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Specific Features of Pancreas and Blood Enzymes Adaptation to Food Quality in Case of High Air Temperature and Insolation

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A B S T R A C T

The influence of the diet with the increased protein content on the pancreatic enzymes' secretion and ferment homeostasis in case of high air temperature (37°-40°C) and insolation have been studied. The results of investigation showed that the increase of proteolithic activity of pancreatic tissue occurs in experimental rats with a high proteins diet in the conditions of high air temperature and insolation. High proteins diet reduces inhibitory influence of high air temperature and insolation on the secretion of amilaza and lipaza in the pancreas of experimental rats.

Introduction

Extremely high temperature and insolation in our region is considered as one of the most important environmental factors, which can be positive - adaptive in a moderate dose as well as harmful – affecting nerve endings, melanocytes and other skin formations, indirectly causes various structural changes in internal organs if the doses are very high (Doroshko and Bulgak, 2015; Karelin and Davydova, 2016; Ulatik and Timoshenko, 2016).

The present study determined to investigate the effect of a diet with high protein content on the secretion of pancreatic enzymes and ferment homeostasis in case of high temperature and insolation taking into consideration complicated mechanism of both physiological and pathological influence of high temperature and insolation as well as great significance of pancreatic enzymes in food hydrolysis.

Materials and Methods

The influence of a diet with a high content of proteins on the secretion of pancreatic enzymes and ferment homeostasis in case of high temperature (37°-40°C) and insolation has been studied. Experimental animals were exposed to high insolation in the sun area. The influence of a daily single 30-minute (from 12.00 to 12.30 pm) exposure to the sun in summer (July) with a radiation power of 10 watts at 37°-40° Cair temperature has been investigated. Before the experiment all the animals

were fed by general laboratory diet. Then the experimental rats were transferred to a high-protein diet. Daily content of protein (casein) in the diet of experimental animals was calculated as 1% of rats' bodyweight. On the 3-d, 5-th, 7-th, 10-th, 15-th and 20-th day of following a high-protein diet, a group of rats (10 animals) was deadened to study the activity of pancreatic tissue and blood enzymes. The data obtained were compared with the indicators of the control groups that were on the general laboratory diet at the optimal (20°-25°C) and high (37°-40°C) temperature of the environment.

Results and Discussion

The results obtained showed that of rats, the total proteolytic activity of the pancreas at a high air temperature (37°-40°C) in the control groups is approximately three times lower than at the optimal (20°-25°C) temperature of the external environment (Table 1). Literature data on the inhibitory effects of high temperature (Rakhimov, 2016; Romanov, 2014; Shakirova and Abdullaev, 2010) on the secretory activity of the glands of the gastrointestinal tract has been again confirmed by our experiment.

Feeding experimental animals by a high-protein diet had positive effect on the secretion of proteolytic pancreatic enzymes. On the 7th day of the experiment total proteolytic activity in the pancreatic tissue has been increased not only up to the level of control data at the optimal temperature, it became significantly greater than the above-mentioned ones.

On the 10th and 15th days of the experiment, total proteolytic activity of the pancreatic tissue in rats receiving a high-protein diet, increased in 1, 7 and 5 times, respectively, than the results of control groups at optimal temperature. If we compare these data with those of the control group at high temperature, the increase in protease activity in the pancreatic tissue of the experimental groups was much greater (in 4, 7 and 30 times respectively). On the 20th day of the experiment, the activity of proteases in the pancreatic tissue remains high in rats which were fed by a high-protein diet, respectively, in 2.7 and 7 times more than in two control groups. It means that the enrichment of the diet of rats with protein leads to rather distinct adaptive changes in general proteolytic activity of the pancreatic tissue. Thus, we can conclude that the enzyme spectrum of the pancreatic tissue depends on the type of food taken, i.e. adapted to its nutritional composition and aimed at optimizing the hydrolysis of macronutrients in the small intestine.

The amylolytic activity of the tissue and blood of the two control groups (Table 2) also differ. At a high air temperature, the amylase activity of the pancreatic tissue and blood is in 1.6 and 2.3 times lower, respectively, than the control values at the optimal (20°-25°C) temperature. After the transfer of animals to a high-protein diet on the 3rd and 5th days of the experiment, the amylolytic activity of the pancreatic tissue significantly increased than the control indicators at high temperature, but did not reach the control level at a temperature of 20°-25°C. From 7 to 20 days of the experiment, the activity of pancreatic tissue amylase decreased to the level of the initial values.

Quite different results were obtained in experimental animals according to the activity of blood amylase. Beginning from the 5-th up to the 20-th day of the experiment after the transfer of animals to a high-protein diet, the activity of blood amylase significantly increased than the control data at high air temperature. But at the same time, it remained much less than the control data at a temperature of 20°-25°C.

It means that a high-protein diet during the initial 3-5 days increases the secretion of pancreatic amylase in some degree, and during the next days the incretion of this enzyme into the blood was also increased. These results are consistent with the data obtained by Khamrakulov (2017) that, regardless of the accepted food irritant, the incretion of amylase by the digestive glands is increased. Pancreatic hydrolases are delivered into the blood through

several approved mechanisms from the lumen of the small intestine, from destroyed acinocytes, the lumen of the ductal system of the pancreatic gland, and by the incretion of enzymes by pancreatic acinocytes. The quantitative correlation of these transport ways may be different depending on the functional state of the pancreas and small intestine, the permeability of their hystohaematic barriers, degree of pancreatic blood supply.

Relative constancy of the content and activity of hydrolytic enzymes of the digestive glands in the peripheral blood is ensured by the balance of the intake of enzymes into the blood with their inactivation, degradation and excretion from the macroorganism. The term "enzymatic homeostasis" refers to all digestive enzymes. They are continuously released into the bloodstream. However, the portions of this income and, first of all, endosecretion of enzymes, are not constant and depend on a number of factors.

One of the slowly changing factors with great diagnostic significance proved to be "enzymatic potential" of the gland. Total number of acinocytes of the gland, which is producers of its hydrolytic enzymes, should be understood as the enzyme potential of the pancreas. This concept is more appropriate for the characterization of endosecretion of pancreatic enzymes. Table 3 demonstrates the data of the correlation coefficient between the activity of amylase homogenate of pancreatic tissue and blood with a high-protein diet in the conditions of high air temperature and insolation.

Table.1 Total proteolytic activity of the pancreas of experimental rats in case of a high-protein diet in the conditions of high air temperature and insolation (M±m, P<)

Control under the temperature of 20^0-25^0C	$\frac{221.0 \pm 13.3}{100}$
Control under the temperature of 37^0-40^0C	$\frac{78.9 \pm 4.8(0.001)}{36 \pm 2.1(0.001)}$
3-d day	$\frac{82.9 \pm 3.1(0.001)}{37 \pm 1.4(0.001)}$
5-th day	$\frac{80.1 \pm 2.5(0.01)}{36 \pm 1.7(0.001)}$
7-th day	$\frac{252.9 \pm 14.8(0.1)*}{114 \pm 6.1(0.05)*}$
10-th day	$\frac{373 \pm 5.7(0.001)*}{169 \pm 6.4(0.001)*}$
15-th day	$\frac{1108.9 \pm 24.9(0.001)*}{501 \pm 8.6(0.001)*}$
20-th day	$\frac{557.9 \pm 18.7(0.001)*}{252 \pm 8.4(0.001)*}$

Notes:

- numerator, enzyme activity;
- denominator, as a percentage to the control indicator at a temperature of 20^0 - 25^0C.

* - the reliability of the difference from the control at a temperature of 37^0-40^0C

Table.2 Amylolytic activity of the homogenate of the pancreas and blood in experimental ratswith a high-protein diet in conditions of high air temperature and insolation (M±m, P<)

	Pancreatic homogenate	**Blood**
Control under the temperature of 20^0-25^0C	1427.0 ± 64.6 / 100	529.0 ± 14.0 / 100
Control under the temperature of 37^0-40^0C	887.4 ± 16.4(0.001) / 62 ± 1.1(0.001)	232.8 ± 3.9(0.001) / 44 ± 0.9(0.001)
3-d day	1084.6 ± 27.6(0.001)* / 76 ± 1.9(0.001)*	248.7 ± 8.6(0.001) / 47 ± 1.2(0.001)
5-th day	1034.2 ± 18.1(0.001)* / 72 ± 1.2(0.001)*	341.3 ± 2(0.001)* / 64.5 ± 1.2(0.001)*
7-th day	886 ± 27.3(0.001) / 61 ± 1.9(0.001)	405.4 ± 3.3(0.001)* / 76 ± 3.3(0.001)*
10-th day	841.8 ± 22.6(0.001) / 59 ± 1.6(0.001)	335.5 ± 3.3(0.001)* / 63 ± 1.6(0.001)*
15-th day	843.6 ± 13.5(0.001) / 59 ± 1.3(0.001)	334.4 ± 3.3(0.001)* / 63 ± 1.4(0.001)*
20-th day	844.2 ± 17.2(0.001) / 59 ± 1.4(0.001)	315 ± 1.1(0.001)* / 59.5 ± 1.6(0.001)*

Notes:
- numerator, enzyme activity;
- denominator, as a percentage to the control indicator at a temperature of 20^0 - 25^0C.
* - the reliability of the difference from the control at a temperature of 37^0-40^0C

Table.3 Correlation coefficient between the amylolytic activity of the pancreatic homogenate and blood in experimental rats with a high-protein diet in the conditions of high air temperature and insolation (r±mr)

Control under the temperature of 37^0-40^0C	**0.91±0.18**
3-d day	0.26±0.07
5-th day	0.45±0.10
7-th day	0.35±0.12
10-th day	0.54±0.13
15-th day	0.41±0.17
20-th day	0.40±0.16

Correlation coefficient is positive and high in the control group of animals. After the transfer of animals to a high-protein diet, this indicator decreases in some degree, but always remains positive. It proves the fact that there is a direct relationship between the activity of amylase in the blood and the level of secretion of this enzyme by pancreatic acinocytes. This correlation is confirmed by the phenomenon that, in case of equal conditions, the more hydrolases enter the bloodstream, the greater of acinocytes will be produced. Approximately similar results of the lipolytic

activity of pancreatic tissue and blood have been obtained in case of high-protein diet in the conditions of high air temperature and insolation (table 4).

This table demonstrates that in case of high air temperature, the activity of lipase in the pancreatic tissue and especially in the blood decreases. Lipolytic activity is 30% less in the gland tissue in a high air temperature in comparison with the optimal temperature (20°-25°C). Lipolytic activity in the blood is much more (70%) reduced in a high air temperature.

After the transfer of experimental animals to high-protein nutrition on the 7th and 10th days of the experiment, the lipolytic activity of the pancreatic tissue increases. It rises up to control data in case of optimal temperature (20°-25°C). It remains at the level of the initial values during the last days of the experiment

Table.4 Lipolytic activity of pancreatic homogenate and blood in experimental rats with a high-protein diet in the conditions of high air temperature and insolation (M±m, P<)

	Pancreatic homogenate	**Blood**
Control under the temperature of 20°-25°C	$\frac{65.4 \pm 3.1}{100}$	$\frac{15.1 \pm 0.2}{100}$
Control under the temperature of 37°-40°C	$\frac{46.7 \pm 4.1(0.01)}{71 \pm 4.7(0.001)}$	$\frac{4.4 \pm 0.1(0.001)}{29 \pm 0.4(0.001)}$
3-d day	$\frac{45.6 \pm 1.2(0.01)}{70 \pm 4.3(0.001)}$	$\frac{7.3 \pm 0.4(0.001)*}{49 \pm 0.5(0.001)*}$
5-th day	$\frac{51.6 \pm 2.9(0.01)}{79 \pm 4.3(0.01)}$	$\frac{7.7 \pm 0.4(0.001)*}{51 \pm 0.4(0.001)*}$
7-th day	$\frac{68.9 \pm 6.8(0.1)*}{105 \pm 4.1(0.1)*}$	$\frac{6.3 \pm 0.3(0.001)*}{42 \pm 0.4(0.001)*}$
10-th day	$\frac{67.2 \pm 1.8(0.1)*}{103 \pm 3.7(0.1)*}$	$\frac{7.6 \pm 0.5(0.001)*}{50 \pm 0.4(0.001)*}$
15-th day	$\frac{46.3 \pm 3.4(0.01)}{71.4 \pm 3.7(0.001)}$	$\frac{5.5 \pm 0.1(0.001)*}{36 \pm 0.4(0.001)*}$
20-th day	$\frac{49.7 \pm 1.4(0.01)}{76 \pm 3.6(0.001)}$	$\frac{5.0 \pm 0.3(0.001)}{33 \pm 0.6(0.001)*}$

Note:

- numerator, enzyme activity;

- denominator, as a percentage to the control indicator at a temperature of 20° - 25°C.

* - the reliability of the difference from the control at a temperature of 37° -40°C

Table.5 The content of total protein in homogenate of the pancreas and blood in experimental rats with a high-protein diet in the conditions of high air temperature and insolation (M±m, P<)

	Pancreatic homogenate	**Blood**
Control under the temperature of 20°-25°C	$\frac{4.4 \pm 0.8}{100}$	$\frac{67.3 \pm 4.3}{100}$
Control under the temperature of 37°-40°C	$\frac{1.2 \pm 0.05(0.01)}{27 \pm 1.0(0.001)}$	$\frac{57.4 \pm 2.0(0.1)}{85 \pm 3.1(0.001)}$
3-d day	$\frac{2.5 \pm 0.06(0.05)*}{57 \pm 1.6(0.001)*}$	$\frac{62.7 \pm 2.0(0.1)}{92 \pm 3.0(0.05)}$
5-th day	$\frac{1.7 \pm 0.04(0.01)*}{39 \pm 1.8(0.001)*}$	$\frac{54.4 \pm 0.7(0.05)}{81 \pm 2.0(0.001)}$
7-th day	$\frac{1.7 \pm 0.05(0.01)*}{39 \pm 2.0(0.001)*}$	$\frac{61.0 \pm 2.5(0.1)}{91 \pm 3.0(0.05)}$
10-th day	$\frac{2.3 \pm 0.1(0.05)}{52 \pm 2.0(0.001)}$	$\frac{62.0 \pm 1.7(0.1)}{92 \pm 3(0.05)}$
15-th day	$\frac{2.1 \pm 0.07(0.05)*}{48 \pm 2.6(0.001)*}$	$\frac{68.3 \pm 0.9(0.1)*}{101 \pm 3(0.1)*}$
20-th day	$\frac{1.6 \pm 0.04(0.01)*}{36 \pm 1.0(0.001)*}$	$\frac{59.1 \pm 2.3(0.1)}{88 \pm 3.1(0.01)}$

Note:

- numerator, enzyme activity;

- denominator, as a percentage to the control indicator at a temperature of 20° - 25°C.

* - the reliability of the difference from the control at a temperature of 37°-40°C

If we consider the increased secretion of proteases in animals with high-protein diet as the result of adaptive reactions of the pancreas to food quality, then the increased secretion of other enzymes (amylase and lipase) proved to be the result of metabolic component of the postprandial reaction of the specific and dynamic action of protein nutrients. Perhaps, hormonal changes in animal's body after injection of food result in a transformation not only in the composition and properties of the blood as a manifestation of the specific dynamic action of food, but also change the functioning of the digestive glands.

The content of total protein in pancreatic tissue at high temperature is approximately 3 times less than in the control group at a temperature of 20^0 - 25^0C (table 5). This is most likely the result of inhibition of the secretory process in the pancreas, especially the secretion of enzymes.

The transfer of animals to a high-protein diet increased the content of total protein in the pancreatic tissue into1.5-2 times than the control values at a temperature 37^0-40^0C. At a high temperature, there is an insignificant decrease in the content of total protein in the blood (table 6).

This indicator, due to the high variability, is reliable only in percentage terms. In the blood, the portion of enzymes is less than that of its own proteins, so the decrease in enzyme proteins at high air temperature did not change significantly the content of total protein in the blood.

The high-protein diet increased the content of total protein up to the control level only on the 15th day of the experiment; in the remaining period of observation, its content in the blood remained unchanged.

Summing up the discussion, we can come to the following conclusions:

The increase in the proteolytic activity of the pancreatic tissue occurs in rats with a high-protein diet in case of high air temperature and insolation.

A high-protein diet reduces insignificantly the inhibitory effect of high air temperature and insolation on the secretion of amylase and lipase of the pancreas.

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