended in summer and in autumn and shortened in spring and in winter.

In Happy, the secretion both to meat and to bread was considerably greater in spring than in winter (Fig.2). A particularly large increase occurred in May. In this dog, the acidity of the juice did not show the typical fluctuations, but nevertheless the greatest increase was found in May and in December, while a reduction occurred in January and in April.

TABLE 3

Variation in the Secretion of Gastric Juice in Grey in Response to Meat in Different Months

Month	Number of experiments	Amount of juice (in ml)	Acidity (in titration units)		Latent period (in minutes)	Digestive power of juice (in mm)
			free acid	total acid		
May 1953	5	35.5	103	126	4.5	4.7
June	6	26.6	92	119	5.0	5.6
July	2	21.7	75	90	5.0	6.8
August	8	20.1	109	133	4.0	5.8
September	4	29.5	118	143	5.2	4.3
October	5	27.2	122	146	4.5	5.2
November	6	32.3	117	153	4.3	6.6
December	5	33.9	129	154	4.6	7.5
January 1954	5	24.7	115	135	5.1	4.8
February	3	26.3	110	130	5.0	4.4

Both the secretion and the acidity of the juice secreted in response to meat during the winter and spring months were considerably greater than in August (almost twice as great in winter, and more than twice as great in spring), while to bread, the increase was even greater (almost three times).

The latent period of the secretion to meat was least in August and greater in winter and Spring (January and April). The latent period of the secretion to bread showed small variations, increasing in August and in December, and being reduced in January.

From this work we may conclude that the meteorological factors, which include increase of the environmental temperature, intensity of solar radiation, and fall in barometric pressure, cause a reduction in the amount and in the acidity of the gastric juice secreated, while cooling causes an increase. One set of meteorological factors are operative in summer and another in winter. In this way it is possible to produce a partial expalanation for the seasonal variations observed in our experiments.

Naturally, the meteorological factors enumerated are not the only ones which might influence secretion, but they are sufficient to affect it.

SUMMARY

Gastric juice secretion has been investigated in 10 healthy persons with empty stomachs and after a test meal for a period of from one to three years. The results of the experiments point to seasonal variations of gastric secretion and to the acidity of the juice, both in healthy persons and in those suffering from various diseases. It increases in autumn and declines in summer. Gastric secretion has also been studied on 3 dogs with the isolated Pavlov pouch. The secretion to the natural stimuli also exhibited the variability of seasonal secretion (with a maximum in autumn and spring and a minimum in summer). Meteorological conditions are important factors with influence seasonal changes in gastric secretion. Sunshine and the temperature of the environment are of major importance.

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