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CONTENTS

MEDICINE

THE EFFECT OF THE TRACTION THERAPY ON PATIENTS WITH LUMBAR DISC DISEASE

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Abstract. *The goal of this research is to examine the efficiency of a set of physical factors with the inclusion of traction therapy in treating lumbar static and dynamic pain and the opportunities to influence the quality of life of patients with lumbar disc disease (LDD).*
100 patients with lumber disc disease participated in the clinical study. They were equally divided into a control group (CG), which has been treated with basic therapy (LFMF and IFC) and experimental group (EG) where traction therapy was part of the treatment protocol. For evaluating the effectiveness of the treatment was used quantitative assessment for static and dynamic pain and the quality of life before and after the treatment.
Results of both treatment protocols have statistically significant effect (p<0,001) in reducing low back pain and improving the quality of life. In comparison between the two groups, EG has a statistically significant (p<0,001) advantage over the CG.
The inclusion of extension therapy in basic physical therapy gives excellent results, contributes to a more significant reduction of pain and improves the quality of life of patients.
Keywords*: lumbar disc disease (LDD), physical therapy, traction therapy, LFMF (low-frequency magnetic field), Interferential current (IFC).*

Introduction. One of the most common reasons for hospitalisation is the back pain (12). In many cases the cause lies in degenerative-dystrophic changes in the vertebrae (6,7,13). Research shows that roughly 80% of the vertebral pain syndromes originate from the lumbar region (7,13,14). This is due to the area taking the biggest load while moving or resting (3,6). The physical therapy has mandatory part of the complex treatment of low back pain, because of its proven effectiveness. Recovering the statics and kinetics of the vertebrae is achieved mostly through physical therapy means (5,8). Lots of research shows that the inclusion of traction therapy to the treatment protocol offers faster improvement of both vertebral and neurological syndromes of the disease (2,4). This method is the only one with mechanical effect, which helps the removal of disco-radicular issue, causing the neurological materialisations of the disc disease (4,8).

The treatment of back pain through traction is known since the age of Hippocrates (17). The method is scientifically proven in the XIX century by the works of Charcot, Mitchell etc. Nowadays, traction therapy offers high efficiency potential, but only if using a rigorous protocol in regards to the therapy itself as well as following specific regime after the procedure (2,4). Traction therapy eases the load on intervertebral disc, back joints, normalizes the interjoint fluid exchange, improves the blood circulation in tissues and their metabolism. This leads to significant reduction of pain and improves the mobility of the lumbar mobile segments (4,8,9).

One of the modern ways to apply traction therapy is the impulse traction therapy using the apparatus of the Dutch company Enraf Nonium – Eltrak 471, which allows traction therapy in both impulse and constant mode.

The goal of this paper is to examine the efficiency of a set of physical factors with the inclusion of traction therapy in treating lumbar static and dynamic pain and the opportunities to influence the quality of life of patients with lumbar disc disease (LDD).

Subject and methodology:

100 patients with lumber disc disease participated in the clinical study. They were divided equally into two groups. The experimental group (40+ 4,5y) consisted of 18 women and 32 men, while the control group (41+ 4,9y) had 17 women and 33 men. Data from CT scan and NMR shows that the patients has disc protrusions and hernias. The lumbar disc pathology in 10% of the cases was in L3-L4 level, 25% in L4-L5, 40% in L5-S1 and the remaining 35% in more than 2 levels.

Main criteria for inclusion of patients in the study: age 18-55; presence of low back pain; proven degeneration of the spinal discs in the lumbar region – disc protrusions and hernias; onset of the disease no more than two years, no surgical treatment

Criteria for exclusion of the study: patients bellow 18 years of age; individuals with a pacemaker, neoplasm, infectious or other diseases, which are contraindicative of conducting physical therapy; presence of severe spinal pathology such as tumors, compressive fractures, infections, severe arthritic changes (bone bridges) etc.; presence of symptoms of root compression-Lassegue below 30º; reduced reflexes and senses, paralysis and paresis; pregnancy; rhythmic pathology; surgery in the lumbar region.

The basic treatment protocol consisted of interferential current (IFC), using the bipolar method and low-frequency magnetic field (LFMF). Through randomization, the patients were equally divided into two groups – a control group (CG), which has been treated with basic therapy (LFMF and IFC) and experimental group (EG) where traction therapy was also part of the protocol. The EG protocol consisted of the following procedures in their sequence: Magnetic therapy with the following parameters: 16 000 A/m, 1Hz, 0,2s, 15-20 mins,10 procedures; Bipolar IFC by paravertebral positioning of the electrode levels (L1-S1) with parameters 90-130Hz – 15 mins; Traction therapy for 20 mins; Rest for 2 hours in Williams posture (upper body laying down, legs elevated on a stool folded in 90º in the knee and tight joint) in order to turn the lumbar lordosis into kyphosis and unload the pressure of the lumbar spine; After the procedure, the patient puts an orthopedic corset on his lower back; Number of procedures: 10.

The pulling pressure is dependent upon the level of degenerative-dystrophic changes and the pain syndrome, the stage of the disease as well as patient's weight. Traction treatment is performed in an impulse manner, which reduces the risk of developing spinal imbalance.

To track the effect of the treatment were used the following clinical methods: For subjective assessment of the pain before and after the treatment – the static scale of Borg and the dynamic scale of Merl d'Aubigne, following T. Todorov's protocol (11). The quality of life assessment is done by the Roland-Morris test (18).

Results. Before the treatment the average values of the Borg's scale are very close, because of the randomized selection of the group's members. The comparison between the group's results by Paired Samples T-test, one and three months after the therapy shows a statistically significant ($p<0,001$) superiority of the EG (Figure 1).

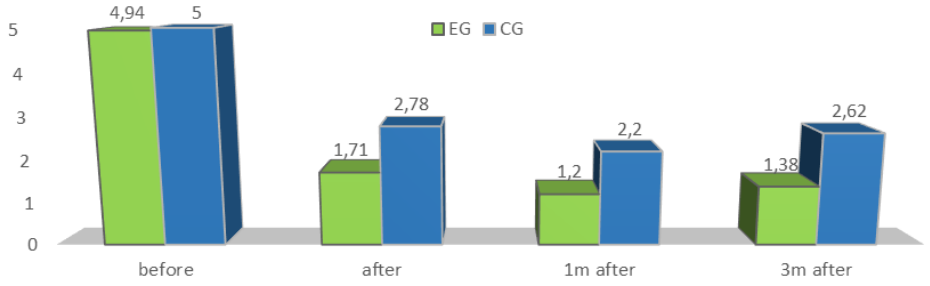

Fig. 1. Assessment of the static pain through Borg's scale

After analyzing the data of average values for the dynamic pain, through the Merl d' Aubigne scale in both groups a statistically significant improvement was found in both groups. However, the results in the EG have an average value of 1,12, compared to 2,12 in the CG, which is a statistically significant difference in favour of the EG (Figure 2).

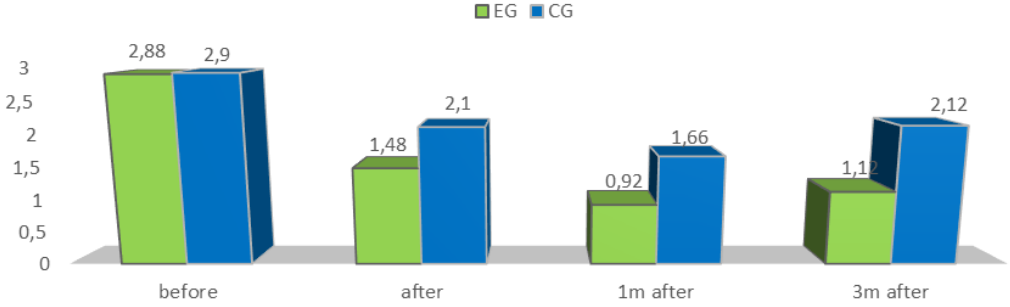

Fig. 2. Assessment by the modified scale of Merl d' Aubigne for dynamic pain

The analysis of the results of both groups from RMDQ shows that both groups register statistically significant improvement. The results in the EG are 12,18 and 4,44 before and after the treatment, respectively (p<0,001). At the same time, CG's results are 12,16 before and 5.82 after the treatment (p<0,001). This proves the improvements regarding the quality of life of the patients with superior results of those in the EG. The latter group keeps improving after the therapy with RMDQ scores of 4,02 and 4,2 one and three month after the treatment, respectively. These results reveal the lasting effect of the complex treatment with traction therapy. The CG's results also show slight improvement one month after the treatment with a score of 5,52 and 5,68 after three months. When comparing the results between the two groups, the difference is statistically significant (p<0,001) in favor of the EG (Fig. 3).

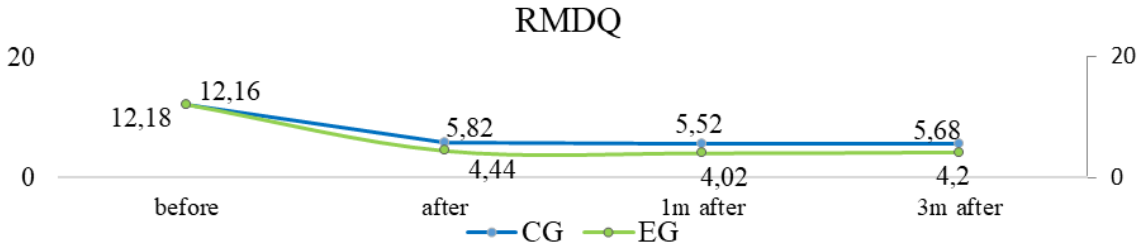

Fig. 3. Dynamics of the results from RMDQ in patients from EG and CG

The results reaffirm the hypothesis of traction therapy as a successful addition to basic therapy in the treatment of patients with LDD.

Discussion. The results from the study clearly show that both treatment protocols yielded favourable results and reduced both static and dynamic pain as well as improved the quality of life of the patients. The results of the EG are superior to those of the CG. The lasting decrease in static and dynamic pain in patients from EG leads to increased mobility of the individuals, due to far less pain while being active (15,16). We relate the obvious superiority, regarding pain reduction, of the protocol used in EG with traction therapy's specific impact over the main causes of pain. This more pronounced effect is due to the decompression of afferent nociceptive conductors in the area of impact and also because of subsequent permanent muscle relaxation and unblocking of intervertebral joints.

Traction therapy is the only conservative method that is applied on local level pathogenically (2). The topographical anatomic changes that emerge as a result of the reduces pressure of the intervertebral disc on the anterior internal venous plexus and the posterior longitudinal ligament lead to decrease of the venous and cerebrospinal fluid stasis, reduction of root and intervertebral ligament swelling (4,9). Due to those changes the irritation of the venous nociceptors and the meningeal branch of the spinal nerve (sinuvertebral nerve) is reduced, i.e. the pain trigger mechanism is eliminated. There are also indications of recovery in the mobility of the lumbar mobile segments and elimination of the blockages in the intervertebral joints.

Conclusions. Both treatment protocols improve significantly the condition of the patients, but the addition of traction therapy yields superior result as evident from the assessment in both groups.

The results from this study prove that the inclusion of traction therapy in a complex physiotherapeutic program benefits patients with lumbar disc disease in terms of reduced pain syndrome and improved quality of life. The proper application of traction therapy has its place in the complex treatment of lumbar disc disease.

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EARLY IDENTIFICATION OF THE NEUROLOGICAL COMPLICATIONS OF DIABETES MELLITUS

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Abstract. *Diabetes mellitus is still a very common disease in the world and affects the daily lives of patients negatively. Diabetes is also known to be associated with neurological diseases such as peripheral nerve diseases, stroke and dementia. Among these, the most common disease is a peripheral nerve disease, and it has been reported that poor diabetic control increases the risk of development and can be prevented by education of the patients. Vascular dementia is more common in patients with diabetes than Alzheimer's disease, and it is thought that cerebrovascular diseases may be related to cognitive impairment in diabetes. Although the mechanisms by which diabetes affects the brain are not clearly revealed, it is thought that changes in vascular structure, insulin resistance, glucose toxicity, oxidative stress, accumulation of glycation end products, hypoglycemic episodes and amyloid metabolism are effective. The aim of this article is to describe the neurological complications of diabetes and to emphasize the importance of patient education, good diabetes control and early diagnosis in preventing these complications.*

Keywords: *Biomanufacturing, biomaterial's, differentiation, human bone marrow mesenchymal stem cells.*

Introduction. Diabetes mellitus is still a very common disease in the world, negatively affecting the daily lives of patients and continues to be a serious economic burden, especially in countries where obesity is prevalent. It is estimated that diabetes affects 246 million people worldwide and approximately 20-30 million of these patients are affected by symptomatic diabetic polyneuropathy. Considering the increase in obesity rates and the related increase in the prevalence of type 2 diabetes, this number is expected to double in 2030. In young patients with type 1 diabetes, polyneuropathy may occur within a few months from the onset of the disease as a result of poor control of diabetes. Studies show that intense diabetes control reduces the prevalence of clinical neuropathy by 60-69%. Therefore, early diagnosis becomes very important (1-3).

Peripheral neuropathy. Peripheral neuropathy is the most common serious complication of diabetes. This form of neuropathy carries a high risk for pain, atrophic changes, and autonomic dysfunction. Currently, there is no effective treatment for diabetic neuropathy and good glycemic control only minimizes the risk of developing neuropathy in diabetic patients. When diabetic neuropathy occurs, loss of sensation in the feet can be detected, and patient education about the prevention of distal tragic complications is required (1).

Pathophysiology. Diabetic polyneuropathy occurs when there is an imbalance between nerve fiber destruction and repair. Nerve damage formation process mostly affects autonomic and distal sensory fibers. In addition to metabolic factors, ischemic factors and inflammation also have an effect on the development of diabetic neuropathy. While metabolic factors are effective in the long term, inflammation on ischemic nerve damage gains importance in severe forms of focal neuropathy. Ischemia also plays a role in the thickening and hyalinisation of small vessels with a decrease in endometrial oxygenation. Possible mechanisms in the formation of neuropathy are known as oxidative stress, nonenzymatic glycation, polyol and hexosamine pathways, protein kinase c pathway, poly (ADPribose) polymerase, reduction of neurotrophic factors and changes in ion channels, and central excitatory mechanisms. It is accepted that these pathogenic factors play a synergistic role in the development of neuropathy (2,3).

The forms of diabetic neuropathy can be defined according to the anatomical distribution (proximal or distal, symmetric-asymmetric, focal-Multifocal-diffuse), according to clinical course (acute-acute-chronic), characteristic features (painful-painless, sensory, motor or autonomic) or pathophysiologically can be classified (2).

Clinical characteristics of diabetic neuropathy. Chronic distal sensorimotor symmetric polyneuropathy is the most common form of diabetic polyneuropathy is chronic, distal (length

dependent) symmetrical polyneuropathy and is seen in 75% of patients with diabetic polyneuropathy. The initial symptoms of length-dependent distal polyneuropathy are numb, burning feet, stinging and electric shock. Symptoms are more pronounced at night and the burning is more severe with contact. Sensory neuropathy is completely silent and can be diagnosed by detailed foot examination, painless trauma or determination of topic changes such as burns or Charcot joint and plantar ulcers. Symptoms and signs in this pattern start from the distal of the lower extremity by first affecting the long nerve endings and gradually progress to the proximal and often affect the distal of the upper extremities after passing the knee level. Short sensory axons are then affected, and with their involvement, neuropathy is seen more proximally and on the anterior aspect of the trunk when distal sensory nerve fibers of the intercostal nerves are affected. Rarely, when the trigeminal nerve is affected, the complaints spread to the head area. If progression is not prevented, it is observed that almost all sensory modalities such as pain and heat disappear. Vibration and joint position sense are rarely affected, suggesting more thick fiber neuropathy. This distribution pattern is called the length dependent pattern. This neuropathy progression is not specific to diabetes and can be seen in alcoholic and amyloid neuropathies. In some patients, weakness and ataxia due to sensory loss draw attention as the main symptoms (1,2).

Lower extremity Achilles reflex cannot be detected on neurological examination. Various degrees of sensory loss are observed, and muscle weakness is more noticeable in the thumb and ankle dorsiflexion. Distal weakness is usually mild and rarely seen.

Sensorimotor neuropathy shows both demyelinating and axonal features in EMG. The earliest and most sensitive findings show up in nerve conduction studies, as a decrease in conduction velocity and amplitude. As neuropathy worsens, loss of sensory response can be seen. In motor conduction studies, a decrease in conduction velocity can be detected even in asymptomatic patients (3).

Selective Fine Fiber Neuropathy. Fine fiber neuropathy is characterized by pain and reduced sensation of heat and pain. Pain is described by patients as a burning, stinging, stabbing or pressing sensation. Patients often experience dysesthesia. Dysesthesia usually occurs in the big toe, but can also spread to the proximals of the lower extremities and upper extremities. Motor power, vibration, proprioception and muscle tension reflexes are preserved in this neuropathy. Nerve conduction studies in EMG are useful in the follow-up of this neuropathy and are not useful for diagnosis. Nerve conduction studies abnormalities occur when thick fibers are affected. Autonomic functions and thermal sensitivity may be useful in testing fine fiber function (3).

Autonomic Neuropathy. Autonomic neuropathy is one of the characteristic features of diabetic neuropathy and can be life threatening. Cardiovascular involvement usually begins with tachycardia at rest. Heart rate can return to normal in the long term, but responses to changing physiological changes are often not achieved. Postural hypotension is perhaps the most life-affecting symptom of autonomic neuropathy because of the syncope it can cause. Postural hypotension can be aggravated by tricyclic antidepressants used in the treatment of diabetic neuropathy and episodes of diarrhea. The strong association of cardiac autonomic neuropathy with silent myocardial ischemia and mortality is well known.

Gastroparesis seen in the gastrointestinal system is generally asymptomatic and may present with swelling from time to time and rarely with vomiting. Hypoglycemia attacks caused by food remaining in the stomach due to gastroparesis pose difficulties in terms of glycemic control. Diabetic diarrhea occurs at night and after meals and is characteristic of being watery. Fecal incontinence may accompany diarrhea.

Frequent urinary tract infections can be seen due to bladder atony and the large residual volume remaining in the bladder after micturition. Impotence is common in male patients. Left untreated, hypoglycemia can disrupt catecholamine release, complicating autonomic neuropathy. Abnormal pupillary responses such as mosses and decreased light reflex are also common findings in diabetes (1).

Focal and Multifocal Neuropathy. In diabetic patients, focal and Multifocal neuropathies are less common than length-dependent diabetic neuropathy. These forms of neuropathy are generally seen after the age of 50 and mainly in patients with type 2 diabetes. Focal neuropathies include cranial nerve involvement, limb and truncal neuropathies, and lower limb proximal diabetic neuropathy. In diabetic patients, development of sensorimotor deficits in one or more nerves, trunks, root or plexus is rare, and nerve biopsy may be necessary to exclude other causes of neuropathy.

Cranial Neuropathy. Acute onset 3rd and 6th nerve paralysis usually occur in elderly patients with poor glycemic control. Oculomotor palsy is the most common cranial neuropathy. In half of the

cases, it starts with severe pain around the eyes and behind. Oculomotor paralysis develops within a day or two. In diabetic 3rd nerve palsy, the pupil is usually not involved. Spontaneous and complete recovery is observed within months. Multiple cranial nerve paralysis is extremely rare.

Truncal Neuropathy. Truncal neuropathies can be unilateral or bilateral. It can start suddenly and rapidly with pain or dysesthesia, which is the basic clinical picture. Pain often has a radicular distribution and may worsen with touch and at night. Weakness can also be seen in the abdominal muscles.

Isolated involvement of the peripheral nerves in the extremities is extremely rare, except for carpal tunnel syndrome in which the median nerve is trapped. Diabetic polyneuropathy may facilitate the formation of entrapment neuropathies (4).

Proximal Diabetic Neuropathy of the Lower Extremities. This form of diabetic neuropathy, which is less common than distal symmetrical polyneuropathy, draws attention with its acute or subacute, noisy and often asymmetrical onset. The fifth is mostly seen in male patients over women and with weight loss. This syndrome was first described by Bruns in 1890. The disease usually begins with severe pain in one lower limb, mainly in the hip and thigh. Patients have difficulty walking and climbing stairs due to weakness in the quadriceps and iliopsoas muscles. In the early stage of the disease, the patellar reflex disappears due to quadriceps muscle weakness and atrophy. Most cases progress within a few weeks or months and then stabilize, then the pain subsides spontaneously, sometimes abruptly (regardless of glycemic control). The long-term prognosis is good. Nerve conduction studies usually give findings reflecting distal symmetrical neuropathy. Needle electromyography reveals intense partial denervation-reinnervation in the muscles innervated from the legend radix-plexus segments and paraspinal muscles of the symptomatic extremity. CSF protein is generally increased (1,4).

Multifocal Diabetic Neuropathy. Multifocal diabetic neuropathy is observed in a small proportion of patients with diabetes. There may be sequential involvement of the roots, lower extremity, trunk and upper extremity nerves within a few weeks or months, and sometimes a relapsing course may occur. The distal parts of the lower extremities are always involved bilaterally or unilaterally, and most patients may also have proximal deficits. Truncal and upper extremity nerves are less commonly affected (1).

Diabetic Neuropathy Treatment.

Preventive Treatment. Preventing diabetic neuropathy and preventing its complications is the best strategy. Optimum glycemic control reduces the development of peripheral neuropathy, but carries an increased risk of hypoglycemia. Pancreatic transplantation can stabilize neuropathy, but it is not routinely applied yet (1).

Chronic foot wounds of a diabetic patient are the common result of often unnoticed painless traumas, vascular insufficiency, and secondary infections. Patients with diabetic neuropathy should have their examinations repeated frequently, as their prevention is easier than their treatment. Appropriate treatment of developing wounds is very important in terms of preventing limb loss due to gangrene and systemic complications such as sepsis (4).

Symptomatic Treatment. Particular importance are treatments for symptoms of diabetic neuropathy, such as pain, autonomic disorders, and sensory loss. Pain control may be difficult in a length-dependent diabetic neuropathy and focal neuropathies. A combination of carbamazepine, phenytoin, clonazepam, and paracetamol codeine phosphate can be used. Tricyclic antidepressants such as imipramine and amitriptyline are often effective. Tricyclic antidepressants can aggravate postural hypotension. Recently administered duloxetine and pregabalin treatment is also beneficial (1).

Postural hypotension should be treated if symptomatic. Fluorohydrocortisone and midden can be used for this. However, it should be kept in mind that they carry the risk of hypertension (1).

Focal and Multifocal Diabetic Neuropathy Treatment.

Proximal diabetic neuropathy is often very painful, and the pain is often resistant to conventional treatments. In such cases, corticosteroid therapy can be given for a few weeks or months, together with the regulation of glycemic control. It should be kept in mind that the spontaneous prognosis of focal diabetic neuropathies may be good (1).

Central Nervous System Complications of Diabetes.

Cerebrovascular Diseases. Stroke is 2-6 times more common in patients with diabetes than in non-diabetic patients and plays a role in approximately 25% of deaths due to diabetes. The metabolic abnormalities of diabetes also negatively affect the existing stroke. Ischemic stroke is more common

than hemorrhagic stroke in patients with diabetes. It has also been reported that the risk of atrial fibrillation increases by 40% in diabetes (5-8).

The existence of high risk of stroke in diabetes depends on the complex relationships between various hemodynamic and metabolic components. Metabolic syndrome components such as insulin resistance, central obesity, impaired glucose intolerance and hyperinsulinemia are associated with an increased risk of stroke alone and in combination. Diabetic microangiopathy complications also play an important role in the pathogenesis of stroke, as they increase peripheral resistance and cause atherosclerosis. It is accepted that hemoglobin A1C (Hmg A1C) elevation and postprandial hyperglycemia are risk factors for stroke and increase stroke rates twice (5,6,8).

There is no significant increase in mortality in the first 3 months after acute ischemic stroke in diabetic patients compared to those without diabetes, and it is observed that the mortality rates increase in the first year after stroke. The risk of recurrent stroke also increases in these patients. Diabetes is also associated with increased rates of functional deficits in the long term after stroke (8).

Tight glycemic control is known to prevent microvascular complications, but the effects on macrovascular disease and stroke risks are unclear. Several studies have been conducted comparing strict glycemic control with standard glycemic control in stroke prevention. It has been reported that strict glycemic control does not reduce cardiovascular outcomes and stroke risk in most of them. Tight glycemic control has also been shown to increase the risk of hypoglycemia. Therefore, while providing glucose control, the patient's age, comorbidities and hypoglycemia risk should be taken into account (6,8).

Hyperglycemia is seen in 39-40% of patients after acute ischemic stroke. Most of these patients do not have a previous history of diabetes. In some patients, hyperglycemia is a marker of previously, but undiagnosed diabetes, while in most patients it is seen as an acute stress response and is called stress hyperglycemia. In this type of hyperglycemia, glucose levels return to normal after discharge. For this reason, HbA1c levels are useful in distinguishing patients with undiagnosed diabetes, since the high glucose level measured at the time of admission to the hospital cannot be differentiated from stress hyperglycemia and diabetes. Stress hyperglycemia often returns to normal after the acute period. The cause of stress hyperglycemia is the activation of the hypothalamic-pituitary-adrenal axis, the increase in glucocorticoid levels and activation of the sympathetic system (8).

Compared to normoglycemics, patients who are hypoglycemic at admission have a higher mortality risk during hospitalization and after 30 days. This risk is seen as a risk factor independent of other markers in terms of poor prognosis. This relationship between hyperglycemia and poor prognosis is mostly valid in patients with large infarct areas. Moderate hyperglycemia has been found to be associated with better prognosis in patients with lacunar infarction (8).

When the diabetic environment is mentioned, low grade inflammation, endothelial dysfunction, hypercoagulability, dyslipidemia and insulin resistance come to mind. With these factors, new hypotheses have begun to be developed about the pathogenesis of macrovascular complications. 4 different hypotheses have been developed regarding how hyperglycemia affects vascular structure and functions (6).

1. Increased oxidative stress and free radical damage
2. Formation of glycosylation end products
3.Glucose entering the aldose reductase pathway
4. Activation of one or more protein kinase C isoenzymes

With hyperglycemia, the formation of reactive oxygen metabolites (ROM) and insulin-resistant state is toxic to cells. ROMs such as superoxide anions form nitric oxide (NO) toxic peroxynitrite ions and reduce the availability of endothelium-derived NO. In this way, it causes a decrease in endothelial-mediated vasodilation, increased platelet activation, and proliferation and migration of vascular smooth muscles. ROMs also facilitate LDL accumulation in the vascular wall by increasing oxidation. Due to excess glucose, non-enzymatic glycosylation of various proteins and lipoproteins in the vascular wall accelerates the atherosclerotic process, which increases the uptake and oxidation of LDL in the cell and causes foam cell formation (6).

In the 2014 AHA Guideline, diabetes screening with a fasting glucose level, OGTT or HmgA1C is recommended in all patients after an acute cerebrovascular event (9). Studies have reported that hyperglycemia detected during admission and hospitalization is associated with poor clinical results and larger infarct volume. There are pilot studies showing that it is safe to reduce glucose aggressively with insulin therapy in the acute phase. However, it is not yet clear whether

keeping glucose levels at certain levels has a positive effect on the results. The biggest side effect of aggressive hyperglycemia treatment is hypoglycemia. Therefore, differential diagnosis of stress hyperglycemia and diabetes in acute ischemic stroke, treatment with hyperglycemia, but attention should be paid to recurrent hypoglycemia during treatment. The recommendation of the American Diabetes Association is to keep glucose levels between 140-180 mg / deal in all inpatients (6,8).

Dementia. Dementia is a syndrome that affects patients' memory, thinking, behavior and daily life activities. Alzheimer's disease is the most common dementia subtype, and it is considered a primary neurodegenerative disease characterized by neuritic plaques and neurofibrillary tangles. Vascular dementia is the second most common dementia syndrome and is seen after stroke with small vessel disease and chronic brain ischemia. According to the data of the World Health Organization, the number of patients diagnosed with dementia was 35.6 million in 2012, while this number is expected to increase to 65.7 million in 2030 and 115.4 million in 2050. Therefore, dementia emerges as an important public health problem. Because of its increasing prevalence and affecting many systems, diabetes is also seen as an important public health problem (10).

It has been reported in many epidemiological studies that patients with diabetes are at risk for cognitive impairment and dementia. However, in the studies, the subtypes of dementia could not be clearly revealed due to the mixed type of neurodegenerative and vascular pathologies of the patients and therefore contradictory results were obtained. Therefore, the true link between diabetes and dementia is still controversial, and the factors of cognitive decline are not yet clearly understood. In some population-based studies, it has been revealed that there is a relationship between diabetes and dementia. In a meta-analysis examining 18 studies, it was shown that diabetes increased all types of dementia on average 1.7 times (11). Looking at the subtypes of dementia, it is seen that diabetes is a significant risk factor for both Alzheimer's disease and vascular dementia. Some case-control studies have advocated a negative relationship between Type 2 diabetes and Alzheimer's disease and advocated a possible protective effect of high glucose levels on the brain (10-13).

Changes in the hippocampus, amygdala and medial temporal lobe are observed in cranial MRI in the early period in Alzheimer's disease. The decrease in hippocampal and amygdala volume in cranial MRI provides us important information in terms of the degree of Alzheimer's neuropathology. In the Rotterdam study, it was shown that the hippocampus and amygdala volumes in cranial MRIs of diabetic patients decreased compared to patients without diabetes. The relationship between diabetic factors and Alzheimer's disease neuropathology has also been demonstrated by pathological studies. In Hisayama's study, it was shown that after 2 hours OGTT, neuritic plaques increased and this relationship was more pronounced in APOEe4 allele carriers. In the light of these findings, it can be thought that hyperinsulinemia and insulin resistance worsen neuropathologies in Alzheimer's disease, especially in APOEe4 allele carriers.

The mechanism of the relationship between diabetes and dementia has not yet been clearly elucidated. However, considering that demographic and socioeconomic factors and genetic factors trigger different pathological processes in both diseases, as well as cardiovascular risk factors associated with diabetes, glucostoxicity, insulin resistance and inflammation, this relationship can be considered to be multifactorial (12).

Hyperglycemia can cause worsening in memory and attention. Chronic hyperglycemia may cause cognitive impairment and synaptic plasticity pathologies. With glucostoxicity, oxidative stress and the accumulation of glycosylation end products occur and after the formation of vascular damage, neurodegeneration begins in the brain. However, the role of strict glycemic control in the prevention of cognitive impairment is still controversial (14,15).

Studies have reported that hypoglycemia that develops in patients with Type 2 Diabetes is also effective in cognitive breakdown. It has been shown that the rate of cognitive impairment increases 1. 5-2 times in patients with recurrent hypoglycemia. It has also been reported that fibrinogen formation, together with neuronal death and platelet aggregation, can accelerate the cognitive degradation process in severe hypoglycemia (16).

Insulin resistance and hyperinsulinemia are partially associated with cognitive impairment due to vascular disease. There is evidence that insulin and insulin receptors play an important role in cognitive performance through modification of excitatory and inhibitory postsynaptic receptor activity and activation of specific signaling pathways. Insulin receptors are present in many parts of the brain,

including the hippocampus and cortex. It has been found that prolonged hyperinsulinemia impairs the insulin response due to the decrease in the blood-brain barrier and the number of insulin receptors in the brain, and inhibits insulin passage to the CSF and brain tissues. These changes create defects in learning and memory formation. Impairment of insulin sensitivity of the brain has been detected in Alzheimer's patients compared to healthy individuals. The insulin degrading enzyme breaks down both insulin and amyloid. In the case of high plasma insulin levels, destruction enzymes compete, reducing amyloid beta protein degradation and provoking amyloid accumulation (16,17).

Since the pathophysiological findings of dementia appear long before the symptoms, it may be beneficial to control the risk factors that may cause this, especially diabetes, in the early period.

In conclusion, diabetes is a common disease with serious complications affecting the nervous system. Early diagnosis and treatment in preventing complications

Is of great importance.

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PHARMACY

SCIENTIFIC APPROACHES TO THE DEVELOPMENT OF WOUND-HEALING SOFT DRUGS FOR THE TREATMENT OF SERVICEMEN AT THE HOSPITAL STAGE

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In the course of the Anti-Terrorist Operation in Ukraine, gunshot and combined wounds dominate in the structure of sanitary casualties among the combatants (around 86.9%); two thirds of these are limb wounds, combined wounds and head wounds, all of which require urgent and high quality medical treatment, including use of modern highly-efficient wound-healing preparations. Limb wounds which account for 53% dominate localization of patients'groups, and require urgent elimination of the development of the microflora in the wound, creating optimum conditions for the wound process to develop into the regeneration phase [3, 7]. Nowadays the practice of treating wounds under dressings makes possible a significant shortening of the systematic antibacterial therapy period, by searching and active introduction of new medical preparations with poly-factor effect and capable of mutually-potentiating and mutually supporting activity, which meet the current requirements of pharmaceutical safety and allow efficient local treatment of wounds in accordance with the stage of the wound process [1, 8]. The importance of developing wound-healing preparations with complex effects is conditioned by the increase in the number of post-operational infectious complications, resistance of microorganisms to antibiotics, changes in immune-biological responsiveness of the macroorganism, etc. [3, 6].

The search for active substances and adjuvants and methods of technology of production with consideration of physiological peculiarities of the wound surface are the main directions in the development of biopharmaceutics in the sphere of development and enlargement of the nomenclature of domestic soft medical preparations for treatment of the wound process [12]. Currently, vulnerary medical preparations are one of the most common pharmaceutical forms. They make up 10% of the total output of the production of ready to use formulations. Soft pharmaceutical preparations are used in different spheres of medicine for treatment, diagnosis and prevention of diseases (Swarbrick, 2013). They are characterized by relative simplicity and safety of usage, economical and technological effectiveness [13]. The regulation of pharmaceutical changing factors allows modification of the properties of pharmaceutical ingredients, facilitating their distribution on the wound surface, and prolonging their therapeutic effect, etc. [14]. The contact method of implementation of soft pharmaceutical preparations for treating purulent-inflammatory processes allows maximum concentration of the medical substance on the wound area. The method of soft medication introduction is considered the safest, for the greater part of the dose is on the surface of the wounded area [7, 15].

The aim of this article is to present research focused on the scientific grounding and development of a modern Ukrainian-made medical preparation with a complex effect for local treatment of wounds, in the form of an ointment, capable of anti-bacterial, anti-inflammatory and local anesthetic effect, and which does not require frequent changes in the treatment of wounded military personnel.

Materials and methods. Technological, physical-chemical and biopharmaceutical indicators of the ointment were calculated according to the generally accepted methods in accordance with the National Pharmacopoeia of Ukraine [9].

The pharmacotherapeutic effect of medical preparations for treating purulent-inflammatory processes is closely related to the nature, properties and quantitative ratios of the base components. Rationally selected components of the base can increase the therapeutic activity of the active pharmaceutical ingredients, support or impede its release and absorption, increase or decrease its pharmaceutical effect, affect its bioavailability and define various sideeffects, distinguishing the effect of the preparation (resorptive or surface [4]. The base is essential to the pharmacotherapeutic effect and pharmacokinetics of the preparation.

The base impacts the state, properties and the pathological process of the wounded area covered by the soft pharmaceutical preparation. Also, the base determines the consumer properties of the soft pharmaceutical [14]. Currently, pharmaceutical practice includes around 200 individual and combined ointment and gel bases, which possess different properties and correspond to different medical-biological purposes.

There is no perfect base, for provision of the base with required properties involves combining several adjuvants [4, 10]. As we know, ointments, creams for treating purulent-inflammatory processes, should at the same time possess multi-directional impact on the main etiopathogenetic factors of the inflammation, sufficient osmotic activity, preventing secondary infection [8]. Medical usage of the preparation is defined by the usage of the corresponding adjuvants and bases.

In treatment of purulent wounds it is necessary to consider that over the purulent-necrotic phase of the wound process, it is recommended to use soft pharmaceutical forms with a strong antimicrobial, anti-inflammatory, anesthetic and osmolar effect, which are capable of controllable dehydrating activity and impact on the release, bioavailability and therapeutic effect of medical substances [4, 10]. It is generally accepted that the manifestation of osmotic activity in anti-inflammatory preparations promotes dehydration in the zone of inflammation, which leads to decrease of edemas and accelerates the metabolic processes in the tissues [9].

The substances having these properties are polyethylene oxides of the base (from mixture of macrogols), which due to their bacteriostatic properties are resistant to microbial contamination, and also fully release medical substances and prolong their effectiveness [9, 10]. Bioavailability of the active pharmaceutic ingredients is not related to the temperature of the melting of polyethylene oxidal base and is conditioned only by the speed of dissolution of the bases and their diffusion. From the technological perspective, the advantage of polyethylene oxide (PEO) bases is high viscosity, which prevents the sedimentation of non-dissolved medical substances [11, 15]. Chemical indifference, thermal stability, absence of polymorphic modifications and resistibility to pH changes determine the suitability of polyethylene oxide bases for production of many pharmaceutical forms for treating purulent-inflammatory processes. The high affinity of the base to biological fluids in the organism (interstitial fluid) facilitates the full release of the active pharmaceutical ingredients from the pharmaceutical form over a certain period of time [14]. Considering the requirements of wound-treatment preparations, the usage of hydrophobic bases is not appropriate, for they minimize the dynamic processes of absorption, and, therefore decrease penetration and release of the medical substances [11]. Modern production of soft pharmaceutical forms for treating purulent-inflammatory processes prefers pharmaceutical preparations on hydrophilic bases, which can be applied to the wound surface without disturbing the perspiration. Active pharmaceutical ingredients are easily absorbed from such [4]; non-aqueous solvents in the base, which affect the penetrability of the cellular membranes and increase the absorbability of the preparation, contribute to this process.

Therefore, use of hydrophilic or combined bases which are highly effective in releasing active pharmaceutical ingredients is optimal for developing wound-treatment preparations. This is due to the fact that achieving optimum therapeutic effect in the wounded area requires mixing the base and the medical preparation with exudates of damaged tissues [7,8]. Pharmaceutical practice uses bases with elasticviscous flexible environment (emulsion of the I generation) and hydrophilic non-aqueous solvents and carbomer gels on the base of hydrophilic surfactants.

A no less important characteristic of the development of woundtreatment preparations is considered to be the use of I generation emulsion bases (oil/water), which are effective in contacting the wound surface, are capable of a cooling effect due to active evaporation of the water phase of the base, and are able to provide an anesthetic and soothing effect to a certain extent [5].

Recent biopharmaceutical studies on pharmaceutical preparations of local application have shown that with a well reasoned selection of the base, it is possible to provide a strong and sometimes intensified effect of the medical substances included in the compound. The authors introduced new polyethylene-based ointments (combinations of polyethylene oxides with molecular weight of 400 and 1500) into clinical practice. Polyethylene oxides are of low toxicity and express clearly visible osmotic properties [4].

Kadajji and Betageri [10] emphasize that polyethylene - based combined ointments are highly promising, being different from traditional preparations due, first of all, to their multidirectional effect. In particular, these preparations allow management of the intensity and the direction of the diffusion process after applying the formulation to the wound for differential usage at different stages of the wound process. The authors consider [12] that intensified efficiency of the prevention and treatment of the infectious complications in wounds is currently impossible without radically new combined ointments on modern bases, which include highly efficient antibacterial preparations: Levomycetin (Levosin, Levomecol), Dioxydin (5% Dioxydin ointment, Dioxycolum), Nltazolum (Nitacid) [2]. Also, the new ointments include such preparations as trimecaine hydrochloride for providing an anesthetic effect of the ointment and methyluracil, which is capable of anabolic and anti-catabolic activity for stimulating processes of cell. In our research, for achieving optimum pharmaceutical effect, particularly antibacterial, anti-inflammatory, and analgesic effects, the compound of the studied ointment included active pharmaceutical ingredients, which are commonly used and which proved to work well in dermatological and surgical practice: methyluracil CO_2 extract of chamomile, anaesthesin [2].

Choice of hydrophilic non-aqueous solvents in the cream. A number of authors [2, 9] mention glycerine as one of the most common hydrophilic non-aqueous solvents in production of pharmaceutical formulations of local application. It is able to affect the main technological and biopharmaceutical characteristics of a preparation. Also, glycerine is recognized as a classic moisturizing and softening pharmaceutical agent and is capable of being a penetrant and a solubilizer. When it is applied to the skin, this compound absorbs water from the subepidermal layers, forming a hydrogen bond with it. Therefore, it prevents the loss of moisture by keeping the water in the derma. Another significant peculiarity of glycerine is that its molecules structure the extracellular fluid and protect the cells against damage from excessively high osmotic impact. Moreover, glycerine increases transepidermal penetration of water and other substances [14, 15]. Like the other hydrophilic non-aqueous solvents, glycerine influences the frost-resistance and osmotic properties of the base, and also the absorption of active pharmaceutical ingredients.

Introducing glycerine to the compound of the developed pharmaceutical form was mostly conditioned by the necessity to heighten the moisturizing and softening properties of the base. These indicators were the main criteria. Also, the inclusion of glycerine in the proposed composition positively affects the following characteristics of the base: viscosity and other rheological indicators, speed of absorption of active pharmaceutical ingredients; adhesion on application; osmotic properties.

It should be mentioned that when using glycerine included in the ointment base, the phase of active osmosis is followed by the phase of “reverse osmosis”. This solvent is capable of a penetrating effect, which allows its molecules enter the aqueous environment through the membrane.

Due to these properties, glycerine allows the creation of ointment bases with a prolonged but a mild dehydrating effect [4, 14]. According to the authors, it is recommended that cosmetic and pharmaceutical preparations for external application should include glycerine as an active moisturizing component in the amount of up to 15%. At higher content, surplus glycerine forms a non-drying membrane on the skin. Generally, for providing moisturizing and alleviating properties, glycerine is used in concentrations of 5% or 10% [3].

Conclusions. Summarizing the accumulated experience in the treatment of wounds and current knowledge of biopharmaceutical aspects of the creation of soft drugs, it is concluded that successful prevention and rapid treatment of the specified pathological condition is possible with a comprehensive approach and use of common measures. Significantly increase the effectiveness of treatment of wound infection will allow the use of the basis developed by the authors for the combination cream, the composition of which is scientifically substantiated according to the pathogenesis of the wound process, taking into account its phase and nature of the microflora.

Current biopharmaceutical studies of topical medicinal products have proven that, with reasonable choice of carrier, it is possible to provide a pronounced, and sometimes enhanced, effect of

the drugs introduced into its composition. Physico-chemical studies have justified the optimal carrier for ointment - PEO-1500 and PEO-400 (1:4), whose osmotic properties ensure the elimination of purulent discharge. PEO-400, forming complexes with antimicrobial compounds, transports them to the depth of damaged tissues - the main sites of microbial localization, and PEO-1500 provides a uniform and long-term absorption of exudate.

Structural-mechanical studies have proved the concentration of emulsifier № 1 in the amount of 3,2%.

Determination of structural and mechanical properties of the cream base indicate that it belongs to structured systems, has thixotropic properties, which causes good consumer (ease and ease of application) and technological (packing) properties.

The results of biopharmaceutical research on the development of the basis of cream for the treatment of wounds may be the basis for the development of the cream and the conduct of clinical research and introduction into industrial mass production.

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CHEMISTRY

SURFACE MODIFICATION OF CANARIUM OVATUM ENGL. (PILI) SHELL AS ADSORBENT OF LEAD (Pb^{2+}) FROM AQUEOUS SOLUTION

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Abstract. *This study was carried out to investigate the efficiency of raw pili shell (RPS) and the surface modified pili shell using EDTA (EMPS) and oxalic acid (OMPS). A comparative study on the adsorption capacity of the adsorbents was performed against lead (Pb^{2+}) from aqueous solution.*
The adsorbents were characterized by FTIR, which showed higher peak of adsorption bands of carboxylic groups on the acid modified pili shells. Scanning electron microscope or SEM was also used to describe the surface morphology of the adsorbents. The linear form of Langmuir and Freundlich models were applied to represent adsorption data. The calculated equilibrium data of Pb (II) best fitted to Langmuir compare to Freundlich isotherm model with maximum adsorption capacity (qmax) of 27.03 mg/g and 45.45 mg/g using EMPS and OMPS, respectively. Kinetic sorption models were used to determine the adsorption mechanism and the kinetic data of all the adsorbents correlated (R^2 =1) well with the pseudo second order kinetic model. Among the three adsorbents, OMPS shown higher percent removal of lead compared to RPS and EMPS. The large adsorption capacity rate indicated that chemically modified pili shell in present study has great potential to be used as a cost-effective adsorbent for the removal of lead ions from the water.

Keywords: *adsorption, surface modification, heavy metal, isotherm modelling, kinetic modelling.*

Introduction. Heavy metal water pollution has been a major concern worldwide. It is a matter of concern as it causes various health problems that may lead to diseases and disorders in the human population through food chain. Heavy metals are toxic and have the tendency to bio-accumulate. It has been consistently desired that their levels be reduced in industrial and municipal effluents before ultimate repository in the ecosystem (Anwar et al. 2009). At trace level, metals like lead and zinc are necessary micronutrients but can be very deadly in higher concentration.

A wide variety of heavy metal species enters the aquatic compartment through atmospheric deposition, lixiviation of mining areas and cultivated fields, and industrial discharges, and these activities follow an upward curve in response to the world's ever-growing population and its needs (Castro 2011).

Metals cannot be 'degraded' biochemically and are therefore harmful for human health if consumed more than required (for trace elements) or permissible, which is usually in the order of ppm or ppb. Sources of heavy metals in the environment can be both natural (in rocks and soils) or of anthropogenic origin. The main anthropogenic sources are industrial activities such as mining, coal combustion and waste disposal (Chaterjee 2011).

There are several advanced methods for the treatment of heavy metals-contaminated wastewater. Activated carbon is undoubtedly considered as universal adsorbent for effluent treatment and is commonly used for the removal of various pollutants from water. However, its widespread use in wastewater treatment is sometimes restricted due to its higher cost (Gonen 2012). The main techniques which have been utilized to reduce the heavy metal ion content of effluents include lime precipitation, ion exchange, adsorption into activated carbon, membrane processes, and electrolytic methods. All these methods are generally expensive and have significant disadvantages including incomplete metal removal, requirements for expensive equipment and monitoring systems, high reagent or energy requirements, or generation of toxic sludge or other waste products that require disposal (Thirumavalavan et al. 2010).

However, these methods are not widely used due to their high cost and low feasibility for small-scale industries (Lasheen 2012).

Studies show that fruits and their products can be a possible avenue for waste water treatment.

Most studies on the binding capacity of cationic metals have been oriented towards fruit peels. In addition, to author's knowledge, none of these include any adsorption experiments using surface modified Pili shells (*Canarium ovatum* Engl.). The aim of this research is to obtain significant theoretical results for the creation of novel adsorbent of metal ions and reuse of Pili shells (*Canarium ovatum* Engl.) waste through chemical modification (introduction of carboxylic functional group).

Results.

Surface Modification of Pili Shell.

Fourier transform infrared (FTIR) spectrophotometer was used to characterize the surface functional groups of the raw pili shells (RPS), EDTA Modified Pili Shells (EMPS) and Oxalic acid Modified Pili Shells (OMPS).

Raw Pili Shell. The FTIR spectrum of Raw Pili Shells (RPS) is shown in Figure 1. It can be observed that a number of adsorption peaks were displayed in the spectra implying that the nature of the material is complex. The broad absorption peaks at 3416 cm^{-1} are indicative of the existence of bonded hydroxyl groups on the surface of the pili shell. This band was associated with the vibrations of hydroxyl groups in cellulose and lignin.

The peak near 1424 cm^{-1} was also attributed to a stretch vibration of C-O from carboxyl groups. The strong C-O band at 1064 cm^{-1} also confirms the lignin structure of the pili shell. The wide O-H peak at 3380cm^{-1} indicates the –OH stretching vibrations. The peak located at 1050 cm^{-1} is due to C-H and C-O bonds. The raw pili shell (RPS) showed a C=O stretched at 1747 cm^{-1}. The C=O stretched is found to be the attracting group of the Pb ions in the solution.

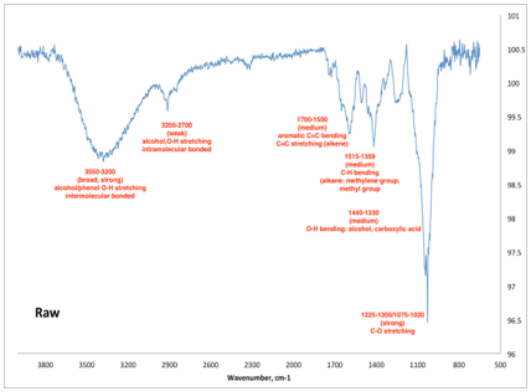

Figure 1 FTIR Result of Raw Pili Shell (RPS)

EDTA Modified Pili Shells.

Surface modification of raw pili shell was done using ethylenediaminetetraacetic acid (EDTA). The effect of EDTA modification is shown in Figure 2.

The wide O–H peak observed in both RPS and EMPS are due to the vibrational mode that being complicated by hydrogen bonding. The EMPS has shown a higher peak at 97.37cm^{-1} compared to the peak of RPS on the same band at 98.93 cm^{-1}. There is also an increase in the presence of O-H bending at peak of 97.52 cm^{-1} which implies presence of carboxylic acid from the medication.

In addition, it can be observed that after the modification of RPS by EDTA, there is an N-H stretch present near region of 3,310–3,500 cm^{-1}.

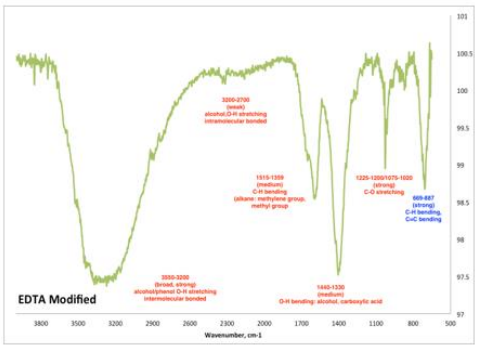

Figure 2 FTIR Result of EDTA Modified Pili Shell (EMPS)

Oxalic Acid Modified Pili Shells.

Raw pili shell was modified using oxalic acid (OMPS). Figure 3 shows the FTIR result after the surface modification of Pili shell. It can be observed that a presence of a medium to strong C=O stretching was found at 1735 to 1815 cm^{-1} with a peak recorded at 1725 cm^{-1}. The presence of C=O in the modified can be accounted to a higher adsorption of lead in the experiment compared to RPS and EMPS. Same with the surface of RPS, there is also a medium O-H bending observed 1330-1440cm^{-1} spectrum. The C=O and O-H may function as proton donors and deprotonated hydroxyl and carboxyl groups may be involved in coordination with cationic Pb^{2+} ions. The dissolved lead ions are positively charged and may be attracted by the anionic OMPS structure. This was also observed on the study of Thirumavalavan et al. using lemon peels and other fruit peels which clearly revealed that the carboxyl and hydroxyl groups content will influence the adsorption capacity, and the higher the content, the better the adsorption capacity.

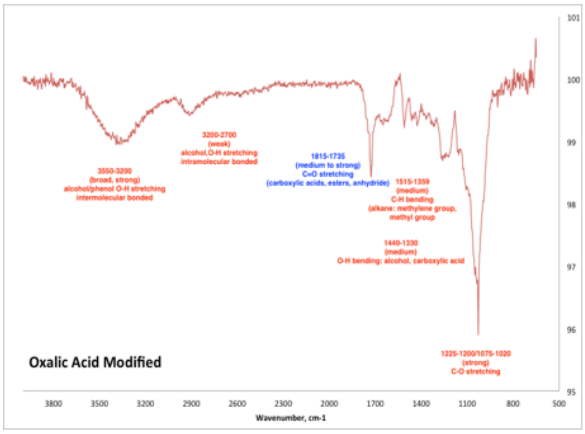

Figure 3 FTIR Result of Oxalic Acid Modified Pili Shell (OMPS)

Surface modification of raw pili shell (RPS) using oxalic acid result to appearance of a peak at 1729cm^{-1}. This appearance located between 1690-1760cm^{-1} confirms the presence of carboxylic group in the surface of raw pili shell. The carboxylic group may be accounted to the high adsorptivity of OMPS in the adsorption test of lead in aqueous solution.

The EDTA modified pili shell (EMPS) shown a very broad trough. The O-H bond can easily be recognized at 2500 - 3300 cm^{-1}. This O-H bond present in EMPS is the O-H bond of carboxylic acid that may explain better adsorption of the modified pili shell compared to the RPS.

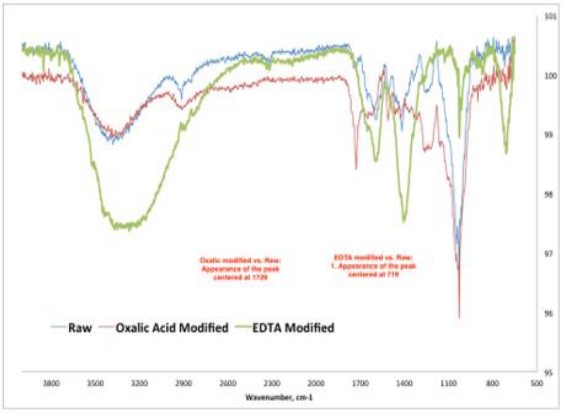

Figure 4 Comparison of the FTIR result of RPS, EMPS and OMPS

In addition to the characterization of the surface using FTIR, the surface structure of RPS, EMPS and OMPS was analyzed by scanning electron microscope (SEM). The scanning electron microscope enables the direct observation of the surface microstructures of the adsorbents.

The surface morphology of the raw pili shell (RPS) in Figure 5 revealed a smooth and compact with low porosity surface. The surface morphology of the samples as determined by scanning electron microscopy (SEM) show notable differences upon the modification of the surface using EDTA and oxalic acid as seen in Figure 6.

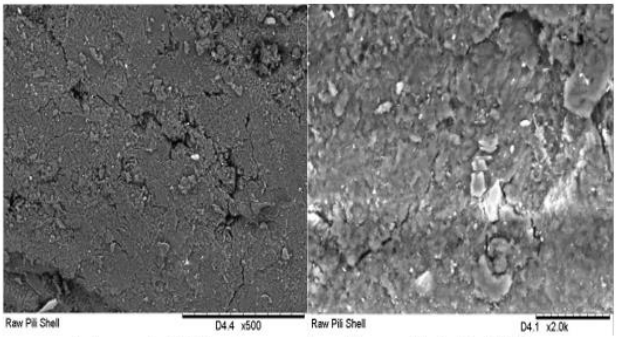

Figure 5 SEM micrographs of raw pili shell (RPS):
(A) x500 magnification (B) x2000 magnification

The modification of raw pili shell using EDTA resulted into fissures, narrow opening or cracks in the surface which represent some pore openings and cavities which may facilitate the solution flow into the pore and enhance the adsorption as shown in Figure 6a. In a higher magnification, Figure 6b revealed a spongy and more amorphous surface of the EMPS indicative of changes in surface area of the RPS. These irregular grooves and porous structure that might favor accessibility of Pb(II) to the adsorbent surface of EMPS.

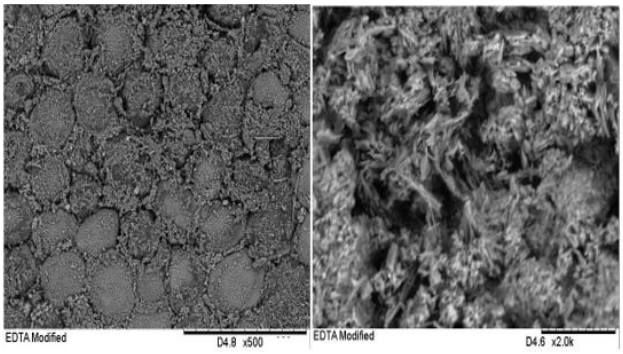

Figure 6 SEM micrographs of EDTA modified pili shell (EMPS):
(A) x500 magnification (B) x2000 magnification

Oxalic acid modified pili shell (OMPS) revealed the combination of small and large particle size, heterogeneous rough and porous surfaces with crater-like pores as shown in figure 7a. The surface of OMPS in figure 7b at higher magnification shows adsorbent surface is rough and porous, offering an easy access for metal ions diffusion inwards and being trapped

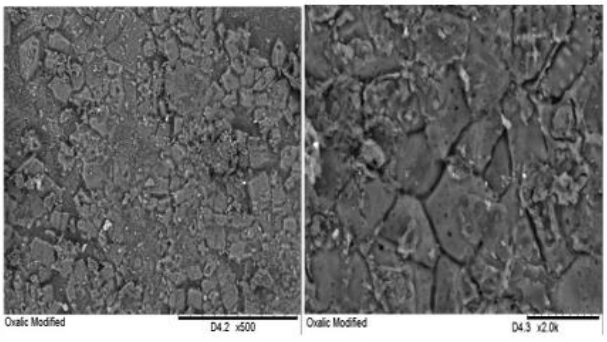

Figure 7 SEM micrographs of Oxalic modified pili shell (OMPS):
(A) x500 magnification (B) x2000 magnification

The particles having irregular shape and the surface exhibiting microrough texture are said to promote the adherence of toxic metal ions. More porous surfaces promote the adherence of lead (Annaduari et al. 2002).

Effect of pH of Pb in Aqueous Solution

Comparison of the effect of pH in the adsorption of RPS, EMPS and OMPS is shown in Figure 8. The highest adsorption of lead was observed using OMPS compared to EMPS and RPS. Although there is no significant variation in the amount of adsorbed lead from pH 1 to 9, it was

observed that adsorption is greater in higher pH. This phenomenon was also observed by Annadurai *et al* (2002). using banana and orange peels in the adsorption of lead where adsorption decreases at lower pH and higher in increasing pH. At low value of pH, the competition would be between the proton and metal ions on the active binding sites. The protonation of active sites therefore prefers to reduce the metal sorption as explained by Abdulrazak (2016).

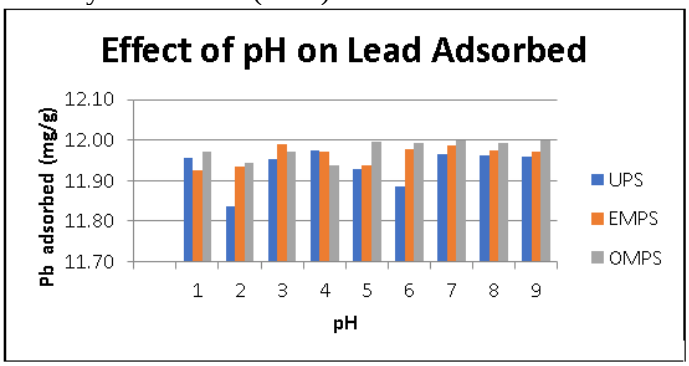

Figure 8 Effect of pH on Pb Adsorption

EMPS and RPS also exhibit the same adsorption property as OMPS. Using EMPS, it was observed that there is no significant variation in the amount of lead adsorbed from the solution. More so, the RPS also exhibits the same result. The amount of lead adsorbed by RPS has shown no significant variation from pH 1 to 9. Among all adsorption test using the three adsorbents, OMPS recorded the highest amount of adsorb lead at 12 mg/g.

Effect of Initial Metal Concentration on Pb Adsorption

The effect of initial metal concentration on the adsorption of lead was tested using the three adsorbents: RPS, EMPS and OMPS.

It can be observed that the result shows no significant variation on the amount of adsorbed lead from 100ppm to 500ppm concentration. However, 100% removal of lead was observed using OMPS at the lowest concentration of 100ppm and decreases gradually in higher concentration. EMPS also showed this phenomenon, as the percent removal of lead was recorded in the lowest concentration. This may be explained by the smaller number of available sites for adsorption as compared to metal ions present in solution. This was also observed in the study by Rajput (2015) using orange peels in the removal of lead.

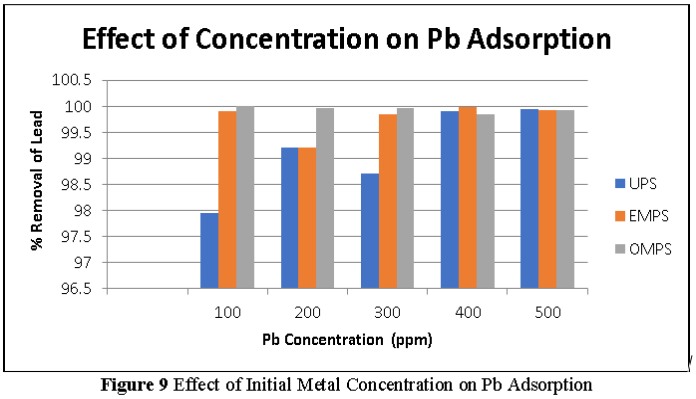

Figure 9 Effect of Initial Metal Concentration on Pb Adsorption

Effect of Adsorbent Size.

The effect of adsorbent size on lead adsorption was tested using the three adsorbents. Figure 10 shows that EMPS and OMPS recorded higher lead adsorption in smaller particles sizes using 40 and 60 mesh. Feng *et al*. (2004) observed that adsorption being a surface phenomenon, the smaller adsorption sizes offered comparatively larger surface area and hence higher adsorption occurs at equilibrium.

UPS on the other hand has higher adsorption on larger particle sizes. According to Charles and Odoemelam (2010) in their study on biosorption of Pb(II) and Cd(II) Ions from Aqueous Solution Crasstrotrea Gasar (Bivalve) Biomass, although one would expect that the smaller particle size should give a greater percentage removal because of the surface area, but as the particle size increased, the number of micro pores also increases. The increase in micro pores increases the number of the accessible sites, hence increases the percentage adsorbed.

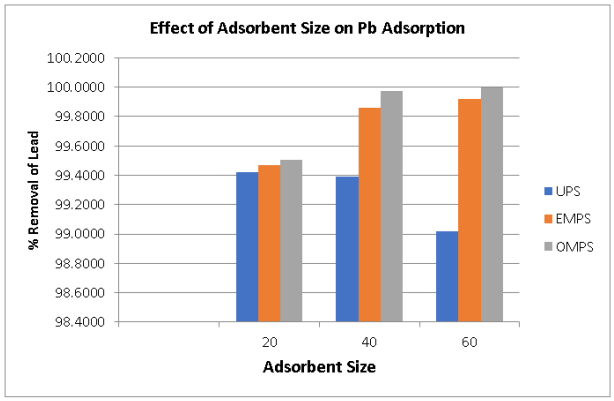

Figure 10 Effect of Adsorbent Size on Pb Adsorption

Effect of Adsorbent Dose.

As shown in Figure 11, the use of OMPS recorded higher adsorption in comparison with RPS and EMPS. More so, the lead adsorption of the three adsorbents in varying adsorbent dose showed no significant variation. Rajput (2015) concluded that it is apparent that the percent removal of heavy metals increases rapidly with increase in the dose of the adsorbents due to the greater availability of the exchangeable sites or surface area. Thus, these adsorption values of RPS, EMPS and OMPS may suggest that the adsorbents have abundant binding sites for lead in the solution.

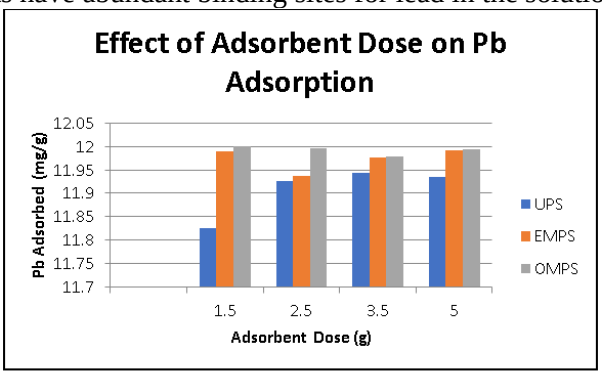

Figure 11 Effect of Adsorbent Dose on Pb Adsorption

Isotherm Modelling.

This study aims to provide an isotherm model using the three adsorbents as it is important to establish the most appropriate correlation for the equilibrium data. The Langmuir adsorption isotherm is a well-established model applied to different pollutants adsorption including heavy metals and widely use for the adsorption of different contaminants from a liquid solution.

The data gathered from the adsorption of raw pili shell (RPS) were fitted to Langmuir and Freudlich Isotherm Model. It can be observed that the correlation coefficient is higher using Langmuir equation (R^2 = 0.967) compare to Freundlich equation (R^2 = 0.867) This implies that the RPS involves a dominant monolayer adsorption.

Data result of EDTA modified pili shell (EMPS) were also fitted to the Langmuir and Freundlich Isotherm. The result shows that the EMPS correlation coefficient fitting the Langmuir model (R^2= 0.965) and Freundlich model (R^2= 0.866) are both high. The first model fits the adsorption of EMPS as the Langmuir model recorded higher correlation coefficient value, this implies that adsorption on a surface of adsorbent is compatible in quality. Same observation was reported in the study of Chanmalee (2016) using nitric solution activated pomelo peel for adsorption of lead.

The OMPS also shows higher Langmuir model correlation value of R^2= 0.967 compare to Freundlich model correlation value of R^2= 0.867. It can also be observed that all three adsorbents recorded higher R^2 value fitting in the Langmuir isotherm model. Yan *et al.* (2014) concluded that the Langmuir isotherm model suggests that all sites within the adsorbent are energetically equivalent, the interaction between molecules adsorbed on neighboring sites can be negligible, and the adsorbent surface is saturated after monolayer adsorption.

Langmuir Isotherm and related parameters are shown in Table 1. OMPS reveals the highest maximum adsorption capacity, qm, for complete monolayer coverage. It can be clearly observed that

all the R^2 (correlation coefficient) value of the three adsorbents are approaching to one (R^2> 0.9) and clearly suggest that adsorption was a monolayer adsorption with assumptions that metal ions are chemically adsorbed at a fixed number of well-defined site and each site can hold only one ion.

Table 1 Summary of Isotherm Parameters

Summary of Isotherm Model Parameters of Pb (II) on RPS, EMPS and OMPS						
Adsorbent	Langmuir Model			Freundlich Model		
	$k_{L, ads}$	q_{max} (mg/g)	R^2	$k_{f, ads}$	n	R^2
RPS	0.00128	25.64	**0.967**	$2.73x10^{-4}$	0.5158	**0.867**
EMPS	0.00125	27.03	**0.965**	$3.97x10^{-4}$	0.5178	**0.866**
OMPS	0.00124	45.45	**0.966**	$6.70x10^{-4}$	0.5192	**0.867**

Adsorption Kinetic Modeling.

The kinetic studies of lead adsorption on surface of raw pili shell (RPS), EDTA modified pili shell (EMPS) and oxalic modified pili shell (OMPS) were carried out using the pseudo first order and pseudo-second-order models on experimental data. The effects of initial lead concentrations were investigated to find the best fit kinetic model.

The kinetic constants and correlation coefficients of pseudo first-order kinetic model fail to give straight line with low correlation coefficient (R^2=0.145). Therefore, pseudo second-order kinetic model is preferred. The pseudo-second-order kinetic model was applied by plotting t/qt versus t, and this model gave high values of regression correlation coefficient (R^2=1). This implies that the mechanism of adsorption of Pb^{2+} ion on raw pili shell (RPS) follows the pseudo second-order kinetics indicating that the rate-limiting step was a chemical adsorption process between the metal ion and the adsorbent.

EMPS yields a low correlation coefficient (R= 0.190) for the Pseudo First-Order Lagergren Plot. The relationship between initial concentration and rate of adsorption will not be linear when pore diffusion limits the adsorption process. Same with the result of RPS in Pseudo First-Order Lagergren Plot, the EMPS yields a better fit on pseudo-second order kinetics with correlation coefficient of R^2=1. The plot of the linearized form (t/qt vs t) of the pseudo second order reaction of Pb (II) on adsorbent surface suggests that it relies on the assumption that chemisorption are rate limiting step.

Kinetic modelling of the OMPS was also fitted to pseudo first-order Lagergren model which yields to a correlation coefficient of R^2=0.678. According to Aderibigbe *et al.* (2017), the insufficiency of the first order model to fit the kinetics may be due to the limitations of the boundary layer controlling the adsorption. It was shown in Figure 4.22 that the date was best fitted into pseudo second-order Lagergren model that exhibits a far better degree on linearity R^2=1.

The pseudo-second-order kinetic model gave high values of regression correlation coefficient which implies that the mechanism of adsorption of Pb(II) ion on the OMPS follows the pseudo second-order kinetics. The same degree of linearity was also observed in the study of Aderibigbe *et al.* (2017) using citric acid modified plantain (Musa paradisiaca) peels in the adsorption of Pb 2+ in aqueous solution.

Table 2 Adsorption Kinetic Rate Parameters of the Adsorbent

Adsorption Kinetic Rate Parameters of the Adsorbents							
Adsorbent	First-order Kinetic			Second-order Kinetic			
	$k_{1, ads}$	qe Model (mg/g)	R^2	$k_{2, ads}$	qe Model (mg/g)	h	R^2
RPS	0.0023	$3.715x10^{-2}$	0.145	6.889	12.05	1000	1
EMPS	0.0069	$.4830 x10^{-2}$	0.190	2.296	12.05	333.33	1
OMPS	0.0552	$.0908x10^{-2}$	0.678	.8611	12.05	125	1

Where: qe(cal) = calculated equilibrium adsorption capacity(mg/g), k_1 = pseudo first order rate constant(L/min^{-1}), R^2 = correlation coefficient; k_2 = pseudo second order rate constant (g $mg^{-1}min^{-1}$), h = initial adsorption rate (mg/g min).

The adsorbents RPS, EMPS and OMPS all obtained a coefficient correlation value R^2=1 which implies that the pseudo-second order is the best sorption kinetic model for the adsorbents.

Conclusions. In this study, raw pili shell (RPS) was surface modified using ethylenediaminetetraacetic acid or EDTA (EMPS) and oxalic acid (OMPS) and used in adsorption test to determine their adsorption capacity.

The Fourier transform infrared (FTIR) spectrophotometer (FTIR- 2000, Perkin-Elmer, USA) analysis offers outstanding information on the nature of the functional groups present on the surface of the adsorbents.

FTIR confirms significant change in the surface of pili shell with the appearance of carboxylic group. New peaks were recorded in the OMPS significantly at 1729cm^{-1} implying the presence of carboxylic group that may be responsible for its adsorption profile. EMPS on the other hand shown a broad O-H group at 2500 – 3300cm^{-1} which means that the O-H detected is from a carboxylic acid. The presence of the carboxylic group in the surface of the pili shell may be accounted for its higher adsorption capacity compared to the raw pili shell.

The adsorbents were also subjected to scanning electron microscope (SEM) observe and compare the surface morphology before and after the surface modification of raw pili shell. It was observed that the EMPS and OMPS revealed a rough and more porous external surface in comparison with RPS. Even though all adsorbents exhibit good adsorption profile, the removal efficiency of EMPS and OMPS is higher in contrast to the raw pili shell. This implies that shapes and size of the particles in the adsorbent is an important factor in the exposure and availability of binding sites.

Batch experiments by varying conditions such as adsorbent dose, adsorbent size, initial concentration, pH, and contact time were conducted to provide an adsorption profile of lead in aqueous solution using RPS, EMPS and OMPS. Although, OMPS recorded higher percent removal in comparison with the other two adsorbents, result reveals that the three adsorbents exhibit a good adsorption capacity with minimal variation in the amount of adsorbed lead across different adsorbent size, pH, adsorbent dose and initial concentration.

Isotherm sorption and kinetic studies were conducted for the adsorption of Pb^{2+} ions from aqueous solution onto raw pili shell (RPS), EDTA modified pili shell (EMPS) and oxalic modified pili shell (OMPS). The equilibrium data have been analysed using Langmuir, Freundlich isotherms. The related correlation coefficients for each isotherm have been determined.

All the adsorbents best fitted in the Langmuir Isotherm model with correlation coefficient value approaching 1 (R^2> 0.9). This implies that RPS, EMPS and OMPS are following the Langmuir isotherm assumptions that metal ions are chemically adsorbed at a fixed number of well-defined sites and all sites are energetically equivalent.

The suitability of the pseudo second-order equations kinetic model for the sorption of Pb^{2+}ions onto RPS, EMPS and OMPS was also observed compared to pseudo-first. The pseudo second-order kinetic model agrees very well with the adsorption of Pb^{2+} ions onto the adsorbents. Thus, the type of adsorption is chemisorption based on the assumption that the rate-limiting step may be involving valency forces through sharing or exchange of electrons between the sorbent and sorbate.

These experimental studies on the three adsorbents would be helpful in developing a technology for the removal of lead ions from contaminated bodies of water. It may be concluded that raw pili shell (RPS), EDTA modified pili shell (EMPS) and oxalic acid modified pili shell (OMPS) may be used as a low-cost, natural and abundant source for the removal of Pb2+ ions from the wastewater.

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AGRICULTURE

RESULTS OF MANDARIN PLANTATIONS MONITORING DAMAGED BY FROST AND EVALUATION IN GEORGIA

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Abstract. *In the paper is discussed the results of mandarin plantations monitoring damaged by frost in winter. Despite the centuries-old history of citrus production in Georgia, the danger of frost damage remains a major limiting factor for the spread of citrus. The monitoring revealed that although the temperature was quite critical for mandarin in February 2020 (-11-12°C, in some places -14°C), the frost damage to the plantations was not high, but was inhomogeneous. Observations revealed that the damage to mandarin plantations was due not only to the impact of low temperatures, but also to many other factors that had a significant impact on the degree of damage to the plantations. Based on the analysis of monitoring results and multi-year data, it was found that the risk of frost damage to the citrus in winter in Georgia due to global warming is significantly reduced compared to previous years, but the incidence of autumn-spring frosts has increased which indicates the adaptation of the citrus crops to the climatic conditions of Georgia.*
Keywords: *Citrus, Frost, Breeding, Mandarin, Frost resistant, plantation.*

Introduction. The subtropical zone of Georgia (Black Sea coastline), where citrus crops are grown, is located farthest north of the subtropical zone and exceeds the geographical boundary of citrus distribution in the world. The climatic peculiarity of the Adjara region is determined by two main factors: The Black Sea, which accumulates heat in summer and gradually releases it along the coast, and on the other hand, the high mountains of the Caucasus, which prevent the entry of cold air masses from the north. Accordingly, in the subtropical zone of western Georgia, winters are moderately warm and characterized by abundant precipitation, where the sum of active temperatures ranges from 3500 to 5500, the average annual temperature reaches +14 + 15°C, the annual sum of atmospheric precipitation is from 1300 mm to 3000 mm, air humidity is 80-95%, and the minimum air temperature drops to -6-7°C in some years and sometimes even more (Elizbarashvili E. 2017).

Although the history of the spread of citrus crops in Georgia is related to the distant past and dates back to the 7^{th}-8^{th} centuries. It's spread for industrial purposes dates back to the early 19^{th} century. In different periods, up to 120 varieties of up to 20 species of citrus were introduced and studied in Georgia, and about 200 varieties of citrus, hybrids, clones and mutant forms were bred by Georgian breeders (List of var. 1990). Despite such diversity, the most adapted to the soil-climatic conditions of Georgia is the frost-resistant and high-yielding variety Satsuma mandarin (*Citrus Unshiu* Marcow). The variety originated in China (Hodgson R. 1967), and was introduced to Georgia from Japan. It covers 80% of the area occupied by citrus in Georgia, where about 20,000 farmers are employed (Baratashvili D., and Khalvashi N. 2016).

Cold tolerance in many plant species is not constitutively expressed. It is induced in response to reduction in daylength and the exposure to non-freezing chilling temperatures. A period of acclimation is important for inducing cold tolerance in Citrus. Most species in the genus Citrus are highly sensitive to low temperatures. Among commercial citrus fruits, Satsuma mandarin is known to be the most frost-resistant species. Studies by various scientists have shown that it can withstand -9.4°C temperature (Yelenosky G. 1985), -11.1°C (Gerber J. and Hashemi F.1965) and -11.0°C (Anderson J. et al., 1983).

It is known that frost resistance or the manifestation of the reaction norm (trait) are related not to one of the genes, but, like many other traits are encoded in the genetic machinery of plant cells and is controlled by many genes. These genes are dormant during the growing season and are activated only when the plant has a critical temperature and a light regime changes during the growing season (He L. et al., 2012; Lang G. et al., 2012; Zhang C. et al., 2005). Warm weather in the autumn prevents the plant from entering a dormant state and becomes more susceptible to frost (Davies F. and Albrigo J., 1994).

It is very important to produce frost-resistant varieties for the production of citrus, for which it is necessary to involve frost-resistant species in the selection processes. However, it should be noted that the use of frost-resistant species within the gene pool of citrus is complicated by many factors: prolonged juvenile (early plant growth) period, sexual incompatibility, polyembryonia (apomixis), heterozygosity, inbreeding (Grosser J. and Gmitter F., 1990; Soost R. and Cameron J., 1975; Soost R. and Roose M. 1990). Recently, genetic modification technologies such as protoplasm transformation (Fleming et al., 2000; Grosser J. and Gmitter F., 1990), particle bombardment (Yao J. et al., 1996), mediator agro-bacterial transformations (Luth D. and Moore J., 1999; Moore J. et al., 1992) and others, the use of which may lead to the formation of genotypes that will have both frost-resistant genes and genes that determine fruit taste and quality.

Proper selection of rootstocks is also important to increase the frost resistance of citrus fruits, as during the acclimatization process, gene expression takes place differently in rootstocks and grafts, leading to frost resistance of citrus (He L. et. Al., 2012; Zhang C. et al., 2005; Ping L., 2005). Frost replication genes have been identified in many species of the orange subfamily - *Poncirus trifoliata* (L), *C. grandis, C. paradisi, C. sinensis, C. Jambhiri* (He L. et al., 2012; Long G. et al., 2012; Richard L. 2005; Mehtap S. and Moore G, 2006). Studies have shown that the most frost-resistant rootstock is *Poncirus trifoliata*, which can withstand -30°C (Long G. et al., 2012) and is the most compatible among other related genera of Citrus and Poncirus. Its use as a rootstock increases the frost resistance of citrus fruits (Ebel R. et. Al., 2005; Huang Y. et al. 2011). Various frost-resistant species belonging to the genus Citrus have been studied and tested in the climatic conditions of Georgia (*Poncirus trifoliata* (L), *C. Insitorum Mabb, C. junos Yuzu Sieb. Ex Tan., C. Wilsoni Tan., C. Aurantium (L), C. ichangensis Sw., C. myrtifolia Raf., C. yuko Hor. ex Tan., C. reshni Tan.). Poncirus trifoliata* L. was considered to be the best among them, therefore all species of citrus in Georgia are propagated on the root of trifoliata (Tatarishvili A. 1980).

Material and methods. The aim of the study was to monitor mandarin plantations in the Adjara region after the frosty winter, to assess the degree of frost damage and analyze multi-year data. After the severe winter of 2019-2020, monitoring was conducted to assess the degree of damage to mandarin plantations in 2 municipalities of Adjara region (Kobuleti and Khelvachauri), which account for up to 70% of citrus fruits produced in Georgia. During the monitoring, we considered that the plantation was cultivated with the same mandarin variety (*Unshiu*). As the Adjara region is distinguished by the diversity of terrain, sometimes different temperatures are observed in the adjacent plots (neighbors), therefore we monitored both in the lowlands at 5-10 m above sea level and in high places (250-400 m). During the monitoring we took into account other factors such as: slope exposure, distance from the sea, the presence of a windbreak, garden age, soil type, garden care conditions, altitude, etc.

To assess the degree of frost damage under natural conditions, plantations were mainly monitored after the onset of wintering and growth renewal (vegetation period) in the spring and continued until the end of the second vegetation period. We made a final assessment of the degree of frost damage when the result of plant damage was fully identified.

The assessment took into account the general condition of the plantation and not the degree of damage to individual plants. We assessed the degree of damage to various organs of the plant (leaves, young shoots, main branches) visually, which was expressed as a percentage (from 1% to -100%). The final assessment of damage was made on a five-point scale (Surguladze Sh., 1975).

- the plots where no damage was observed was assessed with - 0 point;
- the plots that had damaged 50% of the leaves and roughed only part of the tips of young shoots (twigs) were assessed with - 1 point;
- the plots that had damaged 100% of the leaves and young shoots (tips of twigs of the 2nd vegetation) were evaluated with - 2 points;

- the plots that had 100% damaged leaves and 100% of annual growths were evaluated with - 3 points;

- the plots that had damaged leaves, main branches and part of the stem were evaluated with - 4 points;

- the plots that were completely damaged, up to the root collar were evaluated with - 5 points;

Results and Discussion. Low temperatures remain the main risk factor for citrus production in Georgia. The subtropical zone of Adjara region is characterized by quite abundant rainfall and minimal winter temperatures, which are mainly manifested in autumn and spring. This is the period with the highest risk during the annual cycle of plant growth and dormancy, as citrus fruits are most exposed to the negative effects of low temperatures and are damaged during this period. Although there are many ways to prevent frostbite today, it is costly and most Georgian farmers are unable to take preventive measures.

In the subtropical zone of Georgia (Adjara) November-December 2019 were characterized by quite warm and humid weather, which caused the late transition of citrus to winter rest. Added to this was the fact that in 2019 mandarins were abundantly harvested, so the nutrients produced by the leaves were completely spent on fruit formation, the vegetative organs failed to prepare for winter and the plant was delayed to a resting state, which had a significant impact on the degree of damage.

At the end of January 2020, cold air masses began to enter Georgia from the north, which led to a sharp drop in temperature and in most parts of the subtropical zone of Georgia (citrus distribution zone) in February the minimum temperature dropped to -10°C, in some places -11-12°C, and in some parts - Reached 14°C. Added to this were rainless and cloudless weather, which further increased the likelihood of citrus freezing.

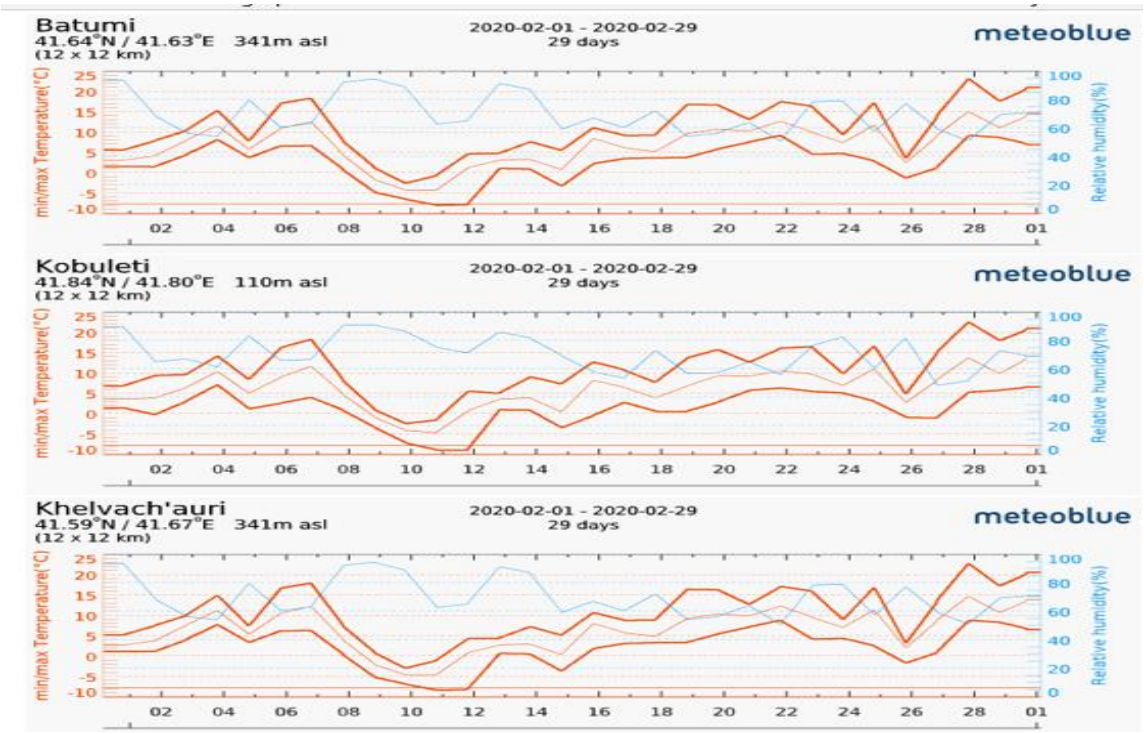

Fig.1. Meteorological data for February 2020 according to different municipalities

The diagram shows the temperature of 2 municipalities of Adjara region (Kobuleti, Khelvachauri) and the city of Batumi in February 2020. These data represent the average indicators of the subtropical zone of Adjara, although they do not fully reflect the situation in individual plantations, which had a significant impact on the quality of frost damage in different terrain conditions. As the subtropical zone of Adjara is characterized by diversity of relief, so the minimum temperatures could not be similar even in adjacent plots, therefore the quality of frost damage of mandarin plantations in the Adjara region was heterogeneous.

Table 1. Degree of frost damage in plantations with different relief in Adjara region according to different villages

Municipality	Populated area (village)	Coordinates	M. asl	Min. Temperature (°C)	Distance from the sea in m	Degree of damage (points)
Khelvachauri	Sarpi	41°63′37″ N 41°63′19″ E	60	-8	50-105	1 point
	Gonio	41°55′00″N 41°56′19″ E	50	-8	30-600	1 point
	Akhalisopeli	41°57′09″ N 41°59′14″ E	130	-9	2500	1 point
	Makho	41°33′24″ N 41°40′09″ E	15	-10	3000	3 points
	Akhalsheni	41°37′38″ N 41°43′14″ E	140	-11	9000	1 point
	Makhvilauri	41°35′57″ N 41°39′36″ E	185	-11	2000-2500	1 point
	Peria	41°38′00″ N 41°39′05″ E	207	-9	1500-2000	0 point
	Ortabatumi	41°38′58″ N 41°43′26″ E	160	-10	1200-2500	0 point
	Agara	41°39′05″ N 41°44′03″ E	380	-10	3500-5500	2 points
	Makhinjauri	41°40′18″ N 41°42′27″ E	45	-9	500-1500	0 points
Kobuleti	Dab Chakvi	41°70′31″ N 41°72′50″ E	10	-12	500- 700	3 points
	Tsikhisdziri	41°76′075″ N 41°65′150″ E	90	-10	900-1200	1 point
	Bobokhvati	41°46′22″ N 41°47′37″ E	110	-10	800-1600	1 point
	Alambari	41°83′32″ N 41°86′98″ E	180	-9	6600-7200	1 point
	Achkhvistavi	41°82′27″ N 41°90′76″ E	260	-11	6200-7500	3 points
	Mukhaestate	41°83′98″ N 41°81′81″ E	90	-10	4200-5000	2 points
	Tskhavroka	41°51′10″ N 41°53′21″ E	180	-11	8000-8400	2 points
	PBI	41°48′40″ N 41°46′31″ E	8	-14	800-1000	4 points
	Khutsubani	41°48′13″ N 41°49′55″ E	190	-11	3000-4500	1 point
	Kondidi	41°48′51″ N 41°52′33″ E	130	-11	5000-5200	2 points
	Khala	41°42′34″ N 41°47′50″ E	150	-11	6400-7100	2 points

Although we monitored mandarin plantations of up to 250 farmers, the table shows only about 20 plots. In order to get a complete picture of the extent of damage in the subtropical zone of Adjara region in frosty winter conditions, we have included in the table the plots that sharply differed from

each other: location, proximity to the sea, different altitudes, slope exposure, different soil types, the presence of a windbreak, temperature indicators, garden age, where an accurate assessment of the degree of frost damage was carried out.

The monitoring revealed that although a risky temperature for mandarin crops (-10-11°C, in some places -12-14°C) was observed in Adjara region in February 2020, it was not found to be very damaging. Although the degree of frost damage in mandarin plantations was not very high, it was heterogeneous. The degree of frost damage in mandarin plantations with the same temperature but different terrain conditions was significantly different from each other, which is due to the special diversity of the terrain of Adjara, but frost resistance is due to its genetic characteristics and many other factors, such as: plot location, soil type, slope exposure, slope, wind direction, wind speed, garden age, plant habitat, vegetation, leafing frequency, agro-technical works carried out in the garden, number of frosty days, etc.

Most of the 250 observed plantations, the experimental-collection plot of the Institute of Phytopathology and Biodiversity (FBI) in Kobuleti Municipality was damaged (4 points). 100% of leaves, 1-and 2-year-old seedlings and main branches were damaged. Although the temperature of -14°C was observed in the mentioned plot, the high degree of damage was not only due to the low temperature. The experimental plot was young (3 years old), planted at the lowest point above sea level (5 m asl), on silty soil (there was a lack of moisture), there was no windbreak and cold air masses rising from the mountain easily reached the plot area. Despite 4 points of damage to the mentioned plot, 90% of the plants survived and gave us sprouts in the spring.

Mandarin plantations in Kobuleti municipality – Daba Chakvi (5 m asl) were significantly damaged (3 points), where the warming effect of the sea was limited by small hills, the plot was located in the valley and suffered from the cold air masses of the mountain. Particularly sensitive and significantly damaged (3 points) were the plots (Makho, Achkvistavi) that were cultivated along the river valley and were severely affected by the cold winds of the forests.

The plantations that were cultivated on the steep slope of the northern exposure (Tskhavroka, Alambari, Achkvistavi, Agara), where water was drained from the slopes, were damaged by 2 points. These processes led to soil water depletion and consequently plant plasma was depleted of water, resulting in increased concentration in cell sap and increased acidity. This led to the coagulation of a protein substance in the plasma, which was accompanied by a frost period and the plant was damaged by frost. Plantations on dry and swampy soils where there was frequent water shortages, were also damaged by 2 points.

Despite the rather low temperature (-10-11°C), the plantations (Makhvilauri, Akhalsheni, Tsikhisdziri, Bobokhvati) that were cultivated at high altitudes on the slope of the southern exposure were slightly damaged (by 1 point). Despite the low temperature, the plantations (Peria, Agara, Makhinjauri, Akhalsheni, Ortabatumi), which are cultivated at relatively high altitudes, on the southern exposure slope and the plot were protected by a windbreak, were not damaged at all (0 point). The monitoring revealed such plots (Gonio, Sarpi) where they were quite damaged even in the conditions of -8°C. In this situation, the temperature factor is less important, as most of these plantations are older (80-90 years old) and depreciated, while some are newly cultivated. No 5-point damage was observed in any of the plantations during the monitoring. 70% of the monitored plantations gave us a crop, only those plantations that were damaged by 3-4 points were left without harvest.

If we analyze the results of the monitoring, we will come to the conclusion that the damage of mandarin plantations during the frosty winter of 2020 was caused by not only one factor (temperature) but also the damage to the mandarin plantations was supported by the following factors: The autumn period of 2019 was distinguished with warm, dry and cloudy weather, which hindered the moving of plants into the rest position. 2019 was distinguished by the abundant harvest, which is why the food substance was completely spent on the formation of the fetus and the plant's vegetative bodies did not manage to prepare for the winter.

If we analyze the results of monitoring and compare with perennial data (Climate Change, 2013), it is clear that in the last century sharply low temperatures (-8-100C, sometimes lower) was observed periodically (once every 5-10 years). From the industrial cultivation of citrus, the exceptionally low temperature has been recorded several times (1910-1911, 1916-1917, 1928-1929, 1944-1945; 1978-1950, 1963-1964; 1988-1979; 1985-1986), in some years (1910-1911, 1949-1950)

the plantations were completely frozen and needed to restore them. From 1961 to 2001, there was almost no critical temperature reported to destroy the mandarin plantations, however, freezing of major branches took place in 1964, 1971, 1983 and 1993. In some municipalities (Kobuleti) was a very strict winter in 1985 (-13,8°C), which should have caused the complete destruction of citrus plants, but fortunately frost was preceded by abundant snow, whose cover reached 1,5-2,0, which saved plants from freezing. In recent years, the rate of recurrence of severe frosts in winter has been quite reduced. For example, in 1960-1985 severe frosts occurred 5 times, in 1985-2000 – 3 times, while in 2000-2015 – only once, which indicates that the risk of freezing citrus in terms of global changes in climate is gradually decreasing.

Based on the analysis of perennial data, it turns out that if the risk of winter frosts decreased in recent years, the autumn-spring frosts and hail were increasing. For example, in 1985-2015, the hail was observed 10 times, the injuries of the fruit in recent years have been almost systematic. If the last period of strong frosts reduced the recurrence of cases, we cannot say the same about the repetition of hail in autumn, but on the contrary, it is significantly increased, but in this period, there is no low temperature that will result in full destruction of the plant. Based on the data of meteorological stations, it turns out that the frost of the autumn (October-November) or hail takes place almost every second year for subtropical zone of Adjara region, which is directly reflected in the damage of the fetus, but it does not affect the overall condition of the plant.

Conclusions. The monitoring and the analysis of frost damage assessment in the mandarin plantations in the subtropical regions of Adjara region (Kobuleti, Khelvachauri) after frosty winter of 2019-2020 allow us to draw the following conclusions: Although the temperature in Adjara region was quite low (critical for mandarin) (-8-14°C) in February 2020, the degree of frost damage was not high. This indicates that after the introduction, the citrus has undergone a long time for acclimatization-adaptation and well adapted to our soil-climatic conditions. If earlier in the -8°C temperature conditions mandarin plantations were significantly damaged, today the damage in such temperature conditions is relatively insignificant. In addition, frost resistance is especially high when they are exposed to negative temperatures for a long time, which in our case was not more than 2 days.

Analysis of multi-year data shows that in the last 50 years there has been no critical temperature for the complete destruction of citrus in Georgia, which indicates that the risk of citrus damage from winter frosts in Georgia under global warming is gradually decreasing, although autumn-spring frosts have increased. There is no complete mechanism for protecting plants from frost, although it is important to breed frost-resistant varieties that will reduce the risk of citrus freezing by at least 1-2°C. Making long-term climate forecasts by scientists will even enable agricultural producers to plan cropping strategies in line with climate change.

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BIOLOGY

SUNBLOCK ACTIVITY POTENTIAL OF LEAF EXTRACT FROM *COLOCASIA ESCULENTA* (GABI) LEAVES

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Abstract. *Evaluation of sunblock activity is an important aspect nowadays, as exposure to sunlight is recognized as a major factor in the cause of the progressive unwanted changes in the skin appearance and physiology due to UV rays present in the sunlight. In this study, sunblock activity of Colocasia esculenta (gabi) leaf extract was determined by absorption spectroscopy using UV-vis spectrophotometry. The in-vitro SPF of the formulations was determined according to the UV Spectrophotometric method.*
The Colocasia esculenta (gabi) leaf extract under study produced high absorbance at 290-320 nm wavelength range and obtained an average SPF (Sun Protection Factor) of 7.39 in five trials. The study can positively conclude that Colocasia esculenta (gabi) leaf extract can considerably contribute in the preparation of sunblock product formulations which could prevent skin damaging effects of ultraviolet radiations.
Keywords*: sunblocks, in-vitro, sun protection factor (SPF), UV-Vis spectroscopy.*

Introduction. UV light has been classified by WHO as carcinogenic and produces several adverse effects including mutagenicity, immune depression of the skin, accelerated skin ageing and photo dermatoses (Nohynek and Schaefer, 2001). Sunlight composed of different wavelengths ranging from UV or ultraviolet light through (IR) infrared to visible light. Exposure to solar radiation is recognized to have negative effects on the human skin. Among all, ultraviolet light is the most harmful to the skin and causes sunburns, ageing of the skin and over the long term, skin cancer (Sudhahar et. al 2013).

The ultraviolet radiation or electromagnetic radiation produced principally by the sun is divided into infrared radiation (IR), visible light (VIS), and UV radiation. Heat not visible to the human eye is part of IR radiation and VIS accounts for the wavelength range of general illumination. Furthermore, UV radiation is divided into three bands in order of decreasing wavelength and increasing energy: UVA (320-400 nm), UVB (290-320 nm), and UVC (200-290 nm) (Korac and Khambholja 2011). Although UVC has the highest energy it was heavily absorbed in the upper atmosphere and thus not a major factor in causing human cancers. However, the major source of the damaging effects of sunlight striking the earth's surface are UVA in more than 90% and UVB less than 10% which comes from the UV spectrum between 290 and 400nm (Ortiz, et. al 2014).

Due to these specifics, sunblocks substances are now included into day-to-day products such as creams, ointment, moisturizers, lotions and other skin care products. The usual application of these products may help to avoid the harmful effects of ultraviolet radiation to some degree. However, it is essential that a very efficient sunblock substance is used in the cosmetic formulation.

Researches in cosmetics have been carried out by scientists because of its popularity and essentiality in our lives nowadays. As a result, more and more products are being developed and marketed. Body and beauty care product are likely to surpass the consumption of drugs in the future (Korac and Khambholja 2011). Hence, the result of this study will give information on the absorptive spectrum profile of Colocasia esculenta (gabi) leaf extract. Furthermore, this study assessed Colocasia esculenta (gabi) species having the potential for sunblock products that can be used as data base information for researchers in the future.

The effectiveness of a sunblock is usually expressed by sun protection factor (SPF) which is the ratio of UV energy required to produce a minimal erythemal dose (MED) in protected skin to unprotected skin (C. Malsawmtluangi et. al 2013).

The in-vitro approaches are generally two types. 1) Measurement of absorption or the transmission of UV radiation through sunblock product films in quartz plates or membranes 2) methods in which the absorption characteristics of the sunblock agents are determined based on

spectrophotometric analysis (Sudhahar et. al 2013). The major benefit of the in vitro test is that it is a fast, objective, cost-effective screening method.

Available marketed sunblock produces protection on the basis of active principles that provide protection through various mechanisms such as reflection or absorption of radiation by them. Studies have been performed on various plant (Helichrysum, Rrangula, Chamomole, Hamamelis virginiana, Cinnamomum zeylanicum and Rosa damascene etc.) (C. Malsawmtluangi et. al 2013). Most sunblock products contain ingredients that provide adequate protection only against UV-B rays.

It is of utmost importance to enrich the knowledge of the general public about the sunblock potential of plants hence the result of this study will benefit the manufacturers in formulating their natural based products. Thus, consumers will be protected from the harmful effects of UV light. Moreover, this study will help provide basic information for every family about common plants that can be used for home-made sunblock products in safeguarding the health of family members.

Results. The SPF is a quantitative measurement of the effectiveness of a sunblock formulation. In this study the leaf extract of Colocasia esculenta (Gabi) leaves was evaluated for sunblock activity using in-vitro SPF method.

The absorption spectra of the leaf extract were obtained by scanning in the wavelength range of 200nm to 400nm using the UV- spectrophotometer. Thereafter, absorbance values of each aliquot prepared were determined from 290-320 nm at 5 nm interval, taking ethanol as a blank. The measurements were taken five times and the determinations were made at each point, followed by application of Mansur equation. Measurements were taken one by one after cleaning the cuvette before taking each sample.

The aliquots prepared were scanned between 290-320 nm and the obtained absorbance values were multiplied with the respective EE (λ) values. Then, their summation was taken and multiplied with the correction factor (10). Data was expressed as mean.

The absorption spectra of sample solution were obtained in the range of 290 to 320 nm using 1 cm quartz cell, and ethanol as blank.

The SPF number of aqueous extracts of the herbal sources was calculated by applying Mansur mathematical equation. The absorbance of different plant extracts was recorded as mean values of three readings. Calculation of Sun Protection Factor (SPF) of the plants will be performed according to Mansur et al. (1986) equation.

$$\text{SPF} = \text{CF} \times \sum_{290}^{320} EE\,(\lambda) \times \text{I}(\lambda) \times \text{Abs}(\lambda)$$

where EE(λ) is the erythemal effect spectrum, I(λ) is the solar intensity spectrum, Abs(λ) is the absorbance of sunblock product; CF is the correction factor (=10). (Mansur et al. 1986, as cited in Dutra et al. 2004).

Table 1: Absorbance of *Colocasia esculenta* (GABI) leaves on different wavelength

Wavelength	EE X I Value	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
290	0.015	0.680	0.533	0.613	0.697	0.747	0.654
295	0.0817	0.550	0.487	0.547	0.560	0.597	0.548
300	0.2874	0.601	0.597	0.700	0.642	0.645	0.637
305	0.3278	0.713	0.733	0.771	0.808	0.775	0.760
310	0.1864	0.967	1.013	0.769	0.671	0.793	0.842
315	0.0839	1.119	0.953	0.907	1.103	0.910	0.998
320	0.018	0.333	0.533	0.663	1.060	0.563	0.631

Table 1 shows the absorbance of Colocasia esculenta (gabi) leaves extract at 290-320 nm which covers that wavelength of UVB. As seen on the table above, highest absorbance of the plant extract was recorded at 315 nm on the five trials.

Table 2: Determination of SPF value Colocasia esculenta (gabi) leaf extract

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
Calculated SPF Value	7.41	7.38	7.39	7.42	7.34	**7.39**

Table 2 shows the SPF value of Colocasia esculenta (gabi) leaf extract on the five trials. As seen in the table, the computed value for the SPF or Sun Protection Factor is 7.39.

This value of SPF makes the plant extract a possible active ingredient for sunblock products in the market.

Table 3: SPF values of different plant samples

Sample		SPF Values
1	Mentha piperita (Leaves)	8.18
2	Azadirachta indica (Leaves)	4.37
3	Oscimum sanctum (Leaves)	2.9
4	Aloe vera (Leaves)	5.43
5	Lycopersicon esculantum (fruits)	6.08
6	Carica papaya (fruits)	2.31
Present Study	Colocasia esculenta (leaves)	7.39

* As presented by Gupta 2013

Table 3 shows the comparison of the different SPF values of different plant samples to the present study. As observed, the computed value of Colocasia esculenta (leaves) is comparable and even better to those of previously studied plants and fruits.

Conclusions. The main objective of the study is to analysed the sunblock potential of Colocasia esculenta (gabi) leaf extracts. It was found that Colocasia esculenta (gabi) leaf extracts has high UV protection capabilities.

The absorption spectrum profile of Colocasia esculenta (gabi) leaf extracts using UV-VIS spectrophotometer is also established by repeating trials and the SPF value was calculated.

The study shows that the Sun Protection Factor (SPF) of the plant extracts for potential sunblock agent is 7.39. The value calculated using the standard Calculation of Sun Protection Factor (SPF) of the plants according to Mansur et al. (1986) equation.

From the result obtained in the study, the researchers can positively conclude that Colocasia esculenta (gabi) leaf extracts have significant UV absorbing property. This will be a better, cheaper and safe alternative to harmful chemical sunblock that used nowadays in the industry.

The study shows that Colocasia esculenta (gabi) leaf extract sunblock has significant UV absorbing property and the proposed UV spectrophotometric method is simple, rapid, utilizes low-cost reagents and can be applied for in vitro determination of SPF values in many cosmetic formulations.

However, there are several aspects affecting the determination of SPF values. For future studies, the researchers suggest:

1. The formulation of a commercial cream using Colocasia esculenta (gabi) leaf extract as the main active ingredient.
2. Different factors may also be considered in the formulation of the cream like the use of different solvents in which the sunblock is dissolved; the combination and concentration of the ingredient.

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COMPUTER SCIENCE

DEVELOPMENT OF TELEMEDICINE PROCESS SUPPORT VISUAL TOOLKIT

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Abstract. *The diagnosis and treatment processes of diseases, the effectiveness of different programming approaches in the automation of the treatment process were studied.*
A telemedicine process support visual toolkit has been suggested, which will allow the doctors to build the treatment schemes using simple blocks, depending on the patient's input data.
The visual blocks that are planned to have in the IDE can be divided to the following groups: dataFlow, arithmetic and logical operations blocks, Artificial intelligence blocks that will be implemented on the basis of various machine learning models, Blocks intended for read data and configure the devices of the IOT network, and custom blocks.
The toolkit will translate the represented treatment visual schemes to python code, which will call the corresponding functions of represented treatment regimen's blocks, which will be developed by us.
Keywords: *IoT, Artificial Intelligence, specialized visualization toolkit, accuracy of the results, IDE.*

Introduction. Chronic diseases have always been a burden for patients which require regular measurements, recording measurement data, visiting doctor regularly, showing the doctor the recorded measurement data, receiving updated treatment plan, and following instructions.

The main problem for this diseases are that they require to have visit the doctor and get care plan updates frequently.

The goal of the research is to create an automated diagnosis and treatment system that is able to monitor the patient in real time and modify/adjust the patient's care plan automatically based on their health state that can be detected by analyzing the data collected from the patient via IoT network, to ensure the best treatment quality. The generated care plan will be available to the patient trough mobile application. [1]

The automated diagnosis and treatment system has the following basic requirements:

- The designed system should have the ability to be easily updated with the latest medical innovations that can improve the quality of patients' treatment.
- The system must have high accurate.

The Problem. A system should be developed which will solve the above-mentioned problems as much as possible.

There are two approaches to software development: the traditional algorithm description approach and the artificial intelligence approach.

In the first case, an accurate software can be developed, but in order to keep the system up to date with the latest scientific innovations, constantly adding new software code will be necessary, which requires programming knowledge that doctors do not have; it's not feasible for this project.

With the help of AI methods a system can be developed that learns medical innovations in real time, but it is impossible to get 100% accuracy. In other words, its answers will be approximate, because the artificial intelligence is based on statistics and probability theory.

Moreover, by these methods not the algorithm of the patient's treatment are taught to the system, but clear cases of the disease with the appropriate care plans are taught to the system. Then, during patient's treatment process, the method of artificial intelligence matches the patient's case to one of the cases it has learned and gives the appropriate treatment plan for the case.

Solution. The best solution to this problem would be the creation of a specialized visualization toolkit for the medical field that would allow doctors to describe treatment schemes through comprehensible visual blocks and to update them in the future.

The structure of the visualization toolkit's blocks should be designed to be convenient, clear and comprehensible to doctors, with preserving the flexibility of language to express the most complex medical algorithms at the same time.

The visual scripts should be compiled then to Web API application that must run on application server to serve the web requests.

For simplicity and benefit from the existing libraries and frameworks, we will translate the visual script to an existing programming language. Thus we won't need to write compilers to compile the scripts to assembly or to write interpreters from scratch. Nor we will need to write web frameworks, database adapters or machine learning libraries.

The language to which the visual scripts will be translated should be easy to deploy new versions during the application runtime, without the need of "blue green deployment" approach. Because the system should be upgraded to newer version every time a doctor makes change to any visual script, and the hard code reload feature will be a must for the language chosen.

As we know hot code reload only works for the scripting languages, thus the language chosen will be scripting language.

From the wide range of the scripting languages, we should choose a one that has a reliable security and good web framework, having good machine learning libraries would be a plus.

It's clear that python would be the best for this case, with its various machine learning libraries including: pandas, Tensorflow, NumPy, etc. And god web development frameworks including Flask, Django, etc.

Each visual script block should have corresponding implementation in python. The toolkit will translate the represented treatment visual schemes to python code, which will call the corresponding functions of represented treatment regimen's blocks, which will be developed by us.

Figure 1 presents an example of diabetes monitoring and care plan adjustment generalized scheme. The real system schemes should be very detailed and complex.

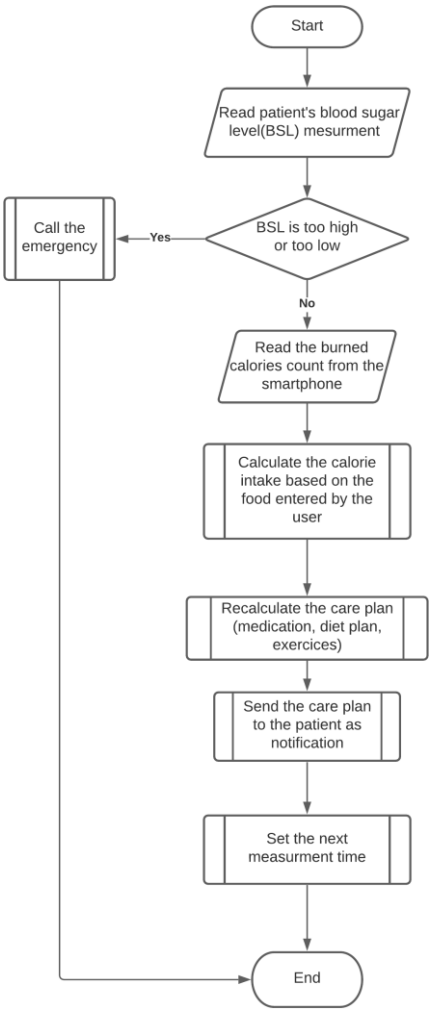

Fig. 1. Diabetes Generalized scheme

We can have two possible policies for visual schemes update permissions

1. Have a team of trusted doctors with that permission.
2. Allow different organizations to have their personal server instance, and each organization will have the right to update only its own instance's visual schemes.

The visual blocks that are planned to have in the IDE can be divided to the following groups:

1. DataFlow, that will include conditional commands, cycles and etc.
2. Arithmetic and logical operations blocks
3. Artificial intelligence blocks, that will be implemented on the basis of various machine learning models
4. Blocks intended for read data and configure the devices of the IOT network
5. Custom blocks.

DataFlow blocks:

1. If
2. If-else
3. For
4. While
5. ForEach

Arithmetic and logic blocks:

1. Add
2. Subtract
3. Multiply
4. Divide
5. And
6. Or
7. Not
8. XOR

Artificial intelligence blocks:

1. Blocks that will perform predefined tasks using pre-selected and trained models.
2. Blocks that will represent various machine learning models, that would be able to be trained through the visual toolkit, by passing the training set and parameters as input.

IOT blocks. Foreseen for receiving data from and configuring the devices that exist in the IoT network.

This blocks are the ones that will interact with the IoT devices that exist in the system. We will split them to two groups: devices' configuration blocks and data fetching blocks.

Devices configuration blocks are responsible to send configuration to the devices that will determine the frequency of the measurements that the device should perform, or the frequency of uploading the collected data to the server. Data fetching blocks are responsible for reading the measured data.

We have two type of devices in our system that require different workflows to collect the data from them. The first is the devices that upload their data to the device's manufacturer's server, for example Dexcom [2] that uploads the user data to its own servers and provides APIs to configure the frequency and the timing of the measurements [3]. In this case the devices' configuration blocks will configure the frequency and the timing of the measurements trough the API. And the data fetching blocks will get the measurements data from the Dexcom server trough the API.

The second type of the devices are those who sync their measurements with health applications: 'Samsung Health' for Android devices, and 'Health' for iOS, which fortunately have corresponding SDKs.

Because we want to write our application with the Xamarin framework we will use Healthkit for Xamarin.iOS [4] and MKM-HealthDataSDK [5, 6] for Xamarin.Android to get the health data from health applications.

For this type of devices the devices' configuration blocks will send to our application the frequency and the timing when it should read the health data through the SDKs and upload them to our server. And the data fetching blocks will fetch the data that is already uploaded to our server from the database.

Custom blocks. It will allow users to build new blocks, the functionality of which will be possible to describe by one of the methods mentioned below:

1. Visual toolkit scheme
2. Python code

The programs represented through visualizations toolkit represent structured data, which we will use for training our machine learning based visual toolkit intellisense. GPT-2 or TabNine models could be used as a model.

The model will help doctors to write effective scripts by hinting the blocks that could be used, cases to consider, etc.

Conclusions. The existing technologies were studied and appropriate programming languages, technologies, strategies, and network systems were selected to develop the telemedicine process support visual toolkit. The toolkit will include various types of already existing blocks and the ability to create new blocks, through which appropriate treatment schemes can be built. Depending on the patient's input data, treatment schemes can give different results. In other words, a toolkit with a simple interface has been developed, in which a logical sequence of blocks can be which will work in case of all possible input data. When running the schemes, each block will be converted to code: and they work as a complete software code.

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METHOD OF ANALYSIS OF HIERARCHIES AND ITS APPLICATION TO THE PROBLEM "DEFINING PRIORITIES IN ASSESSING VARIOUS SKILLS AND COMPETENCES OF SOFTWARE ENGINEERS IN HIRING PROCESS"

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Abstract. *In the paper to solve the problem was used the AHP method, in which a decision-making problem decomposes into a system of hierarchies of objectives and alternatives. The implementation of the method of analysis of hierarchies on the defining priorities in assessing various skills and competencies of software engineers in hiring process is described.*
Keywords*: hierarchical structure, scale for relative importance, eigenvector, eigenvalue, priorities of performance metrics, priorities of topics, micro service, API.*

Brief description of the method of analysis of hierarchies.

The hierarchy analysis method is a systematic procedure for presenting the elements of any problem in a hierarchical form. This method is based on this expert of the problem under study, decomposed into simple components by the decision-maker, followed by pairwise comparisons its elements. As a result, the relative degree (intensity) of the interaction of elements in the hierarchy can be expressed. The judgments will be expressed numerically later on. The hierarchical analysis method involves the procedure of synthesizing plural judgments, prioritizing criteria, and finding alternative solutions.

The solution to the problem is the process of setting priorities in stages. In the first stage, the most important elements of the problem are identified, and in the second stage, the best way to verify observations, tests, and element assessments is determined. The next step is to develop a method for applying the solution and assessing its quality. This procedure is repeated until a complete picture of the problem has been obtained and all characteristics necessary to arrive at a solution have been taken into account. Re-assessments are carried out until full confidence has been achieved. The process is carried out on a sequence of hierarchies. In this case, the results obtained in one of them are used to study the next sequence. The method of hierarchical analysis systematizes the process of solving such a multi-level problem.

Finally, if we consider that intuition and subjective evaluation are the main source material for an individual's full understanding of his creative potential, then the judgment about the superiority of one element over another and the intensity of these judgments can be used to express inner feelings and tendencies. Judgments broaden the scope of communication by enlarging clusters and elements in hierarchies on a particular issue.

Such an approach to the solution of the problem of choice stems from the natural characteristics of people, such as logical and creative thinking, the definition of events and the relationships between them. It should be noted that human beings have two characteristic features of analytical thinking: first, to observe and analyze; the second is to establish relations between them by defining the interrelationships between observations and to synthesize these relations into the general perception of the observed. All this gives an idea of the principle of identity and decomposition, the principles of discrimination of comparative judgments and synthesis.

The principle of identity and decomposition implies the structuring of the problem in the form of hierarchies and networks, which is the first stage in the application of the method of analysis of hierarchies. In its most elementary form, the hierarchy is built from the top (from a management point of view) to the lowest level, which consists of a list of alternatives through intermediate levels (criteria on which subsequent levels depend).

Once the problem is fully understood in the form of a hierarchical or network structure, the question becomes: how can the criteria be prioritized and evaluated according to those criteria so that the most important option can be identified?

It is known that the main purpose of measuring physical quantities is to compare them with each other. Measuring two quantities means determining how many times one of them is in the other. For example, if two straight-line pieces in geometry are given, we can determine how many times the second piece is larger than the first by taking the smallest of them and placing them in sequence on the second piece. In this case, the length of the small piece actually acts as a measure of length. If the measurements of length are millimeters, centimeters, etc., The dimensions between these two pieces are understood to be the comparison between these two pieces using these units of measurement. If a unit of measurement for a physical quantity is given, then it is said, that there is a scale of measurement for that physical quantity. It is well known, that measurement scales differ for different physical quantities. Examples include length, weight, time, money, temperature, and so on. Special measuring devices have been invented to measure a variety of physical quantities. The dimensions of the corresponding quantities are determined with a certain accuracy by means of these devices.

But how can social, political, emotional, and other factors that cannot be measured physically be compared?

Assume that there is no scale to compare certain types of items according to any parameter. For example, suppose you need to compare two stones of different shapes, A and B, by weight, but there is no device to determine their weight. In this case, we can take one of the stones in our right hand and the other in our left hand to estimate their relative weights. We can accomplish this by lifting the stones one at a time so as not to manipulate the senses, even if one hand may be stronger than the other. Of course, by conducting such "experiments", we cannot say that stone A is 3 kg heavier than stone B, but we can judge that stone A is "slightly" heavier than stone B or "very heavy". Similarly, Factors that cannot be quantified and which are not understood can be compared in the same manner.

In the analysis of hierarchies, the elements of a problem are compared in pairs based on the influences they have on a shared characteristic. ("weights" or "intensity"). A relative significance scale was developed for subjective pairwise comparisons (Table 1) [9].

Table 1. Saaty's nine-point scale for relative importance

Stage of Scale	Verbal Judgement	Characteristics
1	Equal Importance	Two activities contribute equally
3	Moderate Importance	Experience and judgement moderately favour one activity over another
5	Strong Importance	Experience and judgement strongly favour one activity over another
7	Very Strong Importance	An activity is strongly favoured and its dominance demonstrated in practice
9	Absolute Importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values bet-ween the two dja-cent judgements	When compromise is needed

With the help from the experts, the following form of the tables are filled with the hierarchy of all the levels (Figure 1):

Top level	Factor 1	Factor 2	.....	Factor N
Factor 1	1			
Factor 2		1		
			1	
Factor N				1

Fig. 1. Relative significance scale

Let's say that as a result of the expert estimation on the basis of the scale of relative importance are numbers: $\omega_1, \omega_2, \omega_3, \ldots \omega_n$. We form from these numbers the following matrix:

If to designate elements of this matrix by a_{ij}, $i, j = 1,2, \ldots n$. Then we will obtain:

$$A = \begin{bmatrix} \varpi_1/\varpi_1 & \varpi_1/\varpi_2 & \varpi_1/\varpi_3 & \ldots & \varpi_1/\varpi_n \\ \varpi_2/\varpi_1 & \varpi_2/\varpi_2 & \varpi_2/\varpi_3 & \ldots & \varpi_2/\varpi_n \\ \varpi_3/\varpi_1 & \varpi_3/\varpi_2 & \varpi_3/\varpi_3 & \ldots & \varpi_3/\varpi_n \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \varpi_n/\varpi_1 & \varpi_n/\varpi_2 & \varpi_n/\varpi_3 & \ldots & \varpi_n/\varpi_n \end{bmatrix}$$

$$A=\begin{bmatrix} 1 & a_{12} & a_{13} & \dots & a_{1,n} \\ 1/a_{12} & 1 & a_{23} & \dots & a_{2,n} \\ 1/a_{13} & 1/a_{23} & 1 & \dots & a_{3,n} \\ \dots & \dots & \dots & \dots & \dots \\ 1/a_{1,n} & 1/a_{2,n} & 1/a_{3,n} & \dots & 1 \end{bmatrix}$$

The table on the left column of the elements of the first line in the elements, according to the relative importance of the appointment are. In other words, the left element in the above-mentioned elements is important, the table with the box, the relative importance scale shown from 1 to 9 as numbers one, the case of the numbers upside down, prices are recorded. Any element of self-according to the relative importance to the 1 equivalent so that the table diagonal elements, only 1 from a must. Table of other symmetrical fields, the one opposite the price is filled, the A element, B element "slight advantage" accepted are, then the table with the row and column intersection awarded scale of 3, the price is written and B element, the element according to the relative importance of this issue, reverse the price, 1/3 of the characterization is. Table all the fields of the rule, with a filling the hierarchy of all levels down security n skew symmetric matrices [8].

But how objectively do the tables filled by the experts reflect the situation, or to what extent do the experts' opinions agree with each other? In general, the eigenvalues and eigenvectors of matrices compiled based on expert estimations for the correct levels of the hierarchical structure must be found by solving the following mathematical problem:

$$Ax = \lambda x, \quad (1)$$

Where, λ is a eigenvalue, and $x = (x_1, x_{2,} x_3, \dots x_n)$) is a eigenvector.

It is known that for a reciprocal matrix takes place

$$\lambda_{max} \geq n, \quad (2)$$

Where, λ_{max} - greatest eigenvalue, n - order of the matrix A. The equality sign takes place only for coherence matrices [11].

As noted above, for elements of each level of the hierarchical structure, the coefficients of relative importance are found as a solution of the eigenvalues and eigenvectors of the matrices of pairwise congruences. In the general case, there are strict mathematical methods for solving this problem. But, T. Saati in his book [8] proposed simple formulas for calculating eigenvalues and eigenvectors. These formulas are proposed in Figure 2.

$$X_1=(1*(W_1/W_2)*\dots*(W_1/W_n))^{1/n}$$

$$\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$X_n=((W_n/W_1)*\dots*(W_n/W_{n-1})*1)^{1/n}$$

$$\lambda(A_1)=X_1/\sum X_i$$

$$\dots\dots\dots\dots\dots$$

$$\lambda(A_n)=X_n/\sum X_i$$

Fig.2. Formulas for calculating eigenvalues and eigenvectors.

Further, for each level, the consistency index (CI) is determined by the formula:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

After computing the CI from values scale 1/9, 1/8, 1/7, ...1, 2, 3, ..., 9 randomly formed the coherence matrices and for different orders are calculated random index (RI). Middle RI matrices for matrices of order from 1 to 10, on the basis of 100 random samples are presented in the form of the following standard table [6].

Table 2. Average random number index for each size of the matrix

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

In this table, the first line specifies the matrix size -n and on the second line the average RI.
Dividing, CI to RI receive ration consistency (RC).

$$RC = \frac{CI}{RI}.$$

It is generally considered that for harmonised data RC must not exceed 0,1 (10%), in some cases, 0,2 (20%).

The expert analysis by the hierarchy analysis method is completed in two stages. In the first stage, the goals of the actors that best suit the overall purpose of the system are identified, and the most important ones are selected. In the second stage of expert assessment, the different scenarios identified through the hierarchical structure of the problem are first compared in pairs according to the "Relative Importance Scale" for each of these objectives. Then, in the same way as described above, the weights of the scenarios are determined and the attributes and characteristics of the municipal experts on the basis of the following table [8]:

Table 3. Scale of difference for comparison

Difference in values	Definition
0	Value does not change
2 (-2)	A small increase (decrease) in value
4 (-4)	A large increase (decrease) in value
6 (-6)	A significant increase (decrease) in value
8 (-8)	The maximum increase (decrease) in value
1,3,5,7,-1,-3,-5,-7	Intermediate values between the two judgments

The calculated weights of the scenarios are multiplied by the appropriate estimates given to them by the experts, and on the basis of these estimates, the attributes and characteristics of the municipalities are assessed on an already generalized scale. Based on the values of the generalized scale, it is not difficult for the decision-maker to construct a generalized scenario.

In order to conclude the study, another question is necessary: how much can the solution be considered optimal? To answer this question, T. Saaty first introduced the concept of the "compromise index".

$$compromise\ index = \frac{\lambda_{max} - n}{n - 1}$$

Finally, the concept of the so-called "reconciliation ratio", which consists of the ratio of the coherence index to the random coefficient of coherence, is introduced ([1]):

$$reconciliation\ ratio = \frac{reconciliation\ index}{random\ reconciliation\ factor} * 100\ \%$$

T. Saaty reconciliation ratio obtained to solve the problem in hours

$$reconciliation\ ratio \leq 10\ \%$$

If the condition is met, the solution of the issue is considered acceptable. If this condition is not met, the issue is reconsidered, the members of the expert group are asked to reconsider their assessments. Thus, the method of "analysis of hierarchies" allows you to search for a solution to the problem until a reasonable solution.

Application to the problem: defining priorities in assessing various skills and competencies of software engineers in hiring process.

Problem statement. DevHQ is the international company headquartered in Austria that helps their customers to assess technical qualification and performance of developer candidates in an automated and efficient way. (DevHq Web Page: https://devhq.de/)

The problem DevHQ solves leveraging AHP is as following: there should be developed a software solution which could assess technical performance and qualifications of candidates transparently without involving any human into the decision-making process. There is a list of certain technical metrics which is used in assessment. These metrics have certain priorities over others. DevHQ had the problem to transparently and correctly identify which metric has to be more prioritized over other metrics and how the priorities should be valuated with numbers.

Application of AHP. Below are some of the technical metrics and their weights (Figure 3):

SSD	LINE	WORD	SIZE	LOGIC	UNIT_TEST_COVERAGE	LOG	CODE_CONVENTION	CODE_DOC	CODE_COMMENT	GIT_COMMIT	GIT_PUSH	CLEAN_CODE	CODE_SMELL	SECURITY_VULNERABILITY	SOLUTION_PERFORMANCE
1	7	7	7	0.142857143	0.25	5	1	5	9	7	3	1	2	0.111111111	0.2
0.142857143	1	5	1	0.142857143	0.2	3	1	7	5	5	8	0.142857143	0.142857143	0.111111111	0.125
0.142857143	0.2	1	1	0.111111111	0.125	0.142857143	0.111111111	0.2	0.2	9	5	9	9	9	9
0.142857143	1	1	1	0.111111111	0.142857143	0.2	0.125	0.333333333	0.2	0.111111111	0.2	0.111111111	0.142857143	0.111111111	0.111111111
7	7	9	9	1	4	8	7	8	9	6	9	3	5	1	3
4	5	8	7	0.25	1	8	5	8	8	6	9	3	3	0.166666667	0.25
0.2	0.333333333	7	5	0.125	0.125	1	0.2	1	1	0.142857143	5	0.142857143	0.333333333	0.142857143	0.142857143
1	1	9	8	0.142857143	0.2	5	1	9	8	5	9	0.5	5	0.142857143	0.125
0.2	0.142857143	5	3	0.125	0.125	1	0.111111111	1	1	0.142857143	1	0.142857143	0.2	0.111111111	0.111111111
0.111111111	0.2	5	5	0.111111111	0.125	1	0.125	1	1	0.142857143	1	0.142857143	0.2	0.111111111	0.111111111
0.142857143	0.2	0.111111111	9	0.166666667	0.166666667	7	0.2	7	7	1	7	0.166666667	0.2	0.142857143	0.142857143
0.333333333	0.125	0.2	5	0.111111111	0.111111111	0.2	0.111111111	1	1	0.142857143	1	0.111111111	0.142857143	0.111111111	0.111111111
1	7	0.111111111	9	0.333333333	0.333333333	7	2	7	7	6	9	1	5	0.2	0.166666667
0.5	7	0.111111111	7	0.2	0.333333333	3	0.2	5	5	5	7	0.2	1	0.166666667	0.166666667
9	9	0.111111111	9	1	6	7	7	9	9	7	9	5	6	1	1
5	8	0.111111111	9	0.333333333	4	7	8	9	9	7	9	6	6	1	1

Fig. 3. The technical metrics and their weights

From this matrix following values are calculated:

Unnormalized weights

The weight *w* of each metrics *i* of the unnormalized AHP matrix is calculated through the function below:

$$w_i = \prod_{i=1}^{n} (C_{ij})^{\frac{1}{n}}$$

Here, C_{ij} is the significance value of each metric i in the row against the metric *j* in the respective column. n is the size of the metrics matrix. In our case above $n = 16$

Normalized priorities.

Once weights have been calculated, unnormalized matrix should be normalized further with the following function to get normalized priorities for each metrics:

$$p_i = \frac{w_i}{\sum_i^n w_i}$$

For final assessment of the solution of the user, normalized priority of each metric is multiplied with its respective function of score and each product of multiplication is summed up:

$$\Phi = \sum_{i=1}^{n} (p_i * F_i)$$

Here F_i is a score function that calculates value for each metric i. Once the metric score has been calculated, its final score is calculated with the help of the gained AHP priority. The overall assessment result Φ is calculated for the candidate by summing up candidate's final metric scores which is in our example 16 different final metric scores with their corresponding priorities.

Whenever priorities of technical metrics gets updated in the given matrix above, assessment decision gets updated automatically. With this way DevHQ was able to provide solution to its customers to define their own decision making system flexibly and transparently.

The solution for this problem implemented as a standalone REST micro service and available through the following API documentations:

- https://lb.devhq.in/ahp/swagger-ui.html
- https://lb.devhq.in/ahp/monitoring/info

Some outputs from system.

As the usage of this system is secured from outside, some screenshots are shared as a reference (Figure 4, Figure 5.):

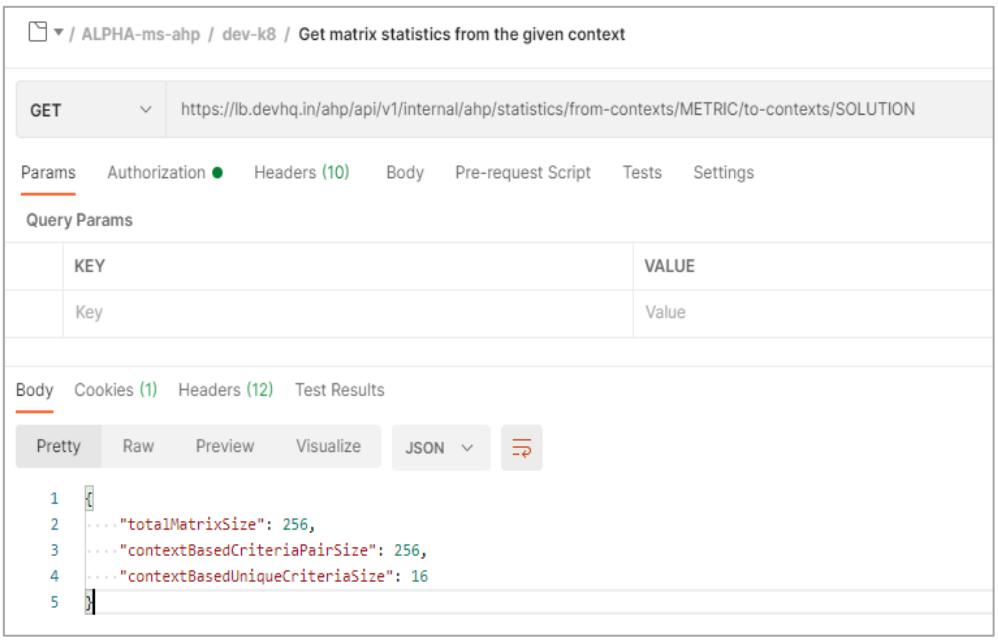

Fig. 4. Getting the statistics via AHP REST API

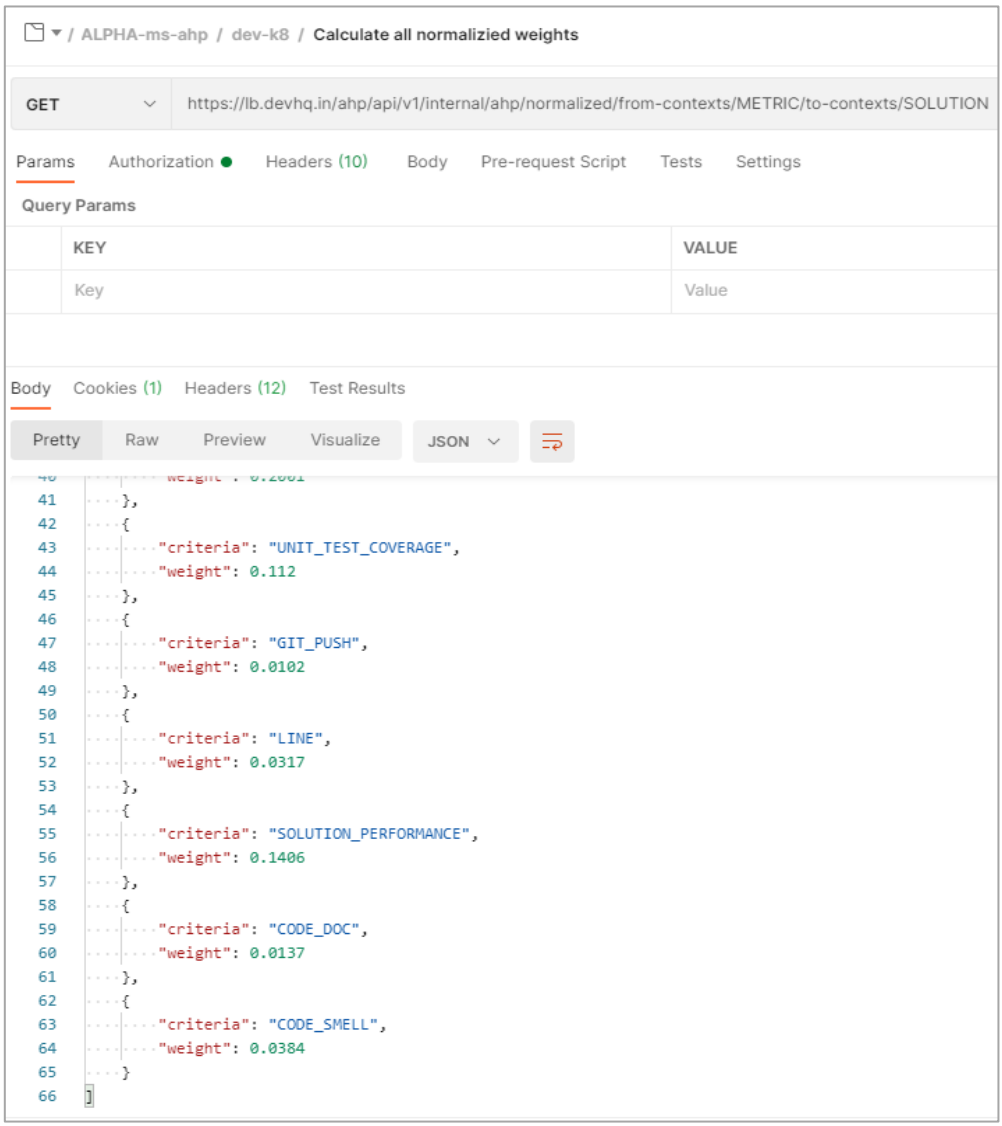

Fig. 5. Getting the weights for each criteria via AHP REST API

Conclusions. The method of analysis of hierarchies has been applied in the software solution, which could assess technical performance and qualifications of candidates transparently without involving any human in the decision-making process. There is a list of certain technical metrics, which are used in the assessment. These metrics have certain priorities over others. AHP identifies which metric has to be more prioritized over other metrics and how the priorities should be evaluated with numbers.

In conclusion, AHP is used in the following use-cases for the software solution:

• Calculation of priorities of performance metrics on any challenge solution. This means for any challenge we specify all available criteria, hence it calculates the scoring for all existing performance metrics accordingly after the deadline of the challenge.

• Calculation of priorities of performance metrics on topics, skills, and competencies. The priority here is used further to figure out how much scores of performance metrics have an influence on the assessment of users' topics, skills, and competencies on the given challenge.

• Calculation of priorities of topics on skills. It is defined what topics encompass what skills.

Thus, AHP provides a proper solution to define the decision-making system flexibly and transparently.

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THE IMPORTANCE OF SOIL INFORMATION SYSTEM (SIS) AND THE WAYS TO IMPROVE ARMENIAN SIS

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Abstract. *Humans use soil as a holding facility for solid waste, filter for wastewater, and foundation for our cities and towns. Finally, soil is the basis of our nation's agroecosystems which provide us with feed, fiber, food and fuel. Soil information is very important for making decisions at micro, macro and global levels. Modern digital technologies enable the development of national and global soil information systems. Armenia has had its soil information system since 2020. The article presented the importance of soil information systems, the work carried out in this diraction, as well as a number of proposals for the improvement of Armenian soil information system.*
Keywords: *information system, soil, partnership, GlOSIS, ArmSIS*

Introduction. Soil is an essential resource and a vital part of the natural environment from which most of the global food is produced. At the same time, soil provides living space for humans, as well as essential ecosystem services which are important for water regulation and supply, climate regulation, biodiversity conservation, carbon sequestration and cultural services. But soils are under pressure from increases in population, higher demands for food and competing land uses. Approximately 33% of our global soils are degraded and policy makers around the world are exploring opportunities to embrace sustainable development via the sustainable development goals. Although the importance of soils seems clear, in the past it has not received due attention in terms of its use and management, since soils were often considered an infinite resource that will always be able to provide us with its ecosystem services. However, this is not the case and there is an urgent need to raise awareness on the importance of soil, especially the need to protect soils and use them sustainably [1].

Purpose of the research. Soil map delineates the boundaries of different kinds of soils whose characteristics are markedly different due to the various factors affecting soil formation. These factors include climate, parent material, topography, vegetation, and length of time for the soil formation. Detailed knowledge of soil characteristics is important in soil resources use and conservation.

Information systems are the software and hardware systems that support data-intensive applications. A geographic information system (GIS) is used to integrate, store, edit, analyze, share, and display georeferenced information. GIS plays essential roles in integrating a variety of data layers to express a real world. The usefulness of an information system will depend on its ability to provide decision makers with the right data at the right time in the proper manner [2].

Methodology. The basic requirement to develop a soil information system (SIS) is to have large datasets. Such datasets are not generally available for all countries. The geographic information system (GIS) has been an important tool for geo-referencing the soil information system (GeoSIS). Various countries have developed their own SIS. The most widely used system is the Soil and Terrain Digital Database (SOTER; 1 : 1 m). It provides data for improved mapping, modelling and monitoring of changes of world soil and terrain resources. The SOTER methodology allows mapping and characterization of areas of land with a distinctive, often repetitive pattern of landform, lithology, surface form, slope, parent material and soils. The approach resembles physiographic or land systems mapping. The collated materials are stored in a SOTER database linked to the GIS, permitting a wide range of environmental applications. The SOTER method used for studies on carbon stocks and their changes in the Indo-Gangetic Plains (IGP), led to the following, viz. (i) linkage between soil profile data and spatial component of a SOTER map for environmental applications requires generalizations of measured soil (profile) data by soil unit and depth zone, (ii) the set of soil parameter estimates for the IGP should be seen as best estimates, based on the currently available selection of profile data held in IGP–SOTER and World Inventory of Soil Emission Potential (WISE), and (iii) the primary and secondary datasets for IGP will be useful for agroecological zoning, land evaluation and modelling of carbon stocks and changes at a scale of 1 : 1 M. Soil series provide first-hand information on soil resources of the state in terms of

morphological, physical, chemical and mineralogical properties. Such information helps understand the nature and extent of a particular soil under different categories of acidity, physiographic position and land use. This soil information can be systematically arranged according to the users' demand [3].

The role of soils in maintaining ecosystem and climate regulation is increasingly gaining recognition. This demands relevant and useful information on soils throughout the world. The need for relevant and pertinent datasets to develop a SIS at the country, state, and farm level is a dynamic process. This is more so since the soil has many dynamic parameters which control its health affecting crop performance. Digital soil maps have been useful in providing information on dynamic soil properties. Linking datasets of natural resources for web-based solutions requires team-work. With the changing global scenario at present we need expertise with sufficient knowledge on agriculture and allied sciences. Such experts would find GeoSIS and the proposed a decision support system (DSS) useful to analyse issues like land degradation, soil diversity, agricultural land-use planning, and change in soil and land quality parameters as influenced by land-use and/or climate change [4].

Research results. Global Soil Information System (GLOSIS) aims to develop a spatial data infrastructure that brings together soil information collected by national institutions. GLOSIS is envisioned as a federation of soil information systems, which share interoperable soil data sets via web services. This approach will empower countries to develop their soil information systems as reference centres for national soil information [5]. Global soil information system has three primary functions:

1. Answering critical questions at the global scale (e.g. is there enough arable land with suitable soil to feed the world?)
2. Providing the global context for more local decisions (e.g. transnational aspects of food security and degradation of natural resources)
3. Supplying fundamental soil data for understanding Earth-system processes to enable management of the major natural resource issues facing the world (e.g. climate change, food security, biodiversity loss). These data need to be comparable with other fundamental data sets including those for weather, climate, net primary productivity, biodiversity, land cover and geology [6].

The Global Soil Partnership was established in December 2012 as a mechanism to develop a strong interactive partnership and enhanced collaboration and synergy of efforts between all stakeholders. From land users through to policy makers, one of the key objectives of the GSP is to improve the governance and promote sustainable management of soils. Since its creation, the GSP has become an important partnership where global soil issues are discussed and addressed by multiple stakeholders. Key outputs demonstrate that the partnership was needed to fill an existing gap in the promotion of sustainable soil management [1]. Regional Soil Partnerships (RSPs) were established among interested and active stakeholders of the same regions [7]. The Eurasian Soil Partnership (EASP) was established in November 2013, as a sub-regional soil partnership within the ESP, to address the specificities of the eastern European and Eurasian GSP members. The main goal for the EASP is the implementation of sustainable soil management practices at a wider scale, especially in areas affected by soil salinity, as reflected in the EASP implementation plan, which is reviewed and updated at the yearly EASP plenary meetings [8]. Armenia is a member-country of EASP. The mandate of the GSP is to improve governance of the limited soil resources of the planet in order to guarantee agriculturally productive soils for a food secure world, as well as support other essential ecosystem services, in accordance with the sovereign right of each State over its natural resources. In order to achieve its mandate, the GSP addresses five pillars of action to be implemented in collaboration with its regional soil partnerships. The 5 pillars of action are:

1. Promote sustainable management of soil resources for soil protection, conservation and sustainable productivity
2. Encourage investment, technical cooperation, policy, education awareness and extension in soil
3. Promote targeted soil research and development focusing on identified gaps and priorities and synergies with related productive, environmental and social development actions
4. Enhance the quantity and quality of soil data and information: data collection (generation), analysis, validation, reporting, monitoring and integration with other disciplines
5. Harmonization of methods, measurements and indicators for the sustainable management and protection of soil resources [9].

In the framework of the Global Soil Information System (GloSIS), the Armenian Soil Information System (ArmSIS) was launched on 5 December 2020 during the World Soil Day official celebration. The

development of ArmSIS represents a stepping stone in the assessment of soil resources to guide effective and knowledge-based policymaking to combat soil degradation. At the request of the Ministry of Economy of Armenia, ArmSIS was established through a joint collaboration between FAO, the Global Soil Partnership, the Armenian National Agrarian University, the Centre of the Agricultural Services (SNCO) and the Institute of Geological Sciences. ArmSIS is financially supported by the Ministry of Finance of the Russian Federation. The new and fully functional Armenian Soil Information System was populated by digitizing legacy soil data and compiling fresh soil data that originated from Armenia's soil agrochemical sampling campaigns, which occur every 5 years. Soil property maps were created and/or updated using state-of-the-art Digital Soil Mapping (DSM) techniques. The process was supported through a DSM training provided by the GSP. ArmSIS was designed and developed in the framework of GloSIS, using the open-source GeoNetwork catalog application. ArmSIS represents not only a great achievement for Armenia, but also serves as an example for other countries that want to leverage the full potential of soil information. Its launch constitutes a step closer towards the realization of GloSIS, the first-ever nationally federated and globally harmonized Global Soil Information System [10].

Conclusions. Studies show that soil information systems are important for making rational decisions at both the global and local levels. The Republic of Armenia is an integral part of the Global Soil Information System, which has already developed Armenian soil information system (ArmSIS). In order to increase the usefulness and usability of the ArmSIS, it is proposed to create an Armenian version of the system to be useful to Armenian users. To increase the efficiency of the system, it is necessary to add other maps and information, such as soil theme maps and crop suitability maps, fertilizer recommendation. In the future the pedometrics concept for soil mapping and predicting soil and environment properties and remote sensing for the estimation of soil properties also can be added.

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