Compensation for iodine deficiency conditions with drugs based on duckweed substrate

M. Kh. Sadulaev[1,*], *M. I.* Usmanova[2], *T. T.* Tataev[3], *A. M.* Inderbiev[4], *A. S.-A.* Zhamalullayla[5]

Kadyrov Chechen State University, Grozny, Russia

Abstract. Currently, one of the important problems for the entire population of Russia is the problem of iodine deficiency. This pathology is of significant relevance for residents of the North Caucasus. The growth of the goiter epidemic was provoked by the abolition of iodine prophylaxis from salt iodization in the 70s of the 20th century. In order to avoid an increase in morbidity, they began to develop and introduce not only iodine-containing preparations of chemical origin, but also medicines developed from iodine-containing plants acquired particular relevance. Iodine found in plants is well absorbed by the human body, as it is close to it in biological structure. The most common and generally accepted medicinal plants for the treatment of iodine deficiency conditions are white cinquefoil, sugar kelp and bladderwrack. These plants have a high content of natural iodine, but at the same time, the problem is a significant limitation of raw materials. That is why the search for new plant substrates with a high iodine content and the possibility of restoring iodine deficiency states is so important.

1 Introduction

One of the main places among the endocrine glands is occupied by the thyroid gland (Glandula thyroidea). Its most important property is the production of substances such as thyroxine and triiodothyronine, which contain iodine [1, 2]. These substances affect many processes occurring in the human body, for example, the metabolism of fats, proteins and carbohydrates. One of the main properties is an increase in the intensity of basal metabolism (calorigenic effect), the formation of easily combustible products.

These hormones are responsible for the development of the human body and its growth, regulate the functioning of the nervous system, promote the intensity of oxidative reactions in cells, and also balance metabolism.

If a person's body lacks iodine, hypothyroidism occurs. This disease causes disturbances in water-salt balance and the synthesis of glycosaminoglycans, which affects many body functions [3].

With hypothyroidism, the patient exhibits the following symptoms: swelling of the body and a yellowish tint of the skin, excess weight, deterioration of the skin (dryness) and hair condition, possible lethargy and apathy or depression, as well as fatigue and memory

*Corresponding author: as.imran2016@yandex.ru

impairment [4, 5]. With proper treatment, these symptoms and consequences are reversible. It is especially important to prescribe prompt therapy for a congenital disease, as it leads to serious irreversible changes in the entire body.

That is why one of the pressing problems is the issue of thyroidology. Diseases of the thyroid gland, leading to disruptions in the functioning of the entire body, take first place among diseases of the endocrine system. Consequently, new means and treatment options occupy an important place in the study of this problem [6-8]. The direction of studying new medicinal plants capable of accumulating iodine is considered promising. One such plant is duckweed (Lemna minor). Research has revealed that the plant contains many biologically active substances; iodine compounds, macro- and microelements, phytosterols, saturated hydrocarbons, aldehydes and ketones, fatty acids, amino acids and other biologically active substances are of particular interest [9].

For hypothyroidism, one of the traditional methods of treatment is herbal medicine. The most suitable medicinal plants for this are considered to be white cinquefoil, kelp and bladderwrack. Complete elimination of the disease is possible only with combined treatment using herbal and medicinal products.

Duckweed is the smallest flowering plant; methods of its distribution on a production scale, as well as its medicinal properties, have been little studied [10]. One of the important positive properties is its ubiquity.

The plant contains 35% proteins, 34% carbohydrates and about 12% fats, the rest is fiber. Duckweed has numerous medicinal properties and is used for a variety of ailments. It is a non-toxic plant, well tolerated by patients and has lasting results.

2 Research Methodology

The study of this topic was carried out on the basis of the laboratory and vivarium of the Stavropol State Medical University.

For a full study, animal models were used - white rats. The animals were kept in accordance with the rules adopted by the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1986) and the “Rules for carrying out work using experimental animals” (Appendix to the order of the USSR Ministry of Health dated 08/12/1977 . N 755) [54].

At the first stage of the study, the animals were fed a standard diet in accordance with the norms (compound feed granules, low-fat cottage cheese, carrots, greens from sprouted oats).

The entire study was divided into several stages. The first is the collection and preparation of medicinal raw materials from duckweed. The second is a study of the blood of rats for the content of thyroid hormones. The third is the administration of the drug “Mercazolil” to animals in the control and experimental groups to simulate the state of artificial hypothyroidism. The fourth is division into a control group (without treatment) and an experimental group (for the use of the duckweed drug “Lemnor”, “Potassium iodide” and the drug from kelp) (Table 1).

Table 1. Distribution of laboratory animals by groups.

Group number	Number of individuals in the group	Preparations for oral administration
1	5	Control
2	5	The drug "Potassium iodide"
3	5	The drug "Lemnor"
4	5	Laminaria preparation

Medicines were studied for safety and the possible presence of toxic substances. Safety was tested by forming experimental and control groups of clinically healthy animals that had undergone quarantine.

The study used duckweed (Lemna minor), grown for this purpose in laboratory conditions. The plant was sterilized to eliminate microorganisms. The substrate was dried after 7 days of duckweed germination. The raw materials were ground into powder.

Using the proportion method, we calculated the dose of iodine feeding for each drug: dosage of the drug “Lemnor” 0.75 mcg of iodine; dosage of "Potassium iodide" 0.63 mcg of iodine; dosage of the drug from kelp sugar is 0.85 mcg of iodine.

The drug was also studied for the presence of allergic reactions. Over the course of a week, the rats were administered drugs (kelp at a dose of 0.85 mcg, Lemnor - 0.75 mcg, potassium iodide at a dose of 0.63 mcg). No allergic reactions were detected, which allowed us to come to the conclusion that the drugs were harmless.

Before the start of the experiment, blood was taken from the animals to determine the parameters of the thyroid gland and pituitary gland. In rats, the background level of thyroid hormones (T3 and T4) and pituitary hormone (TSH) was determined by ELISA using standard test systems (Table 2).

Table 2. Levels of thyroid and pituitary hormones before the experiment.

Number of animals (white Wistar rats)	Hormones		
	TSH, mIU/l	T3, ng/ml	T4, pg/ml
N=40	0,03±0,0004	2,97±0,14	17,7±1,1

Over the course of two weeks, the administration of an aqueous solution of Mercazolil 500 ml/1 L caused a state of experimental hypothyroidism in animals of the control and experimental groups. Before administration of the drug, it was possible to establish negative dynamics in the levels of hormones T3, T4 and TSH in the blood serum (Table 3).

Table 3. Levels of thyroid and pituitary hormones after the experiment.

Groups of animals	Hormones		
	TSH (thyroid-stimulating hormone of the pituitary gland), mIU/l	T3 (triiodothyronine), ng/ml	T4 (thyroxine), pg/ml
1st (control)	0,2±0,04	0,52±0,08	2,0±0,18
2nd (“Lemnor”)	0,2±0,039	0,51±0,08	1,98±0,23
3rd (“Potassium iodide”)	0,21±0,02	0,52±0,08	1,99±0,21
4th (kelp)	0,21±0,02	0,50±0,1	1,99±0,21

Thus, the use of the Wistar Mercazolil line revealed a decrease in T3 and T4 by 18% and 12%, respectively. However, compensation for the secretion of thyroid-stimulating hormone occurred. The animals showed lethargy, rough hair, weight gain, diarrhea and other signs of deterioration in their general condition.

The next stage of the experimental study was the production of dosage forms for the treatment of the condition of experimental hypothyroidism. The preparations were made from such iodine-containing plants as:

- small duckweed;
- Potassium iodide;
- sugary kelp.

These drugs were fed to animals in the form of boluses for two weeks. Improvement in the condition of the animals began to be observed within a week: appetite appeared,

temperature was restored (it was elevated), diarrhea disappeared, hair and skin improved (dryness and dishevelment disappeared). At the end of the experiment, blood was taken from the experimental animals again. Hormone levels improved (Table 4).

Table 4. Hormone levels based on the results of feeding iodine-containing drugs.

Groups of animals	Hormones		
	TSH, mIU/l	T3, ng/ml	T4, pg/ml
1st (control)	0,22±0,07	0,49±0,1	1,8±0,21
2nd (“Lemnor”)	0,11±0,02*	2,73±0,05*	5,06±0,81*
3rd (“Potassium iodide”)	0,12±0,07*	2,61±0,1*	4,87±0,72*
4th (preparation from kelp	0,11±0,01*	2,74±0,04*	5,05±0,79*

Thus, we can come to the conclusion that after animals took iodine-containing drugs, a positive dynamics of increase in thyroid hormones was observed.

The results of the animals in the control group differed. An iodine deficiency developed, which reduced hormone levels and contributed to the appearance of a disease in the body such as hypothyroidism.

The experiment proved the effect of the drugs on increasing the level of hormones (T3 and T4) of the thyroid gland and decreasing TSH in rats of the experimental groups. All this confirms the positive effect of the drug on the functioning of the thyroid gland.

It was also determined that Lemnor was one of the most effective drugs for the thyroid gland.

3 Results and Discussions

Thus, based on the conducted research, we can come to the following conclusions. Due to disruption of the thyroid gland, a small amount of T3 and T4 hormones is produced, which in turn leads to the development of a disease such as hypothyroidism.

The causes of the disease can be different, but one of the main ones is a lack of iodine in the body.

With this disease, the patient experiences swelling of the entire body, a yellow tint to the skin, muscle pain, skin disorders (dryness), weakness of the body, apathy and lethargy.

Currently, all herbal preparations used for medicinal purposes contain white cinquefoil and kelp sugar. But since these plant species do not grow in all regions, this type of medicine acquires a high cost.

That is why it is so important to study the drug “Lemnor”, obtained from duckweed with a high iodine content.

The most effective effect of the drug (compared to others) on the thyroid gland has been experimentally established. Thus, the use of the drug as a dietary supplement is effective.

4 Conclusions

The thyroid gland produces substances such as thyroxine (T4) and triiodothyronine (T3), which in turn have an active effect on the entire human body. Thyroxine and triiodothyronine are hormones that affect almost all physiological processes. They are the main regulators of metabolism. Thyroxine and triiodothyronine are responsible for heart function, maintaining energy balance, thermoregulation, growth and development of all organs and tissues. The lack of these hormones negatively affects human health. Symptoms such as rapid fatigue and fatigue, stunted growth, decreased attention and even mental

retardation, deterioration of skin condition, brittle hair, and disruption of the cardiovascular system are observed. A deficiency of these hormones leads to the following diseases - endemic goiter and hypothyroidism.

To treat hypothyroidism, medications of both chemical and herbal origin are used. Currently, the development of plant substrates that can accumulate iodine is actively underway. A waterfowl plant, duckweed (Lemna minor), was chosen for the experiment. It is small in size and grows and reproduces quickly. It is actively used in folk medicine to treat many diseases. The chemical composition of duckweed is represented by a diverse set of macro- and microelements. Duckweed contains up to 6% calcium, 3% phosphorus, 2% magnesium, titanium, manganese, zinc, vanadium, radium. 100 g of dry matter of Lemna minor contains 4.8 mg of iodine compared to kelp, which in 100 g of dry matter can contain from 1.7 to 8.5 mg of biogenic iodine.

References

1. R. Bílek, M. Dvořáková, T. Grimmichová, J. Jiskra, Iodine, thyroglobulin and thyroid gland, 225-S236 (2020)
2. J. J. V. Branca, A. Lascialfari Bruschi, A. M. Pilia, D. Carrino, G. Guarnieri, M. Gulisano, A. Pacini, F. Paternostro, The Thyroid Gland: A Revision Study on Its Vascularization and Surgical Implications, **58(1)**, 137 (2022)
3. J. Xie, P. Wu, H. Liu, S. Zhang, Z. Lu, Thyroid gland invasion in total laryngectomy: A systematic review and meta-analysis, 106262 (2022)
4. B. Biondi, D. S. Cooper, Thyroid hormone therapy for hypothyroidism. Endocrine, **66(1)**, 18-26 (2019)
5. A. J. Wassner, Pediatric Hypothyroidism: Diagnosis and Treatment. Paediatr Drugs, **19(4)**, 291-301 (2017)
6. P. Perros, A decade of thyroidology. Hormones (Athens), **17(4)**, 491-495 (2018)
7. R. P. Tufano, A. K. Mohamed, The Year in Surgical Thyroidology: Recent Technological Developments and Future Challenges. Thyroid, **32(1)**, 14-18 (2022)
8. E. K. Lee, Y. J. Park, Best Achievements in Clinical Thyroidology in 2020. Endocrinol Metab (Seoul), **36(1)**, 30-35 (2021)
9. N. N. Zaiko, *Pathological physiology: textbook*, 538-568 (2007)
10. F. Petersen, J. Demann, D. Restemeyer, H. W. Olfs, H. Westendarp, K. J. Appenroth, A. Ulbrich, Influence of Light Intensity and Spectrum on Duckweed Growth and Proteins in a Small-Scale, Re-Circulating Indoor Vertical Farm. Plants (Basel), **11(8)**, 1010 (2022)
11. E. I. Dobrolyubova, The Manager, **12(2)**, 63-73 (2021)