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TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY

BIOMEDICAL AND BEHAVIORAL SCIENCES

(FOUO 1/79)

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CONTENTS PAGE

AEROSPACE MEDICINE

UDC: 612.8.015.348.014.477

EFFECT OF ARTIFICIAL GRAVITY DURING SPACE FLIGHT ON WATER-SOLUBLE PROTEIN CONTENT OF NERVE TISSUE STRUCTURES

Moscow BYULLETEN' EKSPERIMENTAL'NOY BIOLOGII I MEDITSINY in Russian
No 10, 1978 pp 421-423

[Article by A. V. Gorbunova and V. V. Portugalov (corresponding member of the USSR Academy of Medical Sciences), Institute of Biomedical Problems, USSR Ministry of Health, Moscow, submitted 27 Mar 78]

[Text] A study was made of water-soluble protein levels in gray and white matter of the spinal cord, intervertebral ganglia, as well as sensorimotor region of the rat cerebral cortex after an 18.5-day space flight. There was a reliable decrease in water-soluble proteins 4.5-9.5 h after the flight in the gray and white matter of the spinal cord and intervertebral ganglia of rats exposed to weightlessness. Rats exposed to artificial gravity in flight presented a decline of water-soluble protein levels in the spinal cord white matter. In animals previously exposed to weightlessness, there was reliable elevation of water-soluble protein level in the gray matter of the spinal cord 25 days after the space flight. No changes were demonstrable (as compared to the vivarium control), either 4.5-9.5 h or 25 days after the biosatellite landed, in the gray matter of the sensorimotor region of the cerebral cortex of rats exposed to weightlessness and artificial gravity (BYULL. EKSPER. BIOL., No 10, 1978, p 421).

Key words: water-soluble proteins; rat cerebral cortex; spinal cord; intervertebral ganglia; space flight; weightlessness.

Previously [1], it was established that there is a decrease in water-soluble proteins of rat spinal cord gray and white matter after a 19.5-day space flight aboard the Kosmos-782 biosatellite. However, it remained unclear whether these changes were the direct effect of weightlessness.

It was deemed important to analyze material (functionally and histologically of various structures of the spinal cord at the level of the lumbar intumescence--gray matter of anterior, posterior and lateral cornua, where

there is predominant grouping of neurons, and white matter constituting the ascending and descending conduction pathways, intervertebral ganglia, as well as sensorimotor region of the rat cerebral cortex) taken after the landing of Kosmos-936 biosatellite, aboard which the animals were submitted to artificial gravity produced by rotation on a centrifuge, in addition to space flight factors. A continuous acceleration of 1.0 G was produced on the centrifuge (34 cm radius). The objective of this experiment was to differentiate between changes attributed to weightlessness and effects of other flight factors.

Methods

We removed for examination the spinal cord at the level of the lumbar intumescence, adjacent intervertebral ganglia and specimens of gray matter tissue of the sensorimotor region of the cerebral cortex from flight rats exposed to weightlessness and artificial gravity, 4.5-9.5 h and 25 days after an 18.5-day orbital space flight. The spinal cord was separated at 0-4°C into white and gray matter using an MBS-2 microscope to monitor this procedure. Batches of tissue were placed into special polyethylene centrifuge tubes for homogenization. Each batch of nerve tissue was homogenized in a 10-fold volume of distilled water at 0-4°C. Water-soluble proteins were extracted for 2 h at 4°C. The extracts were centrifuged at 15,000 G (60 min, 0-4°C). Protein content of the supernatant was assayed by the method of Lowry [3]. The results were submitted to statistical processing according to the nonparametric criterion of Van der Verden [2]. Rats kept in the vivarium and used in a ground-based model experiment served as a control. In addition, we included two groups of animals in ground-based control experiments. One group was rotated throughout the experimental period on a centrifuge (34 cm radius) at an acceleration of 1.4 G, and the other group, on a centrifuge with the least possible radius ("radius-free centrifuge"), which enabled us to assess the significance of the rotation factor (1.1 G acceleration).

Results

The results of our studies are listed in the Table, which shows that there was a reliable decrease in water-soluble proteins (converted to 1 mg wet tissue weight) 4.5-9.5 h after an 18.5-day space flight, as well as 9-11 h after a 19.5-day space flight [1], in the white and gray matter of the spinal cord and intervertebral ganglia of rats exposed to weightlessness. The levels of water-soluble proteins in the spinal cord gray matter and intervertebral ganglia of rats exposed to artificial gravity during the experiment did not differ from the control (control rats maintained under vivarium conditions and in the ground-based model experiment), whereas the levels were reliably lower in white matter, as compared to vivarium rats, but did not differ from the concentration of water-soluble proteins in the spinal cord white matter of rats involved in the ground-based experiment.

Levels (μg/mg wet tissue) water-soluble proteins in nerve tissue structures

Object	A	Weightlessness										Artificial gravity									
		B	X_1	C	X_1	X_2	D	X_1	E	X_1	X_2	B	X_1	C	X_1	X_2	E	X_1	F	X_1	G	X_1
Spinal cord gray matter	37	36	0.62	30*	3.32	2.56	35	0.16	42*	2.11	2.56	33	2.10	33	2.10	0.36	34	1.87	35	1.09	34	0
Spinal cord white matter	27	26	0.90	18*	3.32	3.32	26	0.57	29	2.38	1.46	23	0.8	19*	3.32	1.99	22*	3.32	24	1.41	21*	2.56
Interverteb-ral ganglia	40	44	2.11	29*	2.56	2.86	43	0.33	43	1.99	0.91	36	2.38	36	0.61	0.36	35	1.41	33	2.14	36	0.91
Cortex, gray matter	45	37*	3.34*	43	1.06	2.86	42	1.07	42	0.34	1.82	36	2.56	46	1.50	2.28	40	0.78	39	2.14	44	1.7
Number of animals	10	4	—	5	—	—	4	—	4	—	—	5	—	5	—	—	5	—	5	—	4	—
X_0	—	—	2.38	—	2.72	2.38	—	2.38	—	2.38	2.38	—	2.72	—	2.72	2.72	—	2.72	—	2.72	—	2.38

Key: A) vivarium animals (control)
B) ground-based experiment (control)
C) 5-9 h after flight
D) 25 days after ground-based experiment (control)
E) 25 days after flight
F) rotation on "radius-free centrifuge" (control)
G) 25 days after rotation on "radius-free centrifuge"

X_1, X_2, X_0) arbitrary units (X_1--referable to vivarium control; X_2--referable to ground-based experiment; X_0--tabular values), calculated and tabular values, respectively at significance level of 5% (reliable differences with $X_{1,2} > X_0$)

*Values are reliably different from the control ($X_{1,3} > X_0$)

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Twenty-five days after the space flight, animals previously exposed to weightlessness presented a reliable increase in water-soluble proteins of spinal cord gray matter, as compared to the control. In the white matter of the spinal cord and intervertebral ganglia, the water-soluble protein levels rose to the control value. In rats exposed to artificial gravity during the flight, there was no difference after 25 days in levels of water-soluble proteins of gray and white matter of the spinal cord and intervertebral ganglia, as compared to the control.

No changes (as compared to the vivarium control) in levels of water-soluble proteins, both 4.5-9.5 h and 25 days after the satellite landed, were demonstrated in the gray matter of the sensorimotor cortex of rats exposed to weightlessness and artificial gravity (see Table).

The findings demonstrated, once more, that long-term space flights lead to a decrease in water-soluble proteins of gray and white matter of the spinal cord and intervertebral ganglia of rats. Since such changes were not observed in animals exposed to artificial gravity, it can be concluded that the observed decline of water-soluble protein levels in the structures examined is apparently the result of the effects of weightlessness. One of the factors involved in these changes, in the peripheral (afferent and efferent) elements of the motor analyzer, is perhaps a decrease in informative flow of interoproprioceptive impulses from skeletal muscles and skeletal bones, which is due to a functional underload and relaxation of antigravity muscles. These changes can be evaluated as an adaptation to new living conditions in weightlessness, related to removal of the static load on the musculoskeletal system. The lack of changes in water-soluble protein content of the gray matter of the sensorimotor cortex warrants the belief that adaptation occurs primarily on the level of the spinal reflex arc. This hypothesis appears plausible, since it is known that antigravity muscles are linked with spinal reflex mechanisms primarily via the myotatic bineuronal reflex arc [4].

Readaptation to ground conditions in animals exposed to weightlessness was manifested 25 days after the space flight by an increase in water-soluble protein content of the spinal cord gray substance. The level of water-soluble proteins in the spinal cord white substance and intervertebral ganglia reached control values. Probably, this hypercompensation was functionally necessary, since it was a response to the increase in the functional load, related to the change from weightlessness to earth's gravity. The presence of artificial gravity on the biosatellite most probably did not require readaptation of animals to ground conditions. One would think that this can explain the lack of changes in animals exposed to artificial gravity during the flight, with regard to levels of water-soluble proteins in the gray matter of the spinal cord and intervertebral ganglia, both in the early postflight hours and after 25 days. Perhaps, in our experiments, the effect of artificial gravity on the animals was not totally equivalent to the effect of earth's gravity, since we observed a decrease in water-soluble protein content of spinal cord white substance in animals exposed

to artificial gravity during the flight. It may be assumed that there is a change in metabolite transport, slowing thereof, in the system of neural conductors of the spinal cord during the flight.

Thus, the results of our studies revealed that the decrease in levels of water-soluble proteins in gray and white substance of the spinal cord and intervertebral ganglia of rats that were weightless during the space flight, demonstrable a few hours after conclusion thereof, is apparently related to removal of the static load from the skeletomuscular system.

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PHYSIOLOGY

BEKHTEREVA DISCUSSES ARTIFICIAL INFLUENCING OF HUMAN MIND

Moscow NAUCHNO-TEKHNICHESKAYA REVOLYUTSIYA I CHELOVEK in Russian 1977 signed to press 8 Aug 77 pp 162-171

[Article by N.P. Bekhtereva from the book "Nauchno-tekhnicheskaya Revolyutsiya i Chelovek" edited by V. G. Afanas'yev, Institute of Sociological Research, USSR Academy of Sciences, Izdatel'stvo "Nauka"; "Possibilities and Limits of Artificial Influence on the Human Mind"]

[Text] Scientific and technical progress is one of those realities which has acquired a vast influence on the conditions of man's existence and the fate of humanity in our time.

The benefit of progress is obvious, however history knows many cases when the direct consequences of scientific and technical advances had a direct or indirect unfavorable effect on man. Of course, not one of the dangers of the progress of science is contained in the knowledge itself, or is an inherent attribute of this progress. The danger is always the result of unskillful or hostile utilization of knowledge and the potentials created by science and technology. The potential and realized results of the scientific and technical revolution should always be regarded from these positions. The results and prospects of the study of man's brain should also be analyzed from these same positions.

The prerequisites for the new stage in understanding the mechanisms of the human brain were the clinical applications of the increasingly perfected pharmacological means and especially the method of implanted electrodes.

The method of implanted electrodes entered clinical practice at the end of the 40's and determined its place among therapeutic-diagnostic methods in the 60's. The prehistory of its clinical use was almost 100 years of use of implanted electrodes in experiments with animals. This method is being used now for diagnosis and treatment of patients with epilepsy, Parkinson's disease, certain mental and other diseases in different countries of the world. It is used in a number of scientific institutions in our country for treatment of Parkinson's disease and epilepsy.

Now data hase been accumulated of the type on which it is possible to base a scientifically founded expansion of the treatment of different types of neurological diseases, and also emotional-mental disturbances. Very much in need of this are espscially those patients for whom pharmacological treatment of their diseases is ineffective or proves to be attainable with very large doses of the preparation, yielding often a serious and difficult-to-remove side effect.

Long-term studies of the structural-functional and neurophysiological organization of cerebral control of the emotions, performed in the Institute of Experimental Medicine of the USSR Academy of Medical Sciences, have made it possible to plot charts of the cerebral organization of the emotions. They showed with what kind of physiological reorientations in the brain the development of very varied emotional reactions and states is connected. On the basis of these data it is possible when necessary to call forth different emotional states and reactions or, on the contrary, to suppress them.

The contemporary level of knowledge about cerebral organization of the emotions and utilization of the method of implanted electrodes make it possible very accurately to turn on certain emotiogenic zones in the brain, to stimulate them, to combine switching off some emotional zones with stimulation of others and with direction form the development of the desired emotional reorganizations. The possibility of direct observations of different physiological indicators of the brain during the performance by a patient of a current activity and one assigned by the physician under ordinary conditions and on the background of the use of pharmacological preparations makes it possible to specify the role of various sections of the brain in the control of different functions. Specialists working in this field can really talk about "love and hate" as if "from within" the working brain, they can say how the nerve cells conduct themselves when man is solving a problem, talking with the physician, is sad or happy, is sleeping or awake.

Delving into the brain mechanisms of the emotions has revealed that the development of a negative emotion is connected not only with the activity of the zones of the brain directly connected with providing them, but also with the inactivation of other zones "working" during positive emotions. It is not excluded that these processes reflect a unique "complexity" of the development of negative emotions and, thus, the protective role of the optimum level of positive emotions. On the other hand, studies of indicators of the vital activity of the brain during the development of strong positive emotions have shown that here too in individual cases it is possible for there to develop in the brain a "residual effect" in the form of reorganization of its physiological state, contributing to the emergence of a negative emotional state.

The data obtained using the method of implanted electrodes in a man have decoded literally in seconds what for a long time remained not more than an interesting set of facts from an experiment, and the experiment,

having created the prerequisites for the clinical study, in turn itself received new goals and stimuli.

The study of man's mental processes has shown that mental activity is provided by a multi-link structural-functional system with links of different degrees of rigidity. The rigid links take part in providing the mental activity independent of those conditions under which man has to carry out this activity. The flexibile links of the system are switched on or not included in providing the mental activity in direct dependence also on the conditions of its realization. Combination of the apparatus of the rigid and flexible links determines the economical nature and the large number of degrees of freedom of the operation of the brain under the changing conditions of the environment. The reliability of the brain system of providing mental activity is connected first of all with the presence in this system of a very large number of links, and including flexible links, and with the fact that the elements of the system are not solitary nerve cells, but a dynamic totality of functionally united groups of nerve cells (neuron groups), and by a number of other, less significant factors. Serving for optimization of mental activity is the brain apparatus for detection of errors, unifying the structure of the brain, "becoming silent" during the realization of mental activity in accordance with a plan and "working" when there is lack of agreement between the activity and the plan. This apparatus, apparently, possesses the ability to mobilize the energy resources of the brain, which creates the bases for correction of the current stage of activity and improvement of the conditions of realization of its subsequent states.

At the present time on the basis of a study of the organization of mechanisms of the brain done on patients with implanted electrodes, it has proven possible to raise a fundamentally new question--about the essence of the change in physiological indicators of the brain during mental activity, about the brain (neurophysiological) code of mental phenomena. Disclosure of this code can make mental processes controllable, at least in that volume in which today emotional reactions are basically controllable.

The task of the study of the most delicate reorganizations in the brain during mental processes, the code of the mind and particularly the code of words was based on the idea that there might be contained in the impulse activity of the nerve cells of the brain a specific correspondence of one of the major bases of mental phenomena to word signals. Solution of this task required the creation of a special mathematical complex and the utilization of modern analog and computer equipment, providing not only separation of functionally united groups of nerve cells (ensembles) from their total number in the zone of placement of the electrode (population), but also a rather detailed study of the dynamics of organization of the ensembles in space and time.

In the process of the study of this problem it was shown that in populations of nerve cells of the brain at the moment of presentation of the words it is possible to detect at least two basic types of reorganizations

of their activity--those connected and those not connected with acoustic (sound) characteristics of the words.

The reorganizations of the activity of nerve cells of the first type disclosed a connection with the function of the current frequency and rounding amplitude of the word signals. These reorganizations are regarded by us as the primary (acoustic) code, determining the possibility of access to the basis of the long-term memory accumulated in the process of individual experience after decoding (deciphering) the sense of the word.

The rearrangements of the activity of nerve cells of the second type, apparently, also reflect the results of this decoding newly converted to impulse activity in the form of a new "sense" code, which further can serve as the basis of a more complex integrative activity of the brain. The development of research has uncovered that the coding of word signals in the populations of nerve cells of man can be characterized as reorganization of the frequency of electric charges of the cells, with the appearance of discharges of a definite grouping, discharges of a definite form and with the change in the type of interaction of nearby nerve cells and populations of nerve cells located in different sections of the brain. Still more precise decoding of the brain code of words has made it possible to single out a brain code of individual letters of a pronounced word--phonemes. These materials in turn have been used for control of the specificity of the code of words detected in the brain.

The dynamics of the acoustic and sense code proved to be essentially dependent on the richness of the individual long-term memory, the presence or absence in it of a basis for decoding of the presented word. Thus, the acoustic code proved to be less stable during presentation of known words and more stable for unknown (foreign) words. It is proposed that the participation of it during presentation of known words is the result of the inhibiting influence of the long-term memory on the short-term after decoding the meaning of the signal. The dependence of the stability of the acoustic code on the degree of familiarity of the signal is shown by an experiment with retraining--during memorization by a patient of the meaning of unknown words the dynamics of the acoustic code took on the character that is distinctive for familiar words. In this case, as well as during initial presentation of known words, in the areas of detection of the acoustic code along with fading of the initially appearing changes in the activity of the nerve cells the appearance was observed of new rearrangements and the emergence of a code linked by its properties with the acoustic characteristics of the word--the answer pronounced by the patient. This code appeared before the patient's answer, which made it possible to attribute it to the controlling process responsible for the patient's spoken answer.

Utilization of data about the code of different words made it possible to proceed from investigation of the coding of words in the brain to study of the mechanisms of ascertainment by the brain of their similarity of meaning. Using the method of recognition of the code of different words,

it was possible after presenting to the patient the words "chair," "table," "cupboard," to detect in the brain the code of the word "furniture" even before it was uttered by the patient, and so on.

The performed study of brain mechanisms of word coding makes it possible to propose for today the following scheme of processing this information. The initial coding of words is performed according to the laws of coding complex sound (acoustic) signals and is independent of the sense content of these words. The emerging acoustic code is addressed then to the long-term memory accumulated as a result of the person's individual experience, activates it or builds up in the absence of a corresponding basis. On the level of acoustic coding depending on a number of additional factors (the emotional coloration of the situation, other stimulating motives and so on) it is possible to have preliminary selection, "filtration" of the information. Activation of the long-term memory leads to formation in the brain of a new operative utit--the sense code, capable of serving as the basis of other, considerably more complex mental processes. In case of necessity of word realization of the mental process in the brain a controlling code is formed. In the absence of a corresponding basis in the long-term memory the function of the controlling code can also be assumed by the primary acoustic code, which was formed in the brain during presentation of the unknown word.

Is it worth, however, striving for further decoding of the physiological code of the mind? Will not the solution of this problem lead to such a situation where the scientists will "let the genie out of the bottle," which it will then not be possible to "put back?"

There is no doubt that it is worth trying, just as it is worth striving for progress in all fields of knowledge. It is hard to overestimate the significance of this task for brain physiology. Success in the study of the nerve code of mental processes is exceptionally important also for philosophy as knowledge of the most subtle material bases of concrete mental phenomena. This is the more important because even now certain outstanding foreign physiologists consider the task of studying cerebral mechanisms of the mind to be unresolvable. Thus, in 1934-1937 Sherrington wrote that we do not have the right to combine an experiment of the mind with a physiological one, and Eccles in 1957 (!) came to the conclusion that "the brain with the aid of a special ability enters into a relation with the spirit, possessing the property of a 'detector.'"

However the significance of the question is not limited by its theoretical aspect. There is every reason to assume that namely on the path of study of the nerve code of mental phenomena it is possible to obtain very important materials for an understanding, and then even treatment of the most serious mental diseases connected, apparently, with disturbances in the code of mental processes.

Progress in the study of the cerebral organization of emotional-mental activity will make it possible to return to the joys of human life those

mental patients whose lot now remains existence in psychiatric hospitals.

Are there in the physiology of the brain problems, questions and aspects where pre-eminence fundamentally and for always will belong to the experiment? There are, and this pertains first of all namely to a number of aspects of studies of the neurophysiology of man's higher nervous activity and the physiology of behavioral reactions.

It is scarcely permissible according to very strict ethical considerations to raise the problem of study of the intimate neurophysiological mechanisms of the interaction of people in human society. By no medical tasks, even if you assume as justified the expansion of the sphere of application of implanted electrodes under clinical conditions, is it possible from ethical positions to justify the raising of such a task and the more so its realization. But the "natural experiment"--the diseases of the brain themselves--do not present the possibility of investigating this problem, at least in an adequately pure form. In the solution of the broad circle of questions of physiology of the human brain the reasonably defined place of experiments on animals will never be occupied by the study of man himself. But still, weighing both the limitations and the new possibilities of acting on man's brain, the "fermentation" of foreign public opinion in connection with these new possibilities, it is advisable to bring lucidity at least to a number of aspects of the problem.

I am convinced: not such an isolated problem is the power of man over man with the use of implanted electrodes. I know: all that we have succeeded and are succeeding in doing in the field of the study of the mechanisms of man's brain will be utilized in our society only for humane purposes. This very society has fostered in us that very attitude toward the study of the brain about which I am writing as the only one acceptable.

However, unfortunately, there is the problem of a social system, full of social contradictions, which encourages coercion, makes it real and, if this coercion is real, it is possible to use very different means for this. And still even in this extreme case it is necessary to recognize that the method of electrode implantation cannot be "recommended" for realization of this coercion.

Let us imagine that, as in a frightening science-fiction novel, electrodes are implanted in people, they are given telemetric commands of "start" and "stop," they are plunged into despondency or forced to experience non-existent joys, they are "forbidden" to think about someting, they are "forced" to think about something else... This, of course, is frightening. But certainly emotional freedom can be taken away by other means. For instance, by forcibly introducing "tranquilizers"--special pharmacological agents or operating in still more "simple" ways. Unfortunately, humanity for a long time has not been sparing in the invention of ever new means of submission and destruction of those like itself.

Using implanted electrodes not only is it hardly possible to create an army of passive pseudorobots, but it requires initially an obedient army of scientists ready to be in the position of executioners fulfilling orders and transmitting commands. This is simply shocking! We are not the only ones who think so. Outstanding scientists, specialists in the field of the brain, regard this question in practically the same way. "Scientists will not begin to fabricate robot-people, fully subordinate to someone's will... Such an idea is simply absurd," writes the Spanish scientist Delgado.

And nevertheless the danger can not be excluded. It is impossible to forget the shocking anti-human atrocities of fascism. First of all humanity should see to it that the utilization of means of coercion will not be the norm of the behavior of society with respect to its members, or of one state with respect to another.

Along with this the chief task is still more specific. The scientist in the modern world has acquired real influence on the fate of man. Mediated through the goal of the society, this influence potentially may be dangerous, it may lead to the creation namely of that bomb which will fall on his brothers in the species. Prompted by a personal excessive "service to science," the scientist may potentially disregard the interests of the people entrusting their fate to him in the name of "higher" goals--of hypothetical benefit to humanity...

Therefore in today's world the moral make-up of the scientist is very important. The ever-increasing role of science makes the education of the scientist a very important not only state task but also an international one. Not only does society determine the utilization of the fruits of the scientist's work, but it also should not be a matter of indifference to the scientist how the society in which he is working utilizes the fruits of his labors. The scientist, whose missions are purely human, medico-biological problems, should always remember the binding precept of serving the high goals of science only through the good of a specific person. A patient, entrusting the physician with his health, and often his life, should be absolutely sure that all the studies performed, although at all debatable regarding their possible influence, are made only and exclusively in his own interests, and not for the good of "the next patient." The physician should always put in the place of the patient not only himself, but even the one who, perhaps, is dearer to him than himself... And at the very same time namely in the interests of the given patient everything should always be done for him that is possible for restoration of health and preservation of life.

Power over patients is acquired only by an active struggle with them. Such a set up of the question with wise organization of the study will in no way hold back the progress of science. An illustration of this are the huges successes attained in the past two decades in the science of the mechanisms of man's brain.

Each following stage in the study of cerebral support of mental activity, undoubtedly, is important in itself as a stage in the development of natural sciences, as a stage in development of a large theory. Even a very small step forward in the science of man's brain is exceptionally important for clinical practice as a very necessary prerequisite for improvement of the treatment of neural and mental diseases, for expansion of the spectrum of curable diseases.

But it should be considered also that each success in the given field of science of the brain is exceptionally important also for philosophy, and for sociology. Modern sociology is concerned about how the brain of our planet is coping with the abundance of information, with the rising and growing demands addressed to the brain. The prerequisites for the scientific and technical revolution which were created by the brain of geniuses and gifted persons, and the scientific and technical revolution itself, backed by the talent and labor of millions, have in turn presented huge demands on the brain. Through the eyes and ears, man wants this or does not want it, a huge volume of information comes to the brain. His brain, whether he wants this or not, reacts to this huge flow of information. Is there really a threat that man may not cope with this complexity?

Theorists in experimental physiology have shown the hypothetical basic principles according to which in interaction with the environment, under the influence of this environment, the brain has developed, has adapted to this environment. Neurophysiologists should attempt to answer these questions: in what way does it prove possible for there to be not only colossal individual improvement, exposure of the potentials of the brain, but also an urgent transition to new stages of interaction with the environment by huge masses of people. How has the brain of man in less than two generations proven capable of adapting in a practically completely new world? What will happen with the brain if in the future too with a vast acceleration there is an increase in the load on it? And why up to our days has there been no "catastrophe" (and we can say that no catastrophes have occurred) on the level of the potentials of the brain? Is there in the brain a mechanism of self-preservation, of self-defense ? What systems of the brain are more vulnerable--the phylogenetic, the later, or the earlier? Will the emotional system surrender and entail a "failure" of the possibilities of the system connected with it in the closest way, the one providing intellectual activity, or, on the contrary, going out of order temporarily, preserve the intellect? Is it necessary to "render harmless" the emotional system and thereby open up space for the intellect or is it necessary to preserve this "safety valve?"

There are many very important questions. Their address is the physiology of man's brain. The answer to the majority of them requires investigations and meditation, and to certain questions the answer is possible, apparently, even now.

It is known that in the brain there is a mechanism providing surplus possibilities upon meeting with each novelty. The one for whom it has been possible to "spy" on what occurs in the brain at the moment when the situation proves to be a new one, when a transition is made unexpectedly to an old situation, when there is even any basis at all to be "surprised," will be able to say that the brain in these cases as if "plays through" the mass of readinesses for this new situation. Activated at the same time is a huge number of nerve elements, a mass of communications is switched on between the different sections and elements of the brain. It is not excluded that this same mechanism, even if partially, was at the basis of preservation of the potentials of the brain, the potentials of the species. It is very probable that this reaction to a new thing is also something in the way of natural training of the brain, something like a mechanism which insures surplus readiness for each concrete, even small novelty of a given minute, and for long centuries has preserved endlessly the great potentials of the brain.

The greater the number of new things, the greater the number of times during short segments of time the brain is "surprised," the more information that passes through the ears, eyes and other sensory inputs, the more rapidly does the brain of a child develop and thereby the more fully is the potential of the brain of the planet revealed, and the more opportunities appear for humanity. Perhaps, it will not be a great exaggeration to say that the scientific and technical revolution is a result of interaction according to the principle of positive feedback between the brain of humanity and the environment, changed by this brain. Scientific and technical progress, in this way, on the one hand is the decisions of personality made by humanity, and on the other a mass upswing of the potentials of humanity, a mass generation of ideas, a clash of ideas, a mutual enrichment of ideas. Somewhere, not having noticed it ourselves, we passed the stage after which there began the general activation of the Brain of humanity, after which there occurred an "explosion" in the form of the scientific and technical revolution.

But the scientific and technical revolution--this is also the huge increase in the possibilities of study of the brain itself, of problem solving--is the same as our brain. And here again we come up against the social aspect of the problem. And this is why. The successes in the study of physiological bases of mental activity can and should give the key to control of the potentials of the brain.

It is not excluded that, having united the efforts of very different approaches to the study of the brain, we will gain in the very near future truly real power over the brain. This power should be used only for the good of the healthy or the sick man.

We believe that the more deeply we penetrate into the secrets of the brain, the smaller will be the danger of using this knowledge against

the brain, against humanity. Knowlege can never be dangerous by itself. Knowledge will become or will not become dangerous depending on in whose hands it falls. Scientists of the whole world, solving the problems of man's brain, contributing their labor and talent to these studies, must be conscious of the burden of responsibility to humanity lying on them, they must strive in every way so that what their brain creates will be utilized always only for the most humane purposes.

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PUBLICATIONS

OBTAINING NUTRIENT YEAST FROM PEAT

Minsk POLUCHENIYE KORMOVYKH DROZHZHEY IZ TORFA (Obtaining Nutrient Yeast From Peat) 1977 in Russian signed to press 14 Oct 77 pp 2-26, 230-231

[Annotation, Table of Contents, Introduction, and Chapter 1 from book edited by Belorussian SSR Academy of Sciences Corresponding Member V. Ye. Rakovskiy, Izdatel'stvo "Nauka i tekhnika", 1000 copies, 323 pages]

[Text] This book presents data on the availability and characteristics of peat recommended as a raw material for hydrolytic processing. The industrial procedures for hydrolyzing peat with concentrated sulfuric acid are described. Data from research on the chemical composition and biological activity of the hydrolysis products of peat and on utilization of the components of nutrient media prepared from hydrolysates by protein, carotene, and lipid-forming yeast are generalized. Data are presented on the use of peat hydrolysis residue to obtain fertilizers, substrates for microbial synthesis, and active charcoal.

The book is intended for scientists, engineers, and technicians in hydrolytic industry, and it may be useful to scientists working on peat chemistry.

Eighty-two tables, 38 figures, 423 bibliographic references.

Contents

Introduction

Creation of a highly productive livestock and poultry raising industry would be possible only if sensible balanced nutrition is provided. The composition of animal and bird feed must include sufficient quantities of essential amino acids, vitamins, hormones, and microelements. Nutrient yeast, which contains up to 50 percent valuable protein, group B vitamins (B_1, B_2, B_6, B_{12}), ergosterol (vitamin D), microelements, enzymes, and other substances, is a source of these compounds.

The demand for nutrient yeast is being satisfied far from fully today. This is why a significant increase in the output of microbiological industry has been foreseen by directives of the 25th CPSU Congress concerning the 10th Five-Year Plan. Projects having the purpose of seeking new raw material sources are becoming important in this connection.

Our country possesses tremendous reserves of peat (almost half the world's resources), including peat suitable for hydrolysis, which affords a possibility for organizing production of protein and other products of microbial synthesis (amino acids, vitamins, and so on) in sufficient quantities for a long period of time.

Over a number of years the Belorussian SSR Academy of Sciences Peat Institute has been working jointly with the Latvian SSR Academy of Sciences Institute of Wood Chemistry, the Planning-and-Design Office of the Lithuanian SSR Administration of Peat Industry, the All-Union Scientific Research Institute of Plant Material Hydrolysis, the Irkutsk Scientific Research and Planning Institute of Chemical Machine Building, and the Belorussian Academy of Sciences Institute of Microbiology to acquire nutrient yeast from upland peat that has undergone mild decomposition. In terms of

carbohydrate content this peat hardly differs at all from wood and other raw plant materials used in hydrolytic industry.

Peat hydrolysates are a good medium for cultivation of yeasts producing amino acids (lysine), carotene, and lipids, and they can be used to synthesize organic compounds.

Analysis of different methods and conditions for hydrolysis of peat by mineral acids showed that one of the promising and acceptable methods is hydrolysis with concentrated sulfuric acid. In this case not only the readily hydrolyzable but also the poorly hydrolyzable peat polysaccharides are broken down with a maximum yield of reducing agents and with satisfactory separation of the nonhydrolyzed residue from the hydrolysate. The residue contains about 25 percent polysaccharides and 50 percent humus compounds, to include 30 percent humic acids, and it is a valuable organic material. Different methods have been developed for its use in the national economy--preparation of granulated organomineral fertilizers, activated charcoal, and plastic fillers, acquisition of total organic acids by means of oxidation with atmospheric oxygen in an alkaline environment, use as a binding agent in pellets, and so on. The postfermentation mash contains nitrogen, protein compounds, organic acids, reducing agents to include some quantity of sugars, and so on. After evaporative concentration, it can be used to acquire feed concentrate. Waste utilization will increase the economy of obtaining yeast from peat.

The industrial procedures were tested out fully in the experimental shop of the Ezherelis Peat Enterprise (Lithuanian SSR), where experimental lots of nutrient yeast were obtained. Research conducted by the USSR Academy of Medical Sciences Institute of Nutrition demonstrated that yeast obtained from peat is distinguished by high nutritional and stimulatory properties, and that it does not have carcinogenic activity.

A worm hydrolyzer mated with a peat-acid mixer underwent tests and improvements at an experimental industrial facility for neutralysate-producing hydrolytic peat processing, erected at the Bobruysk Hydrolytic Plant. The planned productivity of the apparatus has been achieved, and the degree of destruction of peat polysaccharides is good. A way of processing hydrolysate to acquire neutralysate has also been tested in experimental industrial conditions, and the neutralysate has been tested as a yeast growing medium.

This monograph summarizes results obtained by the collective of the Belorussian SSR Academy of Sciences Peat Institute's Hydrolytic Process Research Laboratory. Research on yeast cultivation was conducted by colleagues of the Belorussian Academy of Sciences Institute of Microbiology (Doctor of Biological Sciences M. V. Zalashko and candidates of biological sciences Ye. S. Gurinovich, Zh. N. Bogdanovskaya, I. F. Koroleva, and N. V. Obraztsova).

This book provides a chemical assessment of upland peat used as hydrolytic raw material, substantiates the procedures for evaluating hydrolytic peat,

and cites data from scientific research performed by the laboratory with the goal of creating the industrial hydrolytic procedures and increasing the depth of destruction of polysaccharides.

There is little published information on the composition of hydrolysates and residues formed from peat hydrolysis. Peat hydrolysates obtained from the action of concentrated sulfuric acid contain the destruction products of humus compounds, nitrogen-containing compounds, organic acids, and so on. Procedures have been developed for removing impurities from hydrolysates by means of ion-exchange resins, extraction with organic solvents, and so on. Modern analysis methods are used to establish the chemical characteristics of the components of peat, hydrolysates, and residue from peat hydrolysis--paper and gas-liquid chromatography, ultraviolet spectroscopy, gel chromatography, electrophoresis, and others.

Research on the influence the organic components of hydrolysates have on yeast, performed jointly with the Belorussian SSR Academy of Sciences Institute of Microbiology, revealed that peat hydrolysates are of high quality, demonstrated that 40-70 percent of the organic acids contained in media are consumed, and established the biological action of hydrolysate humic acids on yeast.

This book presents data on the use of peat hydrolysates for microbial synthesis, as well as the results of research on the possibility for utilizing peat hydrolysis residue to prepare fertilizers and activated charcoal, and the process of oxidative destruction of peat hydrolysis residue with the goal of obtaining substrates for microbial synthesis is studied.

The obtained information will broaden our ideas about peat hydrolysis and about the products formed, and it will be a necessary link in development of the ways of utilizing these products.

The botanical descriptions of different types of peat were written by colleagues of the laboratory of peat and sapropel deposits and the genesis of peat and sapropel under the guidance of Doctor of Biological Sciences A. P. Pidoplichko.

Chapter I. Availability and Characteristics of Hydrolytic Peat Raw Material

The significant increase in production of nutrient yeast in our country foreseen by a 25th CPSU Congress decision requires that we find and assimilate new types of nondietary hydrocarbon and plant raw materials. At present we acquire nutrient yeast with the use of the wastes of food and cellulose-and-paper industry, mainly the products from hydrolyzing wood and agricultural plant remains. These raw materials will not be able to satisfy the planned yeast demand within the very near future.

Mildly decomposed upland peat is a promising hydrolysis raw material in certain regions of the Soviet Union. Work done by the Rostorfrazvedka and

Belgiprotorf Institutes with the participation of the Belorussian SSR Academy of Sciences Peat Institute to substantiate and select the priority raw material bases for construction of hydrolytic plants has shown (1) that the reserves of hydrolytic raw material in the European RSFSR total 1,021,000,000 tons (W=40 percent), those of the Soviet Baltic total 453,000,000, and those of the Belorussian SSR total 65,000,000 tons. This means that we can build 95 plants with a total output capacity of 1,965,000 tons of nutrient yeast per year, to include 62 (1,280,000 tons) in the RSFSR, 12 (205,000 tons) in the Latvian SSR, one (60,000 tons) in the Estonian SSR, one (10,000 tons) in the Lithuanian SSR, and three plants (65,000 tons of yeast) in the Belorussian SSR.

Priority status has been recommended for eight raw material bases in the RSFSR, one in the Estonian SSR, one in the Latvian SSR, and three in the Belorussian SSR. These bases are, in the RSFSR, Ulomskoye (Vologodskaya Oblast)--45,000 tons of yeast, Bol'shoye (Sverdlovskaya Oblast)-- 15,000 tons, Lar'yanskoye (Leningrad Oblast)--45,000 tons, Bas'yanovskoye (Sverdlovskaya Oblast)--15,000 tons, Bol'shaya Chist' (Vologodskaya Oblast)--15,000 tons, Orshanskiy Mokh (Kalininskaya Oblast)--15,000 tons, Tukhun (Novgorodskaya Oblast)--15,000 tons, and Zayachiy Otrog (Pskovskaya Oblast)--150,000 tons of yeast; in the Estonian SSR, Likhula-Lavasaare--60,000 tons of yeast; in the Belorussian SSR, Obol'--2,000-10,000 tons of yeast, Mezhdurechenskoye--15,000 tons, and Yel'nya--40,000 tons; in the Latvian SSR, Livany--15,000 tons.

The reserves of hydrolytic peat raw material in the European USSR and the West Siberian reserves, which are two to three times as large as the former, can fully support production of nutrient yeast for animal husbandry in the required amounts, but for the present only, and not in the future (2).

The group chemical composition of different types of peat has been studied well. It has been established that various groups of chemical compounds can be isolated from the organic part of the peat--bitumen, readily and poorly hydrolyzable substances, humic and fulvic acids, and "lignin." The concentration of these compounds in different types of peat varies, depending basically on the type of peat deposit, its botanical composition, and the degree of its decomposition.

Weakly decomposed peat is typified by a large quantity of different readily and poorly hydrolyzable polysaccharides, which transform as a result of the hydrolysis reaction into monosaccharides that are readily assimilated by the yeast cell. Research by the Belorussian SSR Academy of Sciences Peat Institute and other scientific organization (2-8) has demonstrated that some types of sphagnum and (sheykhtseriyevo)-sphagnum peat with a degree of decomposition (R) less than 20 percent contain 63-78 percent (in relation to organic mass) hydrolyzable substances (Table 1), including from 45 to 59.6 percent reducing agents (RA), which are nutrient material in relation to some species of microorganisms producing nutrient yeast.

Polysaccharides from mildly decomposed upland peat are subdivided into readily hydrolyzable (LH) and poorly hydrolyzable (PH) fractions. Readily

Table 1. Concentration of Hydrolyzable Substances in Upland Peats with 20 Percent Decomposition, Percent in Relation to Organic Mass

(1) Компонент	(2) Вид торфа и степень разложения, %					
	(3) медиум		(4) фускум		(5) пушицево-сфагновый	
	5—10	15—20	5—10	15—20	5—10	15—20
(6) ЛГ	42,6—50,2	32,3—42,4	42,0—49,9	36,9—49,9	46,1—52,6	47,3—48,8
В том числе РВ (7)	22,9—28,1	16,7—27,1	21,2—28,1	16,4—28,7	24,1—27,4	23,8—26,2
(8) ТГ	22,2—31,8	21,4—33,5	22,6—30,7	22,6—30,1	25,0—27,5	22,9—31,9
В том числе РВ (7)	16,5—27,8	15,6—33,0	21,7—23,2	24,0—26,9	24,0—26,9	22,1—28,6
(9) Сумма гидролизуемых веществ	70,2—78,0	65,8—71,4	71,0—72,7	63,6—72,3	65,9—72,6	64,5—69,4
В том числе РВ (7)	48,1—59,6	47,7—58,3	46,1—49,8	44,9—51,1	48,0—50,6	42,7—45,4
(10) РВ трудногидролизуемой фракции, % от всей суммы РВ	34—47	49—56	47—50	43—45	50—53	51—62

Key:

1. Component
2. Type of peat and degree of decomposition, %
3. (Medium)
4. (Fuskum)
5. Bog cotton-sphagnum
6. RH
7. Including RA
8. PH
9. Total hydrolyzable substances
10. RA of poorly hydrolyzable fraction, % of total RA

hydrolyzable RA going into solution upon hydrolysis by diluted acids are 40-80 percent monosaccharides--glucose, galactose, mannose, arabinose, xylose, and rhamnose. More than half of all monosaccharides are hexoses (Table 2). Substances going into solution upon hydrolysis with concentrated acid (PH) consist almost entirely of RA, which in turn contain 83-100 percent monosaccharides--80-97.7 percent glucose and small quantities of mannose and xylose.

Table 2. Carbohydrate Composition of Polysaccharides of Upland Peats (R=5-20 percent), Percent of Total Sugars

(1) Компонент	Фракция (2)	
	(3) легкогидролизуемая	(4) трудногидролизуемая
(5) Галактоза	21,0—29,1	—
Глюкоза (6)	20,8—33,3	86,7—97,7
(7) Маннноза	3,1— 6,9	3,3— 8,7
Арабиноза (8)	3,4— 7,8	—
(9) Ксилоза	26,9—35,5	Следы— 4,9 (14)
Рамноза (10)	3,6—17,5	—
(11) Пентозы	33,8—50,5	Следы— 7,7 (14)
Гексозы (12)	49,5—66,2	92,3—100
(13) Сумма сахаров, % от РВ	40—80	83—100

Key:

1. Component
2. Fraction
3. Readily hydrolyzable
4. Poorly hydrolyzable
5. Galactose
6. Glucose
7. Mannose
8. Arabinose
9. Xylose
10. Rhamnose
11. Pentose
12. Hexose
13. Total sugars, % of RA
14. Traces

Other authors (6,9-11) have obtained similar data on the carbohydrate composition of polysaccharides in mildly decomposed upland peats. RA from poorly hydrolyzable polysaccharides make up from 34 to 62 percent of the total quantity (see Table 1). Therefore besides increasing the yield of RA, utilization of the poorly hydrolyzable part of the polysaccharides in these peats significantly improves the qualitative composition of the hydrolysates, inasmuch as glucose is assimilated by yeasts better that all other sugars (12).

The properties of polysaccharides in plant materials depend on molecular structure, the structural order typical of them, tightness of coiling, and the

forces of intermolecular interaction. Their investigation by electron microscopy revealed a fibrillar structure in peat cellulose, with alternating ordered and poorly oriented sections, without dramatic phasal distinctions (13).

The degree of polymerization of α-cellulose from peat plants and from the fibrous part of peat is three to four times lower than tha of woody cellulose (14). X-ray diffraction analysis revealed structural heterogeneity in the forms of α-cellulose studied.

Information on the composition of polysaccharides--cellulose and hemicellulose--and their stability in an acid medium is of special interest to the use of peat as a hydrolytic raw material.

Research has been conducted on hydrolysis of upland peats by weak acids (8,10,15). It has been revealed that the extent to which peat polysaccharides are broken down depends on the conditions of the process (reaction time, number of steps of hydrolysis, and the nature and concentration of the catalyst) (16). In order that a maximum quantity of peat polysaccharides could be placed into solution and subjected to the fullest hydrolysis, Aleshin (16) suggests using an 8-10 percent solution of hydrochloric acid and a hydrolysis time of 60 minutes. D'yachkov (15) established that hydrolysis of RH polysaccharides from weakly decomposed peat at 100°C and use of 4 percent sulfuric acid requires at least 10 hours.

(Medium) and complex upland peat 5 and 15 percent decomposed respectively (see Table 1 of the Appendix for the botanical composition) were heated in a 4 percent sulfuric acid solution, and then the RH fraction was subjected to inversion with 8 percent sulfuric acid for 2 hours (17-19) with the goal of studying the stability of polysaccharides in acid medium and working out the conditions for their maximum yield. Then we determined RA (by the ebulliostatic method), the PH substances, and the nonhydrolyzable residue.

The process of hydrolyzing peat polysaccharides is rather complex, and it consists of several stages. In the first stage, called hydrolytic dissolution and proceeding in heterogenic conditions, the polysaccharide macromolecules undergo depolymerization and the fragments formed go into solution. In the second stage the dissolved oligosaccharides are hydrolized down to monosaccharides, and in the third and final stage the monosaccharides formed are decomposed (16).

Tables 3 and 4 and Figures 1-4 present data on changes in the component composition and yield of RA and monosaccharides depending on the time of hydrolysis with 4 percent sulfuric acid. At first hemicellulose is dissolved, forming oligosaccharides. The concentration of the latter in the hydrolysates is inversely dependent on hydrolysis time. As heating time is increased the difference in the yield of both RA and monosaccharides before and after inversion decreases. In this case the most readily hydrolyzable part of

the hemicellulose dissolves and undergoes hydrolysis in the first 3 hours. After further heating the more-resistant polysaccharides begin to go into solution as well, as is indicated by a decline in the yield of monosaccharides in the poorly hydrolyzable fraction, coupled with a concurrent increase in the quantity of mono- and oligosaccharides in the RH hydrolysate. Obviously groups of polysaccharides with glucoside bonds of varying degrees of stability are present within the composition of the carbohydrate part of peat. As we can see from Figures 3 and 4 the total monosaccharide yield does not change in the time interval from 5 to 7 hours. Apparently an equilibrium occurs at this time: The quantity of decomposed monosaccharides is equal to the concentration of monosaccharides just formed by hydrolysis.

Table 3. Group Chemical Composition of (Medium), Peat (R=5 percent) Depending on Time of Hydrolysis With 4 Percent Sulfuric Acid, Percent of Organic Mass

(1) Продолжительность гидролиза, ч	(2) лг	(3) РВ в ним	(4) РВ после инверсии	(5) тг	(3) РВ в ним	(6) Негидролизуемый остаток	(7) Сумма гидролизуемых веществ	Сумма РВ (8) (9) до инверсии	(10) после инверсии
0,5	21,1	8,7	10,5	57,6	46,0	21,4	78,7	54,7	56,5
1	38,7	13,6	16,3	40,6	40,4	20,8	79,3	54,0	56,7
2	51,0	26,0	31,2	30,2	28,2	19,0	81,2	54,2	59,4
3	54,0	26,5	32,8	27,1	27,0	18,6	81,1	53,5	59,8
4	55,2	29,1	33,8	26,5	25,9	18,3	81,7	55,0	59,7
5	56,3	30,0	33,4	25,0	21,8	18,3	81,3	51,8	58,2
6	56,3	30,6	33,3	25,0	21,8	18,5	81,3	55,0	58,1
7	56,7	31,8	33,0	24,9	24,8	18,8	81,6	56,6	57,8
8	57,4	31,9	32,9	23,2	23,2	19,4	80,6	55,1	56,1
9	58,2	32,0	34,4	20,9	20,7	20,6	79,1	54,7	55,1
10	57,0	32,9	34,9	19,8	19,8	22,8	76,8	52,7	54,7

Key:

1. Hydrolysis time, hours
2. RH
3. RA in the former
4. RA following inversion
5. PH
6. Nonhydrolyzable residue
7. Total hydrolyzable substances
8. Total RA
9. Prior to inversion
10. After inversion

Table 4. Change in Component Composition of Complex Upland Peat (R=15 percent) Depending on Time of Hydrolysis With 4 Percent H_2SO_4, Percent of Peat Organic Mass

(1) Продолжительность гидролиза, ч	(2) ЛГ	(3) РВ в них	(4) РВ после инверсии	(5) ТГ	(3) РВ в них	(6) Негидролизуемый остаток	(7) Сумма гидролизуемых веществ	(8) Сумма РВ (9) до инверсии	(8) Сумма РВ (10) после инверсии
1	34,0	15,8	22,8	29,1	23,3	30,9	56,8	41,1	48,1
2	41,8	21,8	27,4	21,8	21,7	34,4	65,6	43,5	49,1
3	44,2	22,7	28,6	20,9	20,7	34,7	65,1	43,4	49,3
4	45,2	23,2	28,6	20,5	20,4	31,6	65,1	42,6	49,0
5	46,1	25,3	27,6	20,4	20,4	31,6	65,1	41,3	48,0
6	46,3	26,3	29,4	19,0	19,0	31,7	65,3	45,3	48,4
7	46,5	27,0	30,0	18,8	18,9	34,6	65,3	45,9	48,0
8	46,7	27,3	29,0	18,8	18,9	34,4	65,5	46,2	47,9
9	46,6	29,0	29,7	16,1	17,5	37,3	62,7	46,5	47,2
10	46,7	29,6	30,3	16,1	16,5	37,1	62,8	47,1	46,8

Key:
[See Key, Table 3]

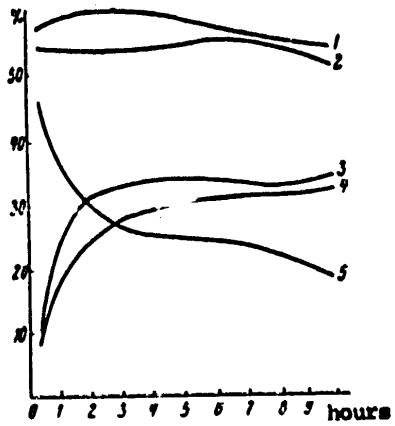

Figure 1. Change in RA Yield Depending on Time of Hydrolysis of (Medium) Peat (R=5 percent) With 4 Percent Sulfuric Acid: *1*--Total quantity after inversion; *2*--Total quantity before inversion; *3*--In the readily hydrolyzable fraction after inversion; *4*--In the readily hydrolyzable fraction before inversion; *5*--In the poorly hydrolyzable fraction

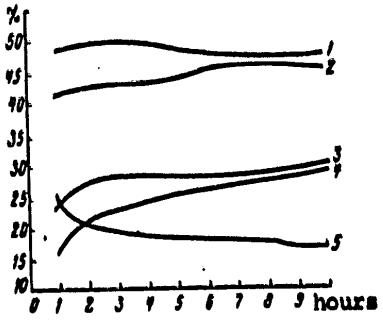

Figure 2. Change in RA Yield Depending on Time of Hydrolysis of Complex Upland Peat (R=15 percent) With 4 Percent Sulfuric Acid. See Figure 1 for explanation of symbols

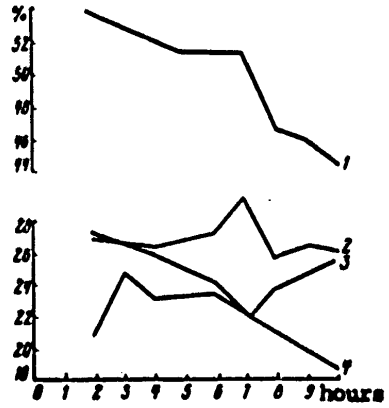

Figure 3. Change in Monosaccharide Yield Depending on Time of Hydrolysis of (Medium) Peat (R=5 percent) With 4 Percent Sulfuric Acid: *1*--Total quantity; *2*--Total quantity after inversion; *3*--In the readily hydrolyzable fraction before inversion; *4*--In the poorly hydrolyzable fraction

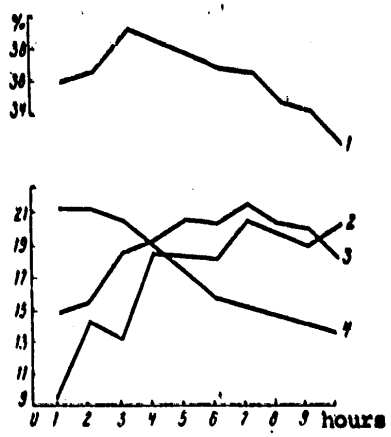

Figure 4. Change in Monosaccharide Yield Depending on Time of Hydrolysis of Complex Upland Peat (*R*=15 percent) With 4 Percent Sulfuric Acid: *1*--Total quantity; *2*--In the readily hydrolyzable fraction; *3*--In the readily hydrolyzable fraction after inversion; *4*--In the poorly hydrolyzable fraction

Concurrently with a decrease in the quantity of PH monosaccharides during 8-10 hours of peat hydrolysis, their yield in the readily hydrolyzable fraction also decreases. In these conditions monosaccharide breakdown dominates over synthesis. As a result the total quantity of monosaccharides drops as the heating time increases. In this case the curve of change in total monosaccharide concentration depending on heating time for (medium) peat characterized by 5 percent decomposition does not have a maximum, while for complex upland peat (*R*=15 percent) a maximum is noted after 3 hours of heating.

Consequently polysaccharides in different types of peat have different qualitative compositions, and they differ in relation to the stability of the glycoside bond in an acid medium. Chromatographic analysis of peat hydrolysates affords a possibility for tracing the behavior of each hydrolysate monosaccharide depending on the time of hydrolysis of peat with 4 percent sulfuric acid.

We can see from the data in Figure 5 that a polysaccharide producing galactose upon hydrolysis is heterogeneous, consisting of several fractions

that differ in the strength of the glycoside bond of the macromolecules, as a result of which there are several peaks on curves *1* and *3*. Hydrolysis of readily hydrolyzable galactan terminates by the 3rd hour for (medium) peat (R=5 percent) and by the 4th hour for complex upland peat (R=15 percent). Also present in solution are intermediate hydrolytic products, which after additional inversion increase the yield of galactose. Arisal of peaks on curves *1* and *2* after the 7th hour of hydrolysis indicates that peat also contains even more poorly hydrolyzable galactan.

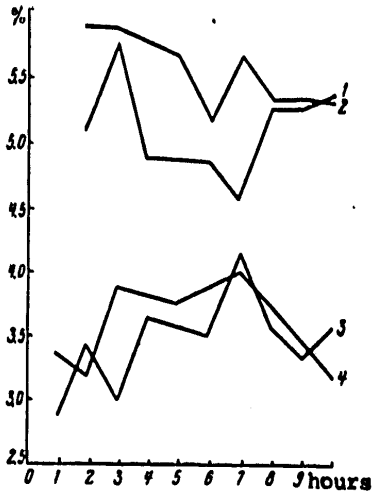

Figure 5. Change in Galactose Yield in the Readily Hydrolyzable Fraction Depending on Time of Hydrolysis of Complex Upland Peat (R=15 percent, Curves *3,4*) and (Medium) Peat (R=5 percent, Curves *1,2*) With 4 Percent Sulfuric Acid: *1,3*--Before inversion; *2,4*--After Inversion

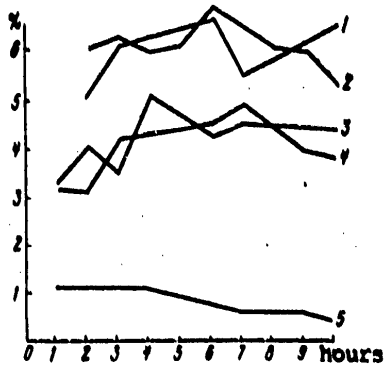

Figure 6. Change in Xylose Yield Depending on Time of Hydrolysis of Complex Upland Peat (*R*=15 percent, Curves *1,3,4*) and (Medium) Peat (*R*=5 percent, Curves *2,5*) With 4 Percent Sulfuric Acid: *1*--In the poorly hydrolyzable fraction; *2,4*--In the readily hydrolyzable fraction before inversion; *3,5*--In the readily hydrolyzable fraction after inversion

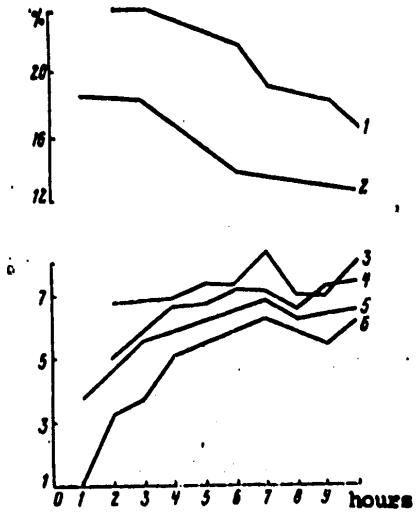

Figure 7. Change in Glucose Yield Depending on Time of Hydrolysis of Complex Upland Peat (*R*=15 percent, Curves *1,2,5*) and (Medium) Peat (*R*=5 percent, Curves *3,4,6*) With 4 Percent Sulfuric Acid: *1,2*--In the poorly hydrolyzable fraction; *3,5*--In the readily hydrolyzable fraction after inversion; *4,6*--In the readily hydrolyzable fraction before inversion

This dependence is also typical of xylose (Figure 6), the only difference being that the products of incomplete hydrolysis--disaccharides and oligosaccharides--are present in somewhat lower quantities in solution. As we can see from Figure 6, hydrolysis of the greater part of the readily hydrolyzable xylane ends by the 3rd hour for (medium) peat and by the 4th hour for complex upland peat. A further increase in heating time causes a drop in the yield of xylose in the readily hydrolyzable fraction. In solution in these conditions, however, we reveal oligosaccharides that are formed by dissolution of poorly hydrolyzable xylane. As a result the quantity of xylose in the poorly hydrolyzable fraction decreases.

We can see from Figure 7, which shows the dependence of the yield of glucose in readily and poorly hydrolyzable fractions on the time of hydrolysis of peat with 4 percent sulfuric acid, that glucan consists of several fractions exhibiting different degrees of hydrolyzability. When (medium) peat (R=5 percent) is heated, RH glucan is hydrolyzed somewhat earlier than that in complex upland peat (R=15 percent). In solution, besides glucose we reveal products of incomplete hydrolysis. After 8 hours the glucose yield is approximately identical before and after inversion, and after 9-10 hours of heating cellulose undergoes dissolution, as a result of which we find oligosaccharides in the solution. The concentration of glucose in the poorly hydrolyzable fraction hardly changes prior to the 3rd hour, and as the peat hydrolysis time is increased subsequently it decreases continuously.

As with the previous polysaccharides, mannan from complex upland peat (R=15 percent) consists of several fractions characterized by different strengths of macromolecule bonds (Figure 8). At first, before the 4th hour, the rate of dissolution of the polysaccharides is greater than the hydrolysis rate, owing to which oligosaccharides are revealed in solution. Then, from the 5th to the 7th hours, the rates of dissolution and hydrolysis approach each other. After 8 hours of heating the poorly hydrolyzable fraction of mannan dissolves, and once again only saccharides appear in solution, undergoing hydrolysis (after 9-10 hours) down to mannose which breaks down concurrently. In the poorly hydrolyzable fraction, the quantity of mannose constantly declines as heating time increases.

Figure 8. Change in Mannose Yield Depending on Time of Hydrolysis of Complex Upland Peat (R=15 percent) With 4 Percent Sulfuric Acid: *1*--In the readily hydrolyzable fraction before inversion; *2*--In the readily hydrolyzable fraction after inversion; *3*--in the poorly hydrolyzable fraction

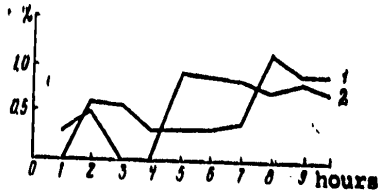

Figure 9. Change in the Yield of Arabinose in the Readily Hydrolyzable Fraction Depending on Time of Hydrolysis of Complex Upland Peat (R=15 percent) With 4 Percent Sulfuric Acid: *1*--Before Inversion; *2*--After Inversion

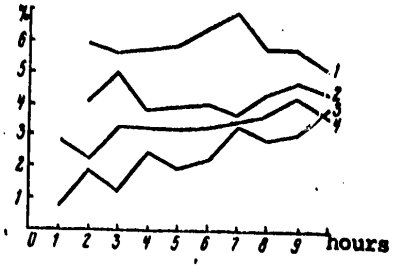

Figure 10. Change in the Yield of Rhamnose in the Readily Hydrolyzable Fraction Depending on Time of Hydrolysis of Complex Upland Peat (R=15 percent, Curves *3,4*) and (Medium) Peat (R=5 percent, Curves *1,2*) With 4 Percent Sulfuric Acid: *2,3*--Before inversion; *1,4*--After inversion

It would be interesting to trace the behavior of the polysaccharide that produces arabinose (Figure 9). After 2-3 hours of hydrolysis of complex upland peat with 4 percent sulfuric acid, only monomers are present in solution, and there are no oligomers. Owing to this arabinose disappears upon inversion of the hydrolysates. After 5 hours of heating the next polysaccharide fraction begins to dissolve, becoming fully hydrolyzed after 8 hours of hydrolysis. It is believed that the polysaccharide producing arabinose is unstable, but presence of arabinose in the acid solution after 9-10 hours of heating indicates that it is typified by several fractions with different degrees of hydrolyzability.

The polysaccharide producing rhamnose upon hydrolysis consists of several fractions (Figure 10). The first stage is its dissolution, as is indicated by the increase in rhamnose yield following inversion of the hydrolysates.

Rhamnose-producing polysaccharides from different types of peat differ from one another in relation to the strength of the glycoside bond. Thus when we hydrolyze (medium) peat (R=5 percent) the maximums appear on the curve of dissolution of different polysaccharide fractions after the 2nd and 7th hours of heating, while for complex upland peat (R=15 percent) the peaks arise after the 3rd and 9th hours.

Thus peat hemicellulose contains groups of polysaccharides with glycoside bonds exhibiting different degrees of resistance to hydrolysis. Several fractions differing in their capability for being hydrolyzed have been established for every polysaccharide.

Comparing the data obtained for (medium) and complex upland peat with 5 and 15 percent degrees of decomposition respectively, we can conclude that the quantitative composition of hemicelluloses in these types of peat differs somewhat, but the basic laws governing the influence of the time of hydrolysis with 4 percent sulfuric acid persist. Hydrolysis of the bulk of the readily hydrolyzable polysaccharides ends by the 3rd-5th hours. The total yield of monosaccharides decreases after 3 hours of hydrolysis. Oligosaccharides are present in the hydrolysates; therefore the hydrolysates must be subjected to additional inversion. In order to permit technical assessment of peat (with R up to 15 percent) as a raw material for acquiring nutrient yeast in terms of its RA content, it would be sufficient to subject RH polysaccharides to 3 hours of hydrolysis followed by 2 hours of hydrolysate inversion.

The reducing agents in hydrolysates from the RH fraction of mildly decomposed upland peat include uronic acids, which have important significance to describing peat as a hydrolytic raw material. According to data in (16,17) their concentration drops as the degree of decomposition of the peat increases, being from 5.0 to 17.4 percent in absolutely dry peat. Other authors have established that the maximum quantity of uronic acids (up to 40-50 percent of the reducing agents) is contained in peat-forming plants, and that it decreases as the degree of decomposition of the peat increases to 25 percent (22).

Uronic acids, which are present in hydrolysates in significant quantity, can significantly influence the yield of yeast biomass. It has been demonstrated that incultivation of *Candida* yeast, which is osmophilic in relation to peat hydrolysates, uronic acids are 100 percent assimilated (23).

But not all uronic acids go into solution during hydrolysis of hemicellulose. Up to 49 percent of the acids are liberated subsequently in hydrolysis of cellolignin with 80 percent sulfuric acid, and 21 percent remain in the nonhydrolyzable residue (24). Moreover uronic acids entering into the hydrolysate can exist in both free state and in the form of the products of incomplete hydrolysis of polyuronides such as aldobiuronic and aldotriuronic acids (25).

In this connection further research is required on peat polyuronides so that the optimum conditions could be found for their most complete

hydrolysis, as a result of which a similar quantity of pentoses would form in addition to uronic acids.

Nitrogen-containing substances are an invariable component of peat. They are represented by the following classes of compounds--nitrates, amonium salts, amido and amino compounds, and proteinaceous substances (26,27). The nitrogen quantity fluctuates in lowland peats from 2.0 to 4.0 percent, and in upland peats from 0.7 to 1.5 percent (26,27). The bulk of it is contained in humus compounds. When the humus substances of peat are hydrolyzed with 5 percent HCl for 2.5 hours, 40-60 percent of the nitrogen contained in these substances goes into solution, with 64-75 percent of it being in amino acids (28). The authors hypothesize on the basis of the obatined data that these compounds are either very readily hydrolyzable protein breakdown products or amino acids bound loosely with humus substances and retaining their individuality.

Detailed analysis of peats revealed 17 amino acids (29-33). Amino acids such as alanine, aspargic and glutamic acid, proline, tyrosine, and phenylalanine are substances typified by high biological activity, and they play a great role in accelerating the growth of microorganisms and plants (33,34). Almost all of them are present in peat hydrolysates (28).

The concentration of amino acids in peat hydrolysates grows as the concentration of the hydrolyzing agent increases, and when the hydrolysis conditions are severe (20 percent HCl or 30 percent H_2SO_4) the amino acid concentration attains 10 percent of the organic substances in peat (28). The strength of the bonds between different amino acids and the organic part of the peat differs, and in the opinion of the authors it increases as the degree of the peat's decomposition rises.

The data presented here on nitrogen-containing compounds of peat, especially on amino acids, have important practical significance to describing peat as a raw material for production of nutrient yeast. Amino acids obtained under the appropriate hydrolysis conditions can provide up to 10 percent more substances for the purposes of biomass accumulation and, moreover, they can stimulate this process.

In addition to RA and amino acids, organic acids serve as a source of carbon for yeast; their concentration in hydrolysates from complex upland peat (R=5-15 percent) is from 4.5 to 15 percent (5). Present in hydrolysates in significant quantities (36), succinic acid is characterized by high biological activity (37).

In addition to low molecular weight organic acids and amino acids, other physiological substances such as, for example, vitamins are also present in peat. Vitamins B_1, B_2, and B_{12} have been found in different quantities in peats of different origin (38,39).

The main source of vitamins in peat, soil, and sapropel is various microorganisms (38). These microorganisms exist in these environments as complex

associations, and they are highly diverse depending on the ecological conditions (40). This is the reason for the diversity of the vitamin composition of peats, which has been studied very little as yet. Further biochemical analysis of greater detail will have great significance to assessing peat as a hydrolytic raw material.

Despite the great differences in chemical composition (41), we can conclude that in relation to the concentration of hydrolyzable substances peat does not differ from other forms of plant raw material. In this case we should note that the composition of polysaccharides in some forms of agricultural plant wastes includes more pentose sugars, while peat hemicellulose is dominated by hexose monosaccharides--a more valuable source of yeast nutrition.

Inasmuch as during formation of peat the most diverse species of bog plants undergo change in heterogeneous conditions and, consequently, in different directions in the presence of a broad spectrum of microorganisms, the chemical composition of peat is more complex than that of wood. Nonreducing components contained within peat hydrolysates (organic acids, amino acids, vitamins) can not only be successfully consumed by living microorganisms but also stimulate their growth, increasing the yeast biomass yield to 65.5 percent of the RA (23).

While to evaluate peat as a raw material with which to obtain nutrient yeast we limit ourselves today to determining the quantity of reducing agents, in the very near future we will also have to consider the composition of the nonreducing part, especially the biologically active substances, which will make it possible to use peat characterized by a high degree of decomposition as well as other types of peat in yeast production.

There is another positive factor that should be noted in the use of mildly decomposed peat to obtain nutrient yeast--concentration of the peat in large quantities over relatively small territory, which precludes the need for conveying it long distances.

All of these data attest to the fact that upland peat characterized by a mild degree of decomposition is a fully adequate raw material for hydrolytic industry.

After analyzing the results of numerous studies, the Belorussian SSR Academy of Sciences Peat Institute developed interim specifications on peat as a raw material for hydrolysis with concentrated sulfuric acid, permitting utilization of total RA of the readily and poorly hydrolyzable parts. According to these specifications peat must be characterized by the following indices: 1) Peat type--upland; 2) peat species--sphagnum and (sheykhtseriyevo)-sphagnum; 3) degree of decomposition--not more than 20 percent; 4) yield of total RA--not less than 45 percent of organic mass in peat; 5) ash content, no greater than 5 percent of absolutely dry peat (ADP). The only criterion for the usability of sphagnum and (sheykhtseriyevo)-sphagnum peats with a degree of decomposition below 15 percent as a

hydrolytic raw material is the species of peat, and for these same species of peat with a degree of decomposition of 15-20 percent data must be available from an analysis of the RA yield, obtained in accordance with the specific method developed by the Peat Institute, presented below.

Selected peat samples are dried in air to an air-dry state, pulverized until able to pass through a 1-mm mesh sieve, and stored in hermetically sealed containers. The moisture and ash content of the peat are determined prior to hydrolysis. The concentration of organic matter in the sample taken for analysis is computed with the formula

$$S_{org} = \frac{S(100-W)\ (100-A)}{10,000},$$

where S_{org} is the weight of the sample's organic matter, gm, S is the weight of the sample of air-dry peat, gm, W is peat moisture content, percent, and A is peat ash content, percent.

Hydrolysis is performend in a 400-500 ml retort to which 2-3 gm of the material being analyzed and 4 percent H_2SO_4 (liquor ratio 1:100) are added. The retort, which is outfitted with a reflux condenser, is placed on an electric hotplate. Hydrolysis is performed for 3 hours, after which the mixture is filtered through thick filter paper into a 500 ml volumetric flask; the residue on the filter is rinsed with hot water until disappearance of the SO_4++ ion reaction, and the volume of the solution in the flask is increased with water to the mark. The residue is quantitatively washed into a weighed beaker, in which the mixture is concentrated by evaporation in a water bath until reaching an air-dry state. The moisture and ash content are determined in the residue. The yield of organic residue (S^1_{org}) is computed similarly as S_{org}. Then the yield of readily hydrolyzable substances is computed in the following fashion:

$$RH = \frac{S_{org} - S^1_{org}}{S_{org}}\ 100\%,$$

where RH is the concentration of readily hydrolyzable substances, percent of organic matter in the peat.

Oligosaccharides in the filtrate are subjected to additional inversion, for which purpose a 100 ml fraction is transferred with a pipette to the retort outfitted with a reflux condenser. Then 3.5 ml concentrated sulfuric acid (specific weight 1.83) are added to the retort to achieve an 8 percent solution, which is then boiled for 2 hours.

The RA yield is determined in the solution by the ebulliostatic method:

$$RA = \frac{X \cdot 500 \cdot (100+3.5)}{S_{org} \cdot 100} 100\%,$$

where RA is the concentration of RA in readily hydrolyzable substances, percent of organic matter in the initial peat sample, and X is the concentration of RA in the sample being analyzed, obtained with a ebulliostat, gm/ml.

Approximately a 1 gm sample of the residue obtained after separating out the readily hydrolyzable substances is placed in a glass weighing bottle, 80 percent sulfuric acid is added (10 ml acid for every gram of sample), the contents of the bottle are mixed thoroughly but carefully, and then the bottle is left for 2-2.5 hours at room temperature, mixing periodically. Next the contents of the weighing bottle are washed into a hydrolytic retort (150 ml) with distilled water, the reflux condenser is fitted on, and the sample is boiled for 5 hours, after which it is filtered through filter paper into a 500 ml volumetric flask; then the precipitate is rinsed with water and the volume of the solution in the flask is increased to the mark. The residue on the filter is washed off quantitatively into a weighed porcelain dish, subjected to evaporative concentration, dried to constant weight, and incinerated.

The concentration of RA in the poorly hydrolyzable fraction is determined with the filtrate:

$$RA_1 = \frac{X \cdot 500\, S^1_{org}}{S_{org}\, S^2_{org}} 100\%,$$

where RA_1 is the concentration of RA in the poorly hydrolyzable fraction, percent of organic matter in the peat, and X is the concentration of RA in the solution being analyzed, gm/ml (using the ebulliostat). In order to calculate the concentration of poorly hydrolyzable substances we would have to compute:

1) The weight of organic matter in the sample taken for determination of poorly hydrolyzable substances:

$$S^2_{org} = \frac{S^2(100-W_1)\ (100-A_1)}{10{,}000},$$

where S^2_{org} is the weight of organic matter in the sample, gm, S^2 is the weight of the sample taken for determination of poorly hydrolyzable

substances, gm, W_1 is the moisture content of the sample, percent, and A is the ash content of the sample, percent;

2) the concentration of organic matter in the nonhydrolyzable residue:

$$NHR_{org}=NHR_{dry}-A_2,$$

where NHR_{org} is the weight of organic matter in the nonhydrolyzable residue, gm, NHR_{dry} is the weight of the absolutely dry nonhydrolyzable residue, gm, and A_2 is ash weight after incineration of the nonhydrolyzable residue, gm. Then the concentration of poorly hydrolyzable substances (PH, percent of peat organic matter) is computed with the formula:

$$PH=\frac{(S^2_{org}-NHR_{org})S^1_{org}}{S_{org}-S^2_{org}}\ 100\%.$$

The concentration of the nonhydrolyzable residue (NHR, percent of peat organic matter) is computed with the formula:

$$NHR=\frac{NHR_{org}S^1_{org}}{S_{org}S^2_{org}}\ 100\%.$$

Summing the RA of the readily hydrolyzable fraction after additional inversion and the RA of the poorly hydrolyzable fraction, we get the total quantity of reducing agents.

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