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DOES BAKUCHIOL DESERVE TO BE CALLED PLANT-BASED RETINOL? ADVANTAGES AND DISADVANTAGES OF BAKUCHIOL AND RETINOL

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Abstract:

In everyday life, more and more attention is paid to the origin of raw materials. They must be natural, ecological, and have the least interference with the environment. For this reason, many cosmetic companies are trying to replace synthetic ingredients with those from nature. One such synthetic ingredient is retinol, which belongs to the family of retinoids - derivatives of vitamin A. Its main function is to improve skin conditions, anti-acne and anti-wrinkle. Despite its many advantages, retinol also has many limitations, so the search for a worthy substitute has begun. One of them may be bakuchiol, which has shown very similar effects to retinol in clinical trials. Bakuchiol is a natural substance extracted from the Bakuchi plant. This article focuses on comparing the chemical and application properties of the vitamin A derivative and its potential plant-based substitute.

Keywords:

retinol, bakuchiol, retinoids, cosmetics, antiaging

Introduction

Vitamins are a group of compounds with a variety of structures that are essential for the proper functioning of the body. We divide them into fat-soluble and water-soluble ones. They are usually supplied with food, but more and more often they can be found in the form of creams, which are applied directly to the skin - they act as active ingredients [1].

Retinoids, belonging to group A vitamins, are one of the most popular groups of compounds used in cosmetics. Due to their versatile action, retinol, i.e. vitamin A, enjoys the greatest interest. The precursor to vitamin A, the so-called provitamin A, or beta-carotene can be found in various foods, such as beef, chicken, eggs, and fish. Provitamin A can also be found in carrots or pumpkins. Nevertheless, it is obtained by chemical synthesis [2].

Bakuchiol is a natural substance of plant origin. This compound is isolated from the Bakuchi plant known as *Psoralea corylifolia*. According to findings, most of this substance is found in the seeds of this plant [3]. Bakuchiol has been known for many years and used in Traditional Chinese Medicine and India, among others [4].



Retinoids

Chemical Structure

Retinoids were first studied in the early 20th century [5]. The term retinoids refer to vitamin A derivatives characterized by similar biological activity and structural formula. The most active one is all-trans-retinol (Fig. 1), which chemically belongs to alcohols. Due to its instability, it is most often used in the form of esters: retinyl palmitate and retinyl acetate, which show higher stability. If retinol is oxidized, it transforms into retinal (Fig. 2), an aldehyde. Further oxidation leads to the formation of retinoic acid. Retinoic acid in which all double bonds are in a trans (all-trans) configuration is called tretinoin (Fig. 3).



Fig. 3. Retinoic acid (tretinoin) Source: own work based on [6]

The very large number of modifications of retinoids has made it possible to rank all vitamin A derivatives in terms of chemical structure. Therefore, we distinguish three generations of retinoids [7]:

- generation I - compounds containing a β -ionone fragment formed by modification of groups on the polar end and side chain of the polyene of vitamin A; this includes the so-called naturally occurring retinoids e.g. retinal (aldehyde),

- generation II - also called "aromatic" are fully synthetic compounds, in which the cyclohexene ring has been replaced with a benzene ring e.g. etretinate and acitretin,

- generation III - polyaromatic retinoids also called "arotinoids" these compounds are formed by cyclization of polyene side chain e.g. bexarotene [7].

In the cosmetic industry, the greatest role is played by first generation retinoids, which, despite their natural origin and occurrence, are obtained synthetically on a large scale.

Biological properties

Retinol, i.e. vitamin A is a lipophilic compound, therefore it dissolves very well in fats. Due to its structure, it can easily penetrate the stratum corneum, where it oxidizes to a more active form - retinoic acid [6]. Retinoids penetrate deep into the skin and regulate epithelial cell growth and differentiation, which justifies their strong regenerative effect on the skin when applied topically [8].

The mechanism of action of retinoids is based on their reaching the interior of keratinocytes and with the appropriate receptor: either with an affinity for retinol (CRBP) or with an affinity for retinoic acid (CRABP). Proteins bind retinoic acid to carry it to the cell nucleus and keep unbound tretinoin at a constant level. Retinoids can affect the transcription of genes as a result of binding to nuclear receptors: RAR-retinoic acid receptors and RXR-retinoid receptors. Both types of receptors differentiate into three subtypes α , β , and γ . In the epidermis, RAR γ receptors are the most abundant, whereas RAR β receptors are absent [9].

The role of retinoids in cosmetics

Retinoids are substances with versatile effects. One of their most popular uses is to improve skin condition by eliminating wrinkles, the so-called anti-aging effect. Skin aging is a natural process progressing with age, during which the skin loses its elasticity, firmness, becomes thinner. There is also so-called photoaging of the skin, which is a consequence of long-term exposure to sunlight (UV). Retinol used systematically contributes to increasing elasticity and improving the density of the epidermis even by 40%, which reduces the visibility of wrinkles. The anti-aging effect is based mainly on induction of proliferation, i.e. intensive proliferation of keratinocytes and their modulation already at a concentration of 0.1% retinol [9]. Some effects of retinoids may also be related to the mediation of these compounds in collagen synthesis. Collagen found collagen in the skin gives it elasticity and firmness [10]. The growth potential of fibroblasts, the cells responsible for producing collagen, elastin, and hyaluronic acid, decreases with age and is stimulated by retinol. Additionally, a Michigan research group has shown that retinol stimulates collagen synthesis in the skin of people over the age of 80 [11].

Collagenolytic enzymes i.e. metalloproteinases found in the extracellular matrix of the skin affect collagen degradation and slow down its synthesis [12]. The concentration of these enzymes increases with exposure to UV radiation, thus accelerating photoaging of the skin, resulting in loss of elasticity and the formation of wrinkles on the skin. Retinoids, by blocking collagenolytic enzymes, provide the ability to synthesize collagen in the skin, thus improving the appearance and condition of the skin and smoothing out wrinkles [13].

Another effect of topical application of cosmetic preparations with retinoids is improvement in skin tone. A study conducted on the reconstructed epidermis and guinea pig ears using a derivative of vitamin A-retinal (aldehyde) showed that it has a melanocytic effect, i.e. reducing the concentration of melanocytes in the skin. This is directly related to the effect of skin brightening by reducing the amount of pigment. The exact mechanism of action of retinoids on melanocytes has not yet been understood [14].



Due to their depigmenting and exfoliating properties, preparations with retinoids are recommended for people struggling with acne. Retinoic acid has been used to treat this condition for over 50 years. It is used both topically and orally. It affects all mechanisms of pathogenesis of the disease inhibiting their development, e.g. sebum overproduction, inflammation or keratinization of hair-oil estuaries [15].

Restrictions on the use of retinol

One of the major restrictions of retinoids is that they should not be used by women who are pregnant, planning to become pregnant, or breastfeeding [16]. Studies have shown that retinoids used systemically (i.e. absorbed through the skin or administered orally) are potentially embryotoxic and teratogenic, i.e. may cause fetal malformations. Therefore, it is recommended that retinoid therapy be avoided during pregnancy [17].

Another disadvantage of retinol use is its low stability against UV radiation. Retinoids are then degraded, which makes them inactive and they do not fulfill their role in cosmetic preparations [18]. This feature limits the use of cosmetics with vitamin A in spring and summer, when it may additionally irritate the skin. If we do not stop retinoid treatment, then we should limit the frequency of use of preparations with this active substance and choose cosmetics with very low concentrations.

Often observed side effects of preparations containing retinoids are: redness and skin irritation - mainly associated with the use of too high concentrations, itching, burning, and dryness of the skin, as well as excessive peeling of the epidermis, which is associated with very easy penetration of these compounds into the epidermis. In addition, alcohol and other retinoid-containing products should be avoided during therapy because they may exacerbate side effects [19].

Use in cosmetic preparations

Retinoids are one of the most popular groups of compounds used by cosmetic manufacturers. In cosmetic preparations, they are mainly advertised as anti-aging ingredients. Retinoic acid shows the highest topical activity, followed by retinal aldehyde, then retinol and finally esters. The highest concentration of retinol used in cosmetics is 5%, but most manufacturers choose to use 0.2-0.5% vitamin A. In cosmetic preparations available on store shelves, apart from retinol, we can also find: retinal, which is about 10 times more active than retinol. In cosmetic preparations available on shelves, apart from retinol, we can also find: retinal, which is about 10 times more active than retinol. In cosmetic preparations available, which are about twice less active than retinol. However, skin tolerance to retinoids is the opposite, i.e. higher concentration of esters can be used in cosmetics than of aldehyde or vitamin A, which is why we can find them most often in cosmetic formulations [20].

Bakuchiol

Chemical structure

In recent years, a substance of plant origin, bakuchiol, has become very popular (Fig. 4). From the chemical point of view, it is a monoterpene phenol, containing one stereogenic (chiral) center. The terpene moiety and the location of the hydroxyl group (position 4, the so-called "para") are most responsible for the biological activity of this compound. Despite the lack of structural



similarity, but due to its low molecular weight and similar mode of action and effects, it has been recognized as a "functional analog of retinol" [21].



Fig. 4. Bakuchiol Source: own work based on [21]

Similarity to Retinoids

Anti-aging effects

A 2014 study in the United States found that bakuchiol, like vitamin A and its derivatives, affects gene expression. It has been proven to stimulate fibroblasts and cause an increase in collagen synthesis. Additionally, application tests of a cream containing bakuchiol were carried out on a group of women aged 40-65, who had signs of photoaging of the skin. After 12 weeks of treatment, wrinkles were noticeably shallower, skin elasticity and firmness improved, and signs of photoaging were reduced. These results confirmed the functionality of bakuchiol, which turned out to be similar to the effects produced by the use of retinoids [2].

Interesting results were obtained by comparing formulations with 0.5% retinol and 0.5% bakuchiol during a study conducted in 2019. During a 12-week treatment, a double-blind study was conducted with 44 participants using the respective formulations once a day. At the end of the study, it was found that both those using the retinol cream and those using the bakuchiol formulation had reduced wrinkles and discoloration. The only difference was the side effects reported by the volunteers. Those using the retinol cream were more likely to feel stinging, itching, and burning of the skin, while those using the bakuchiol product had more facial redness after 4 weeks of use [22].

Another study also conducted in 2019 to evaluate the safety, anti-aging efficacy was conducted under the supervision of a dermatologist by evaluating the clinical and instrumental effects of the bakuchiol serum. After 12 weeks of treatment, they showed a significant decrease in the presence of wrinkles (by 11%), an increase in skin firmness by 8% and a 70% reduction in redness, as well as an overall improvement in skin condition. Studies were conducted on different skin types, thus proving that bakuchiol applied to oily skin does not cause comedogenesis and is safe [23].

Anti-acne activity

Formulations containing bakuchiol in combination with other active substances, such as ginkgo biloba leaf extract and mannitol, were tested in a clinical study lasting 2 months on 111 participants. During this time, one group used a formulation containing the active complexes, while the other group used a placebo. Those who used the cream with active substances showed a reduction in the intensity of seborrhea, as well as an alleviation of inflammation. In the final conclusions, it was concluded that



the reduction of inflammation was probably caused by the antibacterial properties of bakuchiol against *Propionibacterium acnes* bacteria, involved in the formation of acne vulgaris [24].

Action against skin hyperpigmentation

The mechanism of action against hyperpigmentation is not fully known. However, a 2010 study in mice assumes that it involves inhibition of melanin biosynthesis and is concentration-dependent [25].

Bakuchiol in cosmetics

Bakuchiol can most often be found in creams, serums or lotions that are intended for facial care. Cosmetic producers advertise this ingredient on packages as "plant retinol", "bioretinol", "botanical retinol", and similarly to vitamin A, it is found in anti-wrinkle cosmetics. Unlike retinoids, bakuchiol is referred to as a safe substance and is not restricted in its concentration in cosmetics.

Conclusion

Retinoids are a group of compounds that are eagerly used not only by cosmetic manufacturers, but also by consumers. Retinol and its derivatives have a number of clinically proven properties such as anti-wrinkle effect, stimulation of collagen synthesis, anti-acne activity and removal of skin discolorations. Despite many superlatives retinoids also have a number of side effects, so they cannot be used by people with sensitive skin or pregnant women. In addition, the use of vitamin A and its derivatives requires building up skin tolerance to increasing concentrations, as well as the use of measures to reduce side effects such as redness or itching of the skin. Another important limitation is low photostability of retinoids, which makes them not recommended for use in summer.

Bakuchiol is a relatively new substance that became popular several years ago for its skin care properties. Despite the differences in its chemical structure, it was quickly compared to the well-known vitamin A and its derivatives. The advantage of bakuchiol is not only its effective, clinically proven anti-wrinkle effect, but above all its negligible side effects and lack of limitations depending on the season or concentration.

Does bakuchiol then deserve to be called plant-based retinol? The answer to this question is not unequivocal. Despite many similarities in skin care effects, it is not possible to say that the two substances are completely similar. The mechanisms of action of bakuchiol are still not fully known, so the lack of side effects cannot be confirmed. To answer this question, studies are still being conducted to better understand the mechanisms of action of bakuchiol.

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METRICS IN R&D PROJECT MANAGEMENT

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Abstract:

This paper considers the problem of managing R&D projects using metrics. The metrics should be used at various stages of project implementation. They should be closely connected with the specific success factors and criteria of each R&D project. All R&D project stakeholders should be provided with a personal dashboard consisting of metrics adapted to their needs. The idea of the metric is presented, and the specificity of R&D projects discussed. Furthermore, a case study of a real-world R&D project is described. This project was not successful and the relevant reasons are analysed. proposal of a set of metrics for the project is proposed that can be a starting point for the development of project-specific metrics for each R&D project. The role of a project metrics keeper is defined.

Keywords:

metrics, research and development project, project success

Introduction

The literature clearly shows that R&D projects are specific and have characteristics different from projects in other fields. Many authors emphasize the specificity of research and R&D projects and the fact that the uncertainty of achieving specific results must be considered when planning them.

More and more projects are funded and fail. The specific environment of implementation (university or other research institutions), high risk and uncertainty, are important factors of this failure. Questions arise as to how to act effectively to prevent failure in research and development projects?

There is therefore a need to measure all the necessary circumstances of research and development projects implementation to counteract, prevent, or anticipate problems. A research gap is encountered: the problem of measuring the chances of success of research and development projects. The author of this article attempts to propose metrics for measuring research and R&D projects in context during their implementation.

The essence of the concept of project metrics

Nowadays, it is very important to understand which critical factors and indicators need to be identified and managed for the project to be perceived as a success by all stakeholders. Defining project-specific success factors and key performance indicators is a joint task for the project



manager, the client, and other stakeholders (stakeholders are individuals or groups that are influenced by the organisation when pursuing its objectives or that influence the achievement of the organisation's objectives [1]). This is an important conclusion because only by considering the understanding of success of each stakeholder can we understand what we need to measure to achieve project success in the eyes of all the parties involved.

According to H. Kerzner, a project cannot be managed effectively without metrics and accompanying measurements that can provide complete or near-complete information about a project's chances of success [2].

To explain the essence of project metrics in a transparent way, the literature proposes the simplest definition of a project metric: A metric is a measure of the phenomenon that is being measured. H. Kerzner formulates the following statements, which further clarify the essence of metrics:

• if a phenomenon on the projects cannot be measured, it cannot be managed;

- the phenomenon what gets measured gets done;
- it is never really understood anything fully unless it can be measured [2].

Metrics inform stakeholders about the status of the project. Stakeholders need to be confident that the right metrics are being used and that the measurement provides a clear and true representation of the state of the project. Metrics can determine whether it is feasible to undertake and continue a particular project and whether certain actions need to be taken.

The project manager and relevant stakeholders must agree on which metrics will be used and how they will be measured. It is also necessary to agree on which metrics will be part of the dashboard reporting system (each stakeholder will have a dashboard, thus a set of individually selected metrics) and how they will be interpreted. Managing metrics is important because establishing the true status of a project plays the most significant role in project management [1].

Metrics must be well defined, and guidelines for their use must be fully accepted by those who will use them. A project management program through metrics should be designed and implemented so that the project team begins to consider metrics as the basis for activities that support project management excellence and overall organizational improvements. Data provided by a system of metrics can only become the basis for informed analysis if there is consensus on what is happening and what should be happening in projects [2].

However, defining a metric requires answering some key questions about measurement.

-What should be measured?

-when should it be measured?

-How should it be measured?

-Who will do the measuring?

and about information gathering and reporting:

-who will collect the information?

-when will the information be collected?

-when and how will the information be reported? [2]

The metrics can change during each phase of the project lifecycle, and from project to project. The metrics should be closely linked to the project success factors and the project success criteria for each particular project.



In the literature, the concepts of success factors and success criteria are interrelated, and many authors [3-7] suggest defining the concepts criteria and success factors as follows:

- success criteria are dimensions for assessing whether a project has succeeded or failed,

- success factors are variables (conditions) that increase the probability of project success.

Thus, project metrics should measure, during project implementation, to which extent the conditions enforcing project success are fulfilled and the predicted values of project success criteria are satisfactory.

Specificities of research and development projects

It is worth noting that every R&D project is different. Conditions change, implementers change, new challenges are posed [8]. Although this is true for any project, it is especially glaring in the case of R&D projects, because of their specific features.

The theme of the specificity of R&D projects is worth starting to develop from the specific features of R&D activities.

According to the Frascati manual, R&D activities:

- is always oriented towards new discoveries, based on original concepts (and their interpretation) or hypotheses;

- as a rule, there is no certainty about the final outcome or at least about the amount of time and resources needed to achieve it;

- the purpose of R&D activities is to produce results that could be freely transferred or sold on the market [9].

Beginning in the 1950s many publications have emphasised the specificity of research and development projects, which inherently involve lack of full knowledge and uncertainty.

This specificity of R&D projects can be described as follows:

• planning of research and development projects must take into account uncertainty as to the outcome of individual tasks,

• as such, research and development projects require different management methods than, for example, construction or IT projects,

• there are different types of research and development projects which may require different management methods,

• there is no good deterministic plan for research and development projects (i.e. one that has a good chance of being implemented without significant deviations),

• the group of R&D projects is internally diverse (in terms of differently defined project size, organisational structure, stability of the project team, division of labour between project team members, qualifications and degrees and titles held by project team members, etc.),

• the human (social) aspect is an important issue in the management of R&D projects [10].

Initial conception of the metrics for R&D projects – case study

R&D project "Costing method for universities based on activity-based costing"

The aim of the project was to develop a cost management model in a higher education institution (HEI) based on Activity-Based Costing (ABC) [11] and its pilot implementation in a selected area of the HEI.

To achieve the set objective, an in-depth analysis of the costs incurred by the selected HEI and the currently applied system was to be carried out. Next, a cost calculation model was to be proposed, based on activity-based costing, which was to be adapted to the selected HEI and to the changing conditions in which it operates. Then an attempt was made to implement the model and to use the results for a reliable determination of the education and research costs in the HEI. During the implementation, the related problems were to be identified and the conditions for the successful ABC implementation in HEIs formulated, including those concerning the IT environment. The research methods were to include interviews with HEI employees, HEI document analysis, process mapping, etc. [12].

Unfortunately, the project has not been successful. The project team was denied access to the data, and the HEI employees were unwilling to provide the necessary information. Only a theoretical ABC model was elaborated. There was merely a fragmentary possibility to verify it in practice.

Proposal of metrics for the R&D project

After a review of the literature and a preliminary analysis of the case study, the following research questions were posed.

PB1: What factors contributed to the partial failure of the R&D project?

PB2: Would it have been possible to identify project problems before they occurred, and how?

PB3: What metrics could have helped to identify problems earlier in the project?

The purpose of conducting a qualitative study was to indicate the specifics of a selected R&D project, to identify problems and difficulties encountered in its implementation, and to identify metrics that would help identify or prevent these problems earlier.

After conducting a qualitative study, based mainly on an interview with the project manager, the author of the article concluded that some problems in the R&D project could have been identified earlier by using appropriate metrics. The result of the study is a conceptual approach to measuring the success chances of an R&D project during its implementation.

The concept is presented in Tab. 1 according to the following scheme.

- Cause of a problem (identified in the interview).
- Description of the metric (what it is supposed to verify).
- Measurement method (when the metric will be measured, in which way, who will be asked?).
- Possible difficulties with the metric application.



			1 5	
Cause of a problem	Metric	Description of the metric	Measurement method	Difficulties
Failure to identify the weakness of stakeholder relationships.	How many times have you contacted stakeholders by phone or email?	Does the project team feel that the relationships with stakeholders are good?	After each periodic meeting, by email, team members and project manager	No response to email, unwillingness to provide information
	1. Are you familiar with the strategy, vision, and objectives of the project?	Whether all stakeholders who have the greatest influence on the success of the project are involved in project preparation and planning.	Before the project initiation, once, by email, the main stakeholders	Not all stakeholders will respond, resistance to provide information.
Project planning was carried out without active participation of the main	2. How many stakeholder contacts were made prior to project initiation?	Has a stakeholder management plan been prepared to manage its impact on the project?	Before project initiation, once, by email, project manager	Resistance to provide information.
Starcholders.	3. Did you attend the presentation of the project?	Whether project team members and stakeholders have an identical vision of the project.	Before the initiation of the project, after the presentation of the project to all stakeholders, once, by email or phone/smartphone questionnaire, project members and stakeholders.	Not everyone will answer, not everyone will take part in the presentation of the project for various reasons.
Inability to signal problems to the project steering and monitoring institutions.	Do you have support when problems arise in a project that you cannot deal with?	Whether there is an effective project steering and monitoring body	During the project, repeatedly, by e-mail or smartphone questionnaire, project manager.	Due to the organisational culture, the answers will be misleading.

Tab.1. Metrics proposed for the analysed R&D project

Source: own researching on base of case study

According to the author, the person who will be responsible for measurements, data collection, analysis, and interpretation must be a separate person, let us call them 'metrics keeper'. A metrics keeper will be responsible for the whole process. They will not be scientists, but they should have the necessary knowledge about metrics and their management. They will not perform any other activities in the project in addition to keeping the metrics.

In conclusion, it is worth mentioning that early identification of problems related to R&D projects is possible. The starting point for the early identification of problems is not only the risk analysis but also an in-depth analysis of the specific environment in which the research or R&D project is carried out. The result of the analysis will be the identification of factors that can affect the success of the R&D project and can result in the emergence of problems during the implementation of the project. The use of appropriate metrics will allow not only to obtain relevant data but also to anticipate these problems in order to prevent them.



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PREPARATION OF HERBAL EXTRACTS BY EXTRACTION WITH SUPERCRITICAL CARBON DIOXIDE (CO₂)

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Abstract:

Extraction with a supercritical fluid is ecological and one of the most efficient extraction methods that allows to obtain many health-promoting and ecological raw materials that cannot be achieved with other instrumental techniques. The conducted research was aimed at obtaining highly efficient extracts of thyme, sage and lemon balm. The work defined the optimal conditions for the preparation of herbs before the SFE extraction process. Pre-treatment consisting in optimal drying and refining of herbs allowed to obtain extracts with much higher efficiency than without treatment. An important parameter enabling the extraction of all valuable compounds from the plant is the extraction time. Extending the extraction time resulted in two-fold increase in the extraction efficiency for each of the tested herbs. The composition of the obtained extracts was identified by GC / MS technique.

Keywords:

supercritical extraction, herbs, pro-health properties, GC-MS, SFE extraction

Introduction

The healing and health-promoting properties of herbs have been known for thousands of years. The 19th century was a period of significant industrial development and many discoveries, inter alia, synthetic drugs, dietary supplements, etc. This led to the creation of an emergence of large marketing and pharmaceutical concerns, leading to a significant loss of interest and reduction in the use of herbs in everyday life. Currently, thanks to the increased social awareness and many studies that have been carried out on the side effects of using synthetic drugs and their effectiveness, herbs have again gained great popularity in many industries, e.g. food, pharmaceutical, medical, cosmetic, etc. [1-3].

At present, the global production of herbs is over 0.5 million tons per year (dried herbs and the production of herbs for pharmaceutical purposes). Poland is one of the key producers of plant raw materials in Europe. Moreover, analyzes of the Polish herbal market show a high production and processing potential of herbs. Contemporary herbal processing in Poland is focused primarily on the production of herbal medicines, nutraceuticals and cosmetics (cosmeceuticals) [4].

Recently, plant products obtained by supercritical fluid extraction have been of particular interest. Thanks to extraction, it is possible to obtain many valuable raw materials, such as: unsaturated oils, oleoresins, polyphenols, pharmaceutical substances, essential oils, unsaturated fatty acids, natural cosmetics, antioxidants, active ingredients and natural dyes and many other valuable plant raw materials. The most popular herbs occurring in the Poland are: thyme, sage, lemon balm, chamomile and mint [5, 6].

Thyme (Thymi Herba) is a perennial medicinal plant that is used in the food industry as a spice to enrich the taste and aroma of products.

Thyme herb belongs to the oil plants. In addition to essential oil, it also contains flavonoids, tannins, phenolic acids, triterpene compounds, bitterness substances, saponins, vitamins and minerals. Depending on the origin of the plant material, harvest time, drying conditions and raw material storage, the chemical composition of the plant material may vary. Thyme has various beneficial pharmacological properties, such as: antiseptic, antioxidant, antibacterial, antispasmodic and expectorant [7-11].

Medicinal sage (Salvia officinalis L.) is a perennial medicinal plant that is used in the food industry as a product flavor and antioxidant. Sage leaves are a medicinal raw material. In addition to essential oils, it contains triterpenes, tannins, flavonoids, vitamins B1 and C, bitterness. The plant works well in the treatment of problems with the digestive system, improves digestive processes, heals gastroenteritis, helps to eliminate flatulence, diarrhea and excessive fermentation in the intestines. Sage reduces the level of excessively high blood sugar, which is why it is recommended for diabetics.

Lemon balm (Melissa officinalis L.) is a perennial that gives off a pleasant lemon scent. Lemon balm contains a lot of valuable essential oils, tannins, flavonoids, triterpenes, phenolic acids, sugars, mineral salts, bitterness, chlorophyll, carotenoids. This plant is known especially for its calming properties, and also has an antispasmodic effect, stimulates the secretion of gastric juice, and has bactericidal and virucidal properties. Lemon balm also has a strong antioxidant activity due to the presence of phenolic compounds, flavonoids as well as α -tocopherol and β -carotene [1, 3, 7].

Supercritical fluid extraction (SFE) is run in a supercritical fluid. Due the low critical temperature (31.1 °C, Fig. 2), low critical pressure (73.8 bar, Fig. 2), easy preparation, no toxicity, low viscosity, high diffusivity, no corrosivity and low cost, the most commonly used fluid is carbon dioxide (CO₂). The production process for extracts by the SFE method has many advantages compared to other alternative methods. Classic methods for production plant extracts use high temperature, leading to thermal decomposition of many very valuable compounds and harmful organic solvents polluting the extracts. Thanks to SFE extraction, it is possible to obtain high-purity extracts rich in many valuable compounds that are not achievable by other methods [5, 6, 9-12].

This paper describes the gas chromatography methods used to identify volatile organic compounds in the obtained herbal extracts using the SFE method.

Materials and methods

The herbs for extraction with supercritical carbon dioxide were obtained from a Polish herbal company located in the heart of Kujawy, cooperating with neighboring herbal farms. The following materials were used:

- thyme herb (Thymi Herba);
- sage leaves (Salvia officinalis L.);
- lemon balm leaves (Melissa officinalis L.).











Lemon balm

Fig. 1. Tested herbs Source: own collections

Immediately after delivery to the laboratory, the samples were tested for moisture content using a moisture analyzer (Radwag). Herbs with a moisture content above 10% were conditioned at room temperature in the presence of an air dryer to absorb excess water. Herbs with a moisture content below 10% were dried in a thermal research chamber at a temperature of 35°C in accordance with the literature data [7] until the dryness was below 92% and 94%. Dryness was determined with RADWAG MA 50.X2.A moisture analyzer.

After the drying process, the herbs were ground using a Vitamix herb grinder. The grinder was characterized by specialized knives dedicated to dry grinding of herbs with the function of the power regulation depending on the type of ground herb, then the herbs were sieved using a vibrating screen.





Thyme before refining process



Sage before refining proces



Thyme after refining process



Sage after refining process

Fig. 2. Sample photos of herbs before and after the refining process Source: own collections

Extraction with supercritical carbon dioxide was performed with the SFE supercritical extraction kit. In order to optimize the process, the impact of time on the extraction performance of the herbs tested was investigated.

The qualitative analysis of thyme, sage and lemon balm extracts was performed using gas chromatography technique with a mass detector (GC-MS). Approximately 100 μ L aliquots were taken from each extract and transferred to glass tubes. 2 mL of dichloromethane was added to each tube and shaken to dissolve the suspension. The obtained solution was dried with anhydrous sodium (VI) sulfate and filtered through a 0.2 μ m PVDF syringe filter. The solutions prepared in this way were analyzed with the GC-MS technique. A Bruker 436-GC gas chromatograph coupled with a Bruker SCION SQ mass spectrometer (single quadrupole, ionization with EI electrons) was applied (BR-5ms chromatography column; 0.25 mm x 30 m, df = 0.25 μ m, column temperature program: 60°C (4.0 min) at 12°C / min up to 180°C (0 min), at 8°C / min up to 240°C (0 min), at 25°C / min



to 300°C (4.1 min), flow of mobile phase: 1.0 mL/min). Chromatographic signals were identified by comparing the obtained mass spectra with the NIST 11 spectral library.

Results and discussion

Pretreatment of herbs

Before the SFE extraction process, the influence of herb moisture on the extraction efficiency was investigated. The yield of the obtained extracts was tested for raw herbs (without pre-treatment) and dried herbs with a dryness of 92% and 94%. It was observed that the moisture content of all the herbs tested had a significant effect on the extraction efficiency. The highest yield was obtained for 94% dryness (Fig. 3). The difference between the extraction efficiency of herbs without preliminary drying and those dried to the level of 94% is material. A significant difference in yield was observed for the extraction of lemon balm, then sage and thyme, 48%, 44% and 31%, respectively. In addition, extracts containing a considerable water content were obtained during the extraction of herbs without pre-drying (dryness below 80%) (Fig. 4). For these reasons, pre-drying herbs has a significant impact on the yield and quality of the extracts.



Fig. 3. Optimization of the herbs dryness before the SFE extraction process Source: own calculations

Refining of herbs before the extraction process also has a significant impact on the process efficiency. The solvent (carbon dioxide) penetrates and dissolves the compounds contained in the tested herbs much easier thanks to refining, which affects the efficiency of the obtained extracts (Fig. 5).





Fig. 4. Sample photo of the sage extract obtained: 1) without pretreatment, containing water; 2) with pre-treatment without water



Fig. 5. Influence of refining process on the extraction efficiency with carbon dioxide in a supercritical state Source: own calculations

Supercritical fluid extraction and GC analysis of the extracts

The extraction process of thyme, sage and lemon balm was carried out in a high-pressure SFE apparatus on a quarter-technical scale. Extraction was performed at a pressure of 20 MPa, a temperature of 323 K and a CO_2 flow rate of 50 l/h in order to determine the optimal extraction time. Based on Fig. 6., it can be seen that the optimal extraction time for all herbs tested is about 3.5 hours. The highest extraction efficiency was obtained for thyme - 9.1%.





Fig. 6. Graph of extract yield against extraction time Source: own calculations



Fig. 7. Sample photo of thyme extract Source: own collections

The composition of the obtained herbal extracts was determined using GC-MS. Low molecular weight volatile organic compounds can be identified by gas chromatography coupled with a mass spectrometer. Extracts obtained by the SFE method are characterized by the presence of high-molecular compounds: mid-volatile or non-volatile, such as e.g. waxes, fatty acids, dyes, etc. [13]. Therefore, proper sample preparation is essential prior to GC analysis.

In the presented chromatogram (Fig. 8), six valuable compounds present in the obtained thyme extract were identified, which are summarized in Tab. 1. The tested extract was characterized by the highest content of thymol (60.9%), which has many positive pro-health properties, among others expectorant, antibacterial, anti-cough, etc.



Fig. 8. GC - MS chromatogram of thyme extract Source: GC-MS analysis by Poznański Park Naukowo – Technologiczny

Tab.	1.	Substances	identified	in	thvme	extract	bv	GC-MS	method
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No.	Retention time, min	Substance	CAS No.	Share %
1	8,10	Cymen	99-87-6	4,1
2	9,28	Linalool	78-70-6	2,6
3	10,41	Borneol	507-70-0	1,7
4	11,92	Thymol	89-83-8	60,9
5	12,01	Carvacrol	499-75-2	7,29
6	13,53	Caryophyllene	87-44-5	3,26

Source: GC-MS analysis by Poznański Park Naukowo - Technologiczny

SFE analysis of the obtained sage extract revealed eight compounds typical of sage (Fig. 9. and Tab. 2.). The tested extract was characterized by the highest content of camphor (9.7%), which has many positive pro-health properties, including antibacterial, anti-inflammatory, antitussive, etc.



Fig. 9. GC - MS chromatogram of sage extract Source: GC-MS analysis by Poznański Park Naukowo – Technologiczny

No.	Retention time, min	Substance	CAS No.	Share %
1	8.24	Cyneol	470-82-6	1.5
2	9.43	βThujon	546-80-5	6.6
3	9.60	Thujon	546-80-5	2.3
4	10.06	Camphor	464-48-2	9.7
5	10.41	Borneol	507-70-0	4.1
6	13.53	Caryophyllene	87-44-5	6.5
7	13.73	Feranzen	18794-84-8	3.4
8	22.70	Geranyl linalool	1113-21-9	1.1

Tab. 2. Substances identified in the sage extract by GC-MS method

Source: GC-MS analysis by Poznański Park Naukowo – Technologiczny

The analyzes of the sage extract by the SFE method showed twelve compounds typical for lemon balm (Fig.10. and Tab. 3.). Similarly to sage, the tested extract was characterized by the highest camphor content (5.5%). A significant content of thujone (4.3%) and caryophyllene (3.3%) was also identified.



Fig. 10. GC - MS chromatogram of lemon balm extract Source: GC-MS analysis by Poznański Park Naukowo – Technologiczny

No.	Retention time, min	Substance	CAS No.	Share %
1	8.10	Cymen	99-87-6	0.5
2	8.24	Cyneol	470-82-6	1.7
3	9.43	Thujon	546-80-5	4.3
4	9.60	Thujon	546-80-5	1.4
5	10.06	Camphor	464-48-2	5.5
6	10.41	Borneol	507-70-0	1.2
7	11.60	Citral	5392-40-5	0.7
8	13.53	Caryophyllene	87-44-5	3.3
9	13.73	Feranzen	18794-84-8	2.2
10	13.92	1,4,7,-Cycloundecatriene, 1,5,9,9- tetramethyl-, Z,Z,Z-		3.0
11	15.47	1H-Cycloprop[e]azulene, decahydro- 1,1,7-trimethyl-4-methylene-	1113-21-9	2.2
12	19.35	n-Hexadecanoic acid	57-10-3	2.2

Tab. 3. Substances identified in lemon balm extract by GC-MS method

Source: GC-MS analysis by Poznański Park Naukowo – Technologiczny

Conclusions

SFE extraction was carried out on a quarter technical scale at a temperature of 323K, a pressure of 20 MPa and a CO_2 flow rate of 50 l/h for 1 h for thyme, sage and lemon balm without pre-treatment and with treatment. Thanks to the pre-treatment procedure, a much higher extraction yield was obtained than without without the treatment. The difference for thyme was 40%, sage 54%, and lemon balm 58%. The pre-treatment of herbs before the SFE extraction process has a significant impact on the yield and quality of the extracts. The optimal conditions for preparing herbs for extraction are as follows:

- dryness of the tested herb: 94%;
- necessity to refining the tested herbs to a fraction of approx. 1 mm.

During the extraction process, an important parameter in determining the extraction of all valuable compounds from the plant is the extraction time, which is set at 3.5 hours. Extending the extraction time from 1 hour to 3.5 hours had a significant effect on its efficiency. Thanks to this optimization, extracts were obtained with a higher efficiency than during 1 h extraction: for thyme by 56%, sage by 21% and lemon balm by 41%.

GC-MS analysis was performed to determine the quality and composition of the obtained extracts. Chromatographic analysis showed high-quality extracts rich in valuable compounds with health-promoting properties. The thyme extract had the highest thymol content (61%), while the sage and lemon balm extract had a high camphor content, respectively 9.7% and 5.5%.

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PROSTATE CANCER – DIAGNOSIS AND TREATMENT IN PATIENTS WITH PROSTATE CANCER

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Abstract:

Prostate cancer is the most common malignant cancer in men in Europe. Modern diagnostic tools enable the early detection of prostate cancer and the implementation of effective therapeutic tactics. General practitioners play an important role in identifying patients with prostate cancer. The majority of cases detected early are due to referral by the family doctor to a specialist. Many of men diagnosed with prostate cancer will die with it, but not because of it. The majority of patients have a known prostate cancer that is no higher than local. The relative 5-year survival rate for these men is almost 100%. In this context, the importance of early detection of prostate cancer, of carrying out preventive examinations on this direction of men in the general practitioner's practice should be stressed.

Keywords:

prostate cancer, urology

Introduction

Despite the constant medical development, prostate cancer is one of the biggest problems today, which is the most common solid cancer diagnosed in men in Europe. The frequency of occurrence is 214 out of 1000 cases. At the same time, it is the second most common cause of cancer-related deaths in men. This is usually a disease affecting older patients (aged 7-8 decades) and is therefore a major medical problem in industrialized countries where life expectancy has increased [1].

The scientific objective of the project is to analyse the state of scientific knowledge on prostate cancer diagnostics and to find out which treatment method is most appropriate for the patients.

The diagnosis of prostate cancer, as well as the ability to predict the progression of the disease, remain problematic. There is no simple procedure to make a clear diagnosis of prostate cancer. Currently, early detection consists primarily of a rectal examination and determination of the level of the PSA – specific antigen in the blood. Increased levels of PSA antigen in the blood of patients form the basis for a prostate biopsy. However, PSA is not a specific marker for prostate cancer and has relatively low specifity.

Cancers, including prostate cancer, are responsible for the development of changes in the body at the proteomic and metabolic levels. Therefore, the analysis of proteins, peptides and metabolites in the body fluids is a promising tool in the search for diagnostic and prognostic biomarkers for prostate cancer.



The prevalence of prostate cancer has increased in recent years, mainly due to the aging of the population and the practice of screening for prostate specific antigens (PSA) and subsequent biopsies. Prostate cancer therapy is effective only at an early stage of disease development. Despite improved cancer therapies, there is still no effective treatment for advanced prostate cancer [2].

Examination and diagnosis of prostate cancer

Prostate cancer is asymptomic in early development. The main The main diagnostic methods include determination of the plasma concentration of prostate specific antigen (PSA), finger examination of the prostate gland (DRE) and transrectal ultrasound examination (TRUS). There is no generally accepted lowest cut-off value for PSA, although the value >4 ng/ml is most commonly used. It is also known that some prostate prostate cancer develop without PSA growth (e. g. low-level carcinomas). The possibility of detecting cancer is – to a limited extend – a rectal examination of the prostate gland with the finger. The primary importance of the TRUS sonogram is due to the function of a method that facilitates the performance of a prostate needle biopsy. The diagnosis of prostate cancer is made by histopathological examination of the material taken during biopsy. Today, the core biopsy of the prostate under TRUS control (core biopsy) is standard for prostate cancer diagnostics. It is recommended to perform a so-called 6-fold lateral biopsy (sextant lateral, 6-10 sections) as the first biopsy. With an extension of the biopsy protocol of >20 samples (satura cytum biopsy), cancer can be detected in patients eith strong suspicion of the disease who had negative biopsy (repeat biopsy) [3].

The TNM classification is usually used to determine the stage of the tumor and describes the following:

- Size of the primary tumor (T-tumor). A scale of 0 to 4 indicates the degree of hyperplasia of the primary tumor and its relationship to the surrounding tissues. The higher the T-degree, the more advanced cancer is.
- Condition of the regional lymph nodes (N-nodus-nodes). Scale from 0 to 3. The N-feature determines the extend to which the tumor has spread to the regional lymph nodes. This happens when the cancer cells of a growing primary tumor enter the lymph vessels and settle in the nearest lymph nodes of the organ (so-called regional lymph nodes).
- Absence or presence of distant metastases (M metastases) scale from 0 to 1. Remote metastases are secondary tumors of a malignant tumor that occur when the growth of a primary tumor damages the walls of neighboring blood vessels and the cancer cells enter the bloodstream and migrate to the other parts of the body.

The TNM classification is often used to describe the progress and the choice of treatment. The TNM classification of a case determines further treatment – the treatment method used depends on the stage described by the TNM classification [4].

rub. 1. 11(i) elussification of prostate cantor (tamor)			
Τ0	No primary tumor detected		
T1	Tumor clinically indistinct on imaging studies, unremarkable		
T1a	Incidentally detected tumor in the existed tissue <5% of the volume of the excised tissue		
T1b	Incidentally detected tumor in the existed tissue >5% of the volume of the excised tissue		
T1c	Tumor detected by biopsy taken for other indications, such as elevated PSA		
T2	Tumor palpable or visible on imaging studies, within the prostate		
T2a	Size less than half of one lobe, tumor confined to one lobe		
T2b	Size more than half of one lobe, tumor confined to one lobe		
T2c	Tumor includes both lobe		
T3	Tumor exceeds the limits of the prostate capsule		
T3a	Background tumor infiltrates outside the capsule, including microscopic infiltration of		
13a	the bladder neck		
T3b	Seed bladder infiltration		
Τ4	Immobile tumor or infiltrate adjacent structures other than seminal vesicles, e.g. external		
14	sphincter muscle of anus, bladder, anal lifting muscle, pelvic wall		

Tab. 1. TNM classification of prostate cancer (tumor)

Source: oncology service (https://www.onkonet.pl/dp_nump_rakprostaty.php)

Tab. 2. TNM classification of prostate cancer (lymph nodes)

NO	No metastases to the regional lymph nodes
N1	Metastases in regional lymph nodes

Source: oncology service (https://www.onkonet.pl/dp_nump_rakprostaty.php)

Tab. 3. TNM classification of prostate cancer (metastases)

M0	No remote metastases detected
M1	Existing distant metastases
M1a	Metastases in one or more non-regional lymph nodes
M1b	Bone metastases
M1c	Metastases with a different localization from those mentioned above

Source: oncology service (https://www.onkonet.pl/dp_nump_rakprostaty.php)

There is no doubt that regular PSA examination in asymptomatic middle-aged men will reduce the number of late diagnosed advanced prostate cancer cases. Compared to the study of the entire male population, screening studies of a selected group of high-risk patients are economically sound. Therefore, periodic examination should be performed primarily in patients with positive family history and elevated PSA. These include PSA tests, transrectal palpation of the prostate gland (and a prostate biopsy if prostate cancer is suspected). According to the American Cancer Society, regular check-ups should be initiated in people at high risk of prostate cancer infection from about 45 years of age. The importance of an increase in PSA in patients at high risk of prostate cancer are indicative of prostate biopsy. In the event of a negative biopsy in these men, palpation, PSA and /or biopsy should be repeated at short intervals. In the polish population (in view of the fact that a number of DNA markers are known for prostate cancer predisposition), it seems appropriate to supplement the program of periodic examinations with carries of the mutations NBS1, CHEK2 and BRCA1, which are associated with a predisposition to prostate cancer and tumors of the other organs [3].

The histopathological examination determines the degree (Gleason score) of histological malignancy for the tissue from each bioptate. Two extreme values are taken into account and added together. The study assesses the degree of malignancy for the right and left lobe. The degree of



malignancy is determined pointwise between 1 (highly differentiated cancer) and 5 (undifferentiated cancer). The risk of prostate cancer is assessed on the basis of the TNM classification (T-characteristic), the histopathological evaluation of the samples (Gleason scale) and the PSA steroid antigen [4].

	Low risk	Medium risk	High risk
T characteristic	T1-T2a	T2b	T2c
Gleason score (GS)	GS<6	GS 7	GS 8 - 10
PSA level (ng/mL)	PSA<10	PSA 10 - 20	PSA>20

Tab	3	Degree	of	risk	of	prostate	cancer
1 a.	5.	Degree	or	1191	or	prostate	cancer

Source: oncology service (https://www.onkonet.pl/dp_nump_rakprostaty.php)

In elderly men or men at low risk of progression, close monitoring may be performed, requiring regular PSA tests, per rectum tests, SLE tests, small pelvic magnetic resonance imaging and skeletal scintigraphy. Inpatient treatment therefore includes surgical procedures, drug therapies and rehabilitation measures designed to prepare the patient to return to society and take on professional responsibilities. The nurse's role in caring for a patient is to provide comprehensive care, including mental support. Based on a laparoscopic treatment model, the patient was provide with a fully compensating system. Research problems were formulated on the basis of which hypotheses were discovered. Taking into account the previous objectives, patient care was introduced. As a result of the measures, the patient's condition improved [5].

Selected methods of prostate cancer treatment

The optimal treatment for early forms of prostate cancer is the surgical removal of this organ. This is a classic prostate removal, but laparoscopic procedures are more popular. Increasingly, prostate surgery is performed by means of robotic surgery. The most important surgical principles include the removal of the tumor within the limits of healthy tissue, the minimum loss of blood and the maximum reduction of postoperative complications. Recently, quality of life after surgery has also been added to the criteria for the surgical outcome, which is also crucial for the decision on the indication. In view of the stage of the tumor, but also the age of the patient and the accompanying diseases, the medical council of clinical oncologists, radiotherapists, urologists, radiologist and pathologists decides on the treatment after a discussion with the patient. Treatment options, depending on level of risk, are showed in the table below [6, 7].



Low riskMedium riskHigh risk• Radical prostate removal• Radical prostate removal• Accurate periodic inspection• Accurate periodic inspection• Accurate periodic inspection• ADT + radiotherapy + ADT• Brachyterapy (local radiotherapy)• Brachytherapy (local radiotherapy)• Radical prostate removal• Teletherapy (external radiotherapy)• Teletherapy (external radiotherapy)• Radical prostate removal with• Therapy)• Therapy)• Therapy	Tues. It is required by the probability of the former of t								
 Radical prostate removal Radical prostate removal Accurate periodic inspection Brachyterapy (local radiotherapy) Teletherapy (external radiation therapy) Teletherapy (external radiation therapy) Therapy) 	Low risk	Medium risk	High risk						
	 Radical prostate removal Accurate periodic inspection Brachyterapy (local radiotherapy) Teletherapy (external radiation therapy) 	 Radical prostate removal Accurate periodic inspection Brachytherapy (local radiotherapy) Teletherapy (external radiotherapy) +/- ADT (Androgen Deprivation Therapy) 	 ADT + radiotherapy + ADT Radical prostate removal with lymhadenectomy (excinsion of regional lymph nodes) 						

Tab. 4. Treatment options depending on the level of risk of prostate cancer

Source: oncology service (https://www.onkonet.pl/dp_nump_rakprostaty.php)

An interesting treatment option is proton therapy. It based on the application of proton energy by the cumulative beam method, which protects the surrounding tissue in the immediate vicinity of the prostate from its harmful effects. To date, however, there is insufficient evidence that treatment method is therapeutically superior to "classic" radiation therapy.

HIFU (Modern Method of Non-Invasive Local Treatment of Prostate Cancer) it is non-invasive method of treating tumors, including prostate cancer, in which highly concentrated ultrasound waves are used to raise tissue temperature locally to destroy them.

The HIFU method can be used as initial treatment or in the event of failure of other forms of therapy such as brachytherapy. It is characterized by a low complication rate and a similar proportion of local recurrences. The HIFU method is currently considered an experimental therapy but is increasingly being used.

Surgical treatment is not recommended at this stage, except in patients in stage T3a who require radiotherapy after surgery. An operative option is to perform a prostate excinsion in connection with the removal of the regional lymph nodes, but more often antiandrogenic hormone treatment (ADT) is used in combination with radiotherapy (ADT – radiotherapy – ADT) as the prognosis of the lymph nodes is uncertain [8].

If an infiltration of the gland or an infiltration of the seminal vesicles is observed after prostate removal, the patient should be considered for complementary radiotherapy, usually in combination with antiandrogenic therapy.

The treatment with choices are antiandrogenic medications (ADT), which are aimed at lowering testosterone levels. Second generation antiandrogens (enzalutamide, abiraterone – inhibitor of the enzyme CYP17A involved in androgen synthesis), surgical cestration, cytostatics. Radium therapy is also used.

The CyberKnife stereotactic body radiotherapy does not have a long history of use in clinical practice, it appears to be safe and effective in the treatment of prostate cancer that is restricted to the organ. The work already presented shows good results in terms of the early toxicity of the treatment and the quality of life of the patients, which are comparable or even better than the previous methods. However, a longer follow-up period is required for reliable presentation of the results of SBRT treatment, especially as late toxicity is more likely to occur in hypofraction regimens than in conventional fractionation. Finally, it should be noted that current National Comprehensive Cancer Network (NCCN) guidelines indicate an extremely hypofraction SBRT technique with fractionated doses of at least 6,5 Gy as a therapeutic option with similar efficacy and toxicity to conventional fractionated radiotherapy [9, 10].



Studies have shown that overall quality of life did not change significantly during treatment despite worsening of urinary and intestinal symptoms, suggesting that stereotactic radiotherapy with CyberKnife is well tolerated by patients.

Conclusions

The correct classification of the patients plays a crucial role in the treatment of prostate cancer. The stage of the disease, the age and also the general condition of the patient play a decisive role in the decision on treatment. Because of its biology, prostate cancer responds very well to high doses of radiation. Rational and safe dose escalation brings many benefits. Advances in treatment methods are leading to the development of immobilization techniques. In addition to the use of standard protocols to prepare patients with prostate cancer for treatment, innovative applications of substances such as hyaluronic acid, hydrogel, collagen or rectal ballon have been found.

The correct application of the above mentioned substances to the tissue allows a more stable immobilization of the prostate during the session and make better protection of healthy tissue and the position of the prostate is reproducible [1].

Nowadays, the treatment of prostate cancer can be performed with conventional and robotic methods. The treatment with the radiosurgical robot CyberKnife are reimbursed by the public tax office in Poland.

Analysis of the need for treatment of prostate cancer shows that we in Poland do not have sufficient robot equipment to enable modern treatment of prostate cancer [11].

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HEAT LOSS THROUGH WINDOWS – IS IT POSSIBLE TO CONVERT IT TO ELECTRICITY?

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Abstract:

Wireless sensor networks are important components of Internet of Things (IoT) applications. In modern buildings equipped with increasingly sophisticated automation installations and Building Management Systems (BMS), information extracted from the building's distributed measurement systems is essential for the proper functioning of all automation system components responsible for the safety and comfort of the occupants, as well as for the optimal operation of HVAC equipment. For numerous facilities, conventional hard-wired installations of building automation systems can be the solution. Unfortunately, their use is associated with a number of limitations, including the need for cyclic battery replacement. This paper presents an unconventional way of harvesting waste thermal energy to power wireless sensor platforms used as part of building automation systems.

Keywords:

energy harvesting, wireless, sensor network, window, smart buildings

Introduction

Wireless sensor nodes are very important parts of IoT (Internet of Things) applications. In modern buildings equipped with BMS (Building Management System) or other building automation systems, wireless sensors have a serious impact on the ability to collect information from the physical world. This information is necessary for correct work of HVAC (heating, ventilation, air conditioning) devices and in results for regular, economic and safe operation of a building. The optimal work of these systems is also the reason for the most effective energy consumption in building. The firsts building management systems were created in the 1980s. however, along with the dynamic development of technology only now are gaining popularity and are introduced in the vast majority of new investments, in particular those implementing the SmartHouse idea [2].

Wireless sensors can collect data on indoor environmental conditions (temperature, humidity, lights, illumination intensity, CO_2 concentration, people presence, window position, etc.). Compared to conventional wired solutions, wireless sensors have many advantages. For newly constructed buildings the most important factors include: reduction of the wire installation cost, reduced installation time and elimination of risk related to wire installation mistakes. In the case of existing buildings (especially historic buildings), companies implementing building automation



systems face the specifics of such buildings, making it impossible to implement a traditional wired installation. The most important limits in this case include: no opportunity for cable installation in an operating facility, large-scale destruction of infrastructure to make cable installation (furrows in the walls, reconstruction of damaged walls and ceilings, etc.), high cost of installation, as well as legal restrictions (e.g. related to the cable installation imposed by the conservator of historic buildings).

All of the above mentioned difficulties and limitations can be eliminated using wireless devices. However, wireless solutions are not without drawbacks either. Battery-powered devices require cyclic battery replacement and have the risk of immediate interruption of communication with the data gateway when the battery dies. To eliminate these risks, it is necessary to use battery-free energy harvesters operating with sensors of wireless networks enabling stable power supply to them.

The solution using indoor energy harvesters is limited by their energy efficiency, converting waste energy to electricity and storing electrical energy usable to power electronic devices. Among the energy sources possible for use inside a building, only a few of them have sufficient power density to meet the minimum requirements of harvesters and powered electronics.

Waste heat energy harvesting

Among the numerous available sources of waste energy inside a building (light, thermal, mechanical, electromagnetic radiation, etc.), thermal energy is relatively freely available inside a building and offers the possibility of converting it into electricity without any electromechanical systems that affect the reliability and limited length of service time [3].

In industrial buildings, there are a lot of thermal waste energy sources with a high temperature difference in relation to the ambient temperature (e.g. heating systems, cooling systems, ventilation systems, etc.), which characterizes these sources as excellent for use in battery-free powering of IoT devices. A much more difficult environment for using waste heat inside a building to power wireless IoT devices is public space (office buildings, rooms in hospitals, classrooms etc.). In these facilities, window glass is often the only possible source of waste heat energy of useful temperature difference. The article presents research indicating the possibility of using a thermal energy harvester installed on a window glass to power wireless IoT devices.

Energy consumption of IoT devices

The basic technical parameter related to determining the possibility of powering IoT devices in a battery-free way is the total electrical energy required to perform a full cycle involving awakening the sensor, performing the measurement cycle, processing the measurement data and sending a message to the gateway via a radio link, e.g. using recently gaining popularity LoRa standard. LoRa is a low-power long-range wireless (LPWAN) communication system [4]. LoRa uses license-free radio frequency bands (in Europe it is operated at 868 MHz).

It is ideal for indoor radio communication as it was shown by Author's own research [5] related to the power consumption of wireless sensor platforms built using LoRa radio module CMWX1ZZABZ-078 [6] (based on Semtech SX1276 chips and ST Microelectronics STM32L082 low-power microcontroller). It has been demonstrated that in case of ultra-low-energy sensors using the LoRa communication protocol, the power consumption required to realize a full measurement and transmission cycle ranges from 19.2 mJ to 28.3 mJ (depending on the voltage level of the source).



Such a small amount of energy confirms the possibility to power these sensors using waste heat energy harvested on the window surface.

Thermal efficiency of the window

The basic technical parameter that determines the feasibility of using heat transfer through the window for battery-free powering of wireless IoT devices is the verification of the Ug heat transfer coefficient for the window. Based on publications [7, 8], the value of the heat transfer coefficient for a standard double-glazed window (e.g. Aluplast Ideal 2000 EURO system) is 1,1 [W/m²K]. Although this is an exemplary value of the heat transfer coefficient for the window yet, due to the high prevalence of this type of window construction on the market, such value may be assumed as representative and as such it was used in the subsequent calculations.

Based on the data presented above, it was calculated that, using TEC1-12710 thermopile [9] (with the total area of one of its sides equal to 0.0016 m^2), the theoretical amount of thermal power available for use is 35.2 mW if temperature difference of 20 K is supposed. In theory, this is enough power to power ultra-low energy IoT devices. However, this is just theoretical thermal energy. The electrical power obtained using the TEC1-12710 thermopile, taking into account the energy efficiency of the thermopile and the need to raise the supply voltage to 3.3V (the value required to power the wireless sensor) will be much lower. Again, assuming the energy efficiency of the ultra-low voltage DC-DC converter equipped with the energy storage module, the actual output power of the energy harvester will provide 100 - 200 μ W. Assuming the energy requirement of the sensor to perform a full measurement cycle of about 30 mJ, under these conditions the system allows cyclic data transmission at a frequency of about 6 min. On the other hand, when realizing the installation of BMS and building automation systems in existing, old buildings (with definitely older window frames), the estimated value of thermal conductance will be higher. As a result, the power available for the energy harvester will also be higher.

Design of the thermal energy harvester device

Experiments were designed and equipment was built to study the efficiency of producing electricity by converting thermal energy. The element that recovers waste heat energy and converts it into electricity is the TEC1-12710 thermopile [9], which generates a voltage as a result of the Seebeck effect when the temperature difference on both sides of thermopile housing is non-zero. To increase the efficiency of the energy harvester the thermopile was equipped with a heat sink. Thermally conductive paste was applied between the thermopile housing and the heat sink. A controller WAGO PLC 750-8202 [10] equipped with suitable input/output modules was also prepared for the experiment. Using Pt1000 resistive temperature sensors and analog input PLC module the device was logging all the relevant values: thermopile output voltage, outdoor air temperature, outdoor window frame temperature and indoor window glass temperature.

Research

The measurement system was actually duplicated thus it was possible to carry out parallel measurements in very similar external conditions. Measurements were made in January 2021



in Wroclaw and in a village near Wroclaw, at locations about 15 km apart. In both cases, the measurements took a month.

The first test object was a single-family house, equipped with PVC window frames with two glass packages. Harvester was installed on the outside of the window on the second floor. The harvester was glued to the top of the window pane using thermally conductive paste. In addition, it was secured with a steel flat bar attached to the window glass with two neodymium magnets about 2 mm away from the flat bar, so that the harvester's heat sink did not have direct thermal contact with the surface of the glass. The conductive paste between the glass and the thermopile was additionally enriched with carbon nanotubes to increase the absorption of infrared radiation from the room side of the building (or to increase the emissivity of the low-temperature side when the harvester was installed inside the room).

The same device was also installed in an apartment located in a multifamily building on the inside of an older generation double-glazed window with a wooden frame construction.

Results

The following figures (Fig. 1 and Fig. 2) show the daily waveforms of the measured parameters for the station installed in a single-family house on the outside of a PVC-framed window. The first waveform (Fig. 1) shows the temperature and voltage changes in an open, unloaded thermostatic system recorded during a cold winter day. The minimum air temperature reached -13 °C while the temperature inside the building was about 21 °C, resulting in a 34 K temperature difference. With such a high temperature difference between the window partition, the minimum external temperature of the window surface was recorded at -6 °C, which translated into a maximum measured voltage of 10.4 mV.



Fig. 1. Dependence of thermopile output voltage on temperature on a frosty day (18.01.2021 daily record, Wroclaw. PVC double-glazed window). Source: own calculations

The second waveform (Fig. 2) shows measurements recorded during a "warm" winter day during the period of the experiment's implementation when the maximum outside air temperature



reached +11°C, with the temperature inside the building at 22.4°C, translated into an outside window glass temperature of 12.2°C. This gave a 10.2 K temperature difference and a minimum measured voltage of 2.1 mV.



Fig. 2. Dependence of thermopile output voltage on temperatures on a warm day (23.01.2021, daily record, Wroclaw. PVC double-glazed window). Source: own calculations

Similar tests were also carried out for a second building where the harvester was installed on the inside of a wood-frame window. For the coldest day, an outdoor air temperature of -12.45 °C was recorded. With relation to the indoor air temperature of 18.3 °C, the temperature difference between the two sides of the window reached 30.75 K, which resulted in the generation of a voltage of +13.5 mV at an indoor glass temperature of 12.9 °C (for a window glass-air temperature difference of 5.4 K). Over the course of the day, the highest measured voltage was +14.53 mV for a window pane-room air temperature difference of 5.7 K.



Fig. 3. Dependence of thermopile output voltage on temperature on a frosty day (18.01.2021 daily record, Wroclaw. PVC double-glazed window.). Source: own calculations

Similarly, the graph below (Fig. 4) presents the waveforms of the generated voltage during the warmest period studied on 23rd of January. During the day, the highest voltage of 10.86 mV was measured for a temperature difference of 4.3 K between the window glass and the ambient air. The lowest measured voltage was 7.33 mV for the temperature difference of 3.1 K.



Fig. 4. Dependence of thermopile output voltage on temperatures on a warm day (23.01.2021 daily record, Wroclaw. PVC old double-glazed window with wooden frame) Source: own calculations

Tab. 1 presents the largest and smallest values of measured voltages for each of the tested window types on the coolest (MAX designation) and warmest (MIN designation) days of the tests. Along with the values of voltages, the table also lists the temperatures of the surfaces to which the thermal energy harvesters were installed and the ambient temperatures at which the harvesters operated. The table also includes the value of the difference of these temperatures.

Date	Voltage [mV]	T_Surface [°C]	T_air [°C]	ΔT [K]
PVC frame				
18.01 MAX	10,4	-4,05	-9,5	5,45
23.01 MAX	7,15	6,15	2,75	3,4
18.01 MIN	4,39	3,1	-2,14	5,24
23.01 MIN	1,37	11,32	10,71	0,61
Wood frame				
18.01 MAX	14,53	13,1	18,81	5,71
23.01 MAX	10,86	18,06	22,35	4,29
18.01 MIN	9,77	15,17	19,33	4,16
23.01 MIN	7,33	20,14	23,23	3,09

Tab. 1. The values of generated voltages depending on the temperature difference of the harvester's working surface relative to the ambient air temperature.

In the research presented above, the dependence of the voltage generated by the thermopile as a function of the temperature difference was determined, as illustrated in Fig. 5. In case of the window made in PVC technology, the measurement of the minimum voltage value recorded



on 18th of January was removed because this value significantly deviated from the trend line. This was most likely due to the momentary illumination of the thermopile heat sink by sunlight, as a result of which a dynamic increase in the temperature difference of the window surface was registered.



Fig. 5. Comparison of the thermopile output voltage as a function of temperature difference (temperature of the surface adjacent to the thermopile housing and ambient temperature). Source: own calculations

Using the measurements carried out on 18th of January, Fig. 6. compares the voltage waveforms for both test locations with the resulting value of the temperature difference relevant to the operation of the designed energy harvesters (the value of the difference in the temperature of the window surface and the temperature of the air surrounding the energy harvester heat sink).





On the basis of the waveforms recorded for an energy harvester installed on a wooden frame window, a close relationship was observed between the temperature difference and the voltage generated. The waveforms recorded for a harvester installed on the outside of a PVC window during daylight hours (7 a.m. to 2 p.m.) show a significant drop in harvester efficiency despite a constant temperature difference. The reason for this phenomenon may be related to the absorption of solar

radiation, resulting in an increase in the temperature of the heat sink without a noticeable increase in the temperature of the transparent pane. After sunlight hours, even with a decrease in the temperature difference, the value of the generated voltage increases dynamically, coinciding with the characteristics shown in Fig. 5.

An important finding from the analysis of the waveforms presented in Fig. 6 is that the efficiency of the harvester installed inside the building (on the inside of the window) is significantly higher (by about 40 %). The harvester installed on the inside of the wooden framed window was located directly above the heater due to the nature of the heating system design in the building. The presence of the heater directly below the window generated convective air movement, in effect significantly increasing the heat transfer efficiency of the thermopile heat sink. This phenomenon was further compounded by the high temperature of the heater resulting from the shape of the heating curve (tests were carried out even at an external temperature of -12.5 °C, resulting in a high temperature of the heating medium).

Fig. 7. shows the diurnal dependence of the generated voltage on the temperature difference for a complete harvester consisting of a TEC 12710 and a heat sink. These dependencies for ideal objects should have a constant diurnal value resulting from the constant nature of the Seebeck coefficient for the thermopile [8]. The relationships seen in Fig. 7 change significantly over the diurnal cycle. For a harvester installed on a wooden construction window, the coefficient fluctuates between 2.15 mV/K and 4.28 mV/K, while for a harvester operated on a window made in PVC technology, the coefficient oscillates between values of 0.82 mV/K and 2.42 mV/K. The variation in the values of the coefficients over the diurnal cycle indicates that, during the course of the research, in addition to the dependence of the generated voltage on the temperature difference in real conditions, there are a number of other factors influencing the varying energy efficiency of the harvesters tested at both measuring stations.

For a harvester installed outdoors, the significant decrease in the coefficient value is related to the absorption of thermal radiation by the heat sink during the sunny hours of the day (between 7 a.m. and 2 p.m). The sunlight causes the heat sink to heat up and in effect reduces the temperature difference between the thermopile surfaces.

For a harvester installed indoors, the changes in the coefficient over the course of a day are much more chaotic. Due to the indoor location of the harvester, the change in effectiveness is directlyrelated to the activity of the occupants, generating increased air movement, which is reflected in momentary dynamic changes in the heat exchange efficiency of the heat sink. Dynamic changes in the indoor air temperature due to food preparation or other occupant activity also contribute to dynamic peaks in the determined coefficient. This relationship is caused by the high thermal inertia of the glass in relation to the low thermal inertia of the heat sink, which in effect contributes todynamic, short-term increases in the thermal effectiveness of the harvester. These conclusions can be supported by the shape of the waveform during nighttime hours, during which no people were in the room and during which the coefficient value was much more stable. However, the described dynamic changes in the coefficient, indicating an increase in the thermal efficiency of the thermal energy harvester, are desirable phenomena.



• Wood frame Seedback coefficient [mV/K]

Fig. 7. Comparison of the Seebeck coefficients of the thermopile installed on the two windows on the same day as a function of the difference in ambient temperature and window surface Source: own calculations

Analyzing the tests carried out on 18th of January, an estimate of the harvester power was also made when the thermopile is loaded with a resistance of 1 Ω . The resistance value of 1 Ω follows directly from the value of the internal resistance of the thermopile. According to the technical documentation [8], an internal resistance of 1 Ω applies to the operation of the thermopile at 12 °C. It was taken into account that when the thermopile is loaded with a resistance equal to the value of the internal resistance, the voltage generated by the thermopile is halved. On the basis of the power values estimated in this way for the daily operation of both harvesters, the curves for the increase in the energy generated by them were determined, which are illustrated in Fig. 8. As a result, it was estimated that for the harvester installed on the external side of the window with a PVC frame, the total energy generated daily was 2403 mJ, while for the harvester installed on the internal side of the window with a wooden frame structure, the total energy for the daily operation was 8641 mJ. Again, taking into account the amount of energy required by the LoRa wireless sensor platform mentioned in the introduction to perform 1 measurement data transmission cycle, and taking into account the 40 % efficiency of the ultra-low voltage DC-DC converter required in this case the daily energy production of the discussed harvesters would hypothetically be sufficient for 32 to 115 complete cycles of operation of the platform.





Fig 8. Comparison of estimated energy production for harvesters installed on a wooden and PVC window on 18th of January (in similar environmental conditions; 1 Ω load resistance equal to the internal resistance of the thermopile assumed) Source: own calculations

In further research, it is planned to use harvesters to power sensor platforms using the EM8900 ultra-low-voltage DC-DC converter [11]. According to the manufacturer's data, this converter allows input voltages as low as 5 mV to be boosted, making it a real possibility to use the discussed thermal energy harvesting method to power wireless sensor platforms. Fig. 9a. therefore illustrates the results of preliminary measurements carried out for the EM8900 converter working with a 1:100 transformer (LPR6235-752SMR, Coilcraft), a 1:200 transformer (two 1:100 transformers connected in series and parallel) and with a 1:100 transformer and a 5.1V Zener diode at the output of the converter (the diode was used to protect the converter from an excessive increase in its output voltage). The measurements illustrated in Fig. 9a. consisted of measuring the open output voltage of the inverter loaded with only the internal resistance of a digital voltmeter (approximately 10 M Ω). As can be seen, this converter starts to operate even from voltages lower than 2 mV, but under these conditions its output voltage is too low to directly supply the sensor platforms. Only input voltages above 5 mV (for configurations with a 1:200 transformer), above 7 mV (for configurations with a 1:100 transformer) and above 10 mV (for configurations with a 1:100 transformer and a Zener diode) allow output voltages >2.5 V. However, in the configuration with a 1:200 transformer, the inverter has a lower output power and reaches the maximum of this power $(3.25 \ \mu\text{W})$ for lower output currents $(8.5 \ \mu\text{A})$ than in the configuration with a 1:100 transformer (10.6 µW and 12.1 µA, respectively), as illustrated in Fig. 9b. for input voltages in the range 6.7 - 6.9 mV. Therefore, this inverter needs to work in tandem with an additional energy storage and management device.





Fig 9. Characteristics of the EM8900 ultra-low voltage dc-dc converter model for different circuit configurations (description in text) Source: own calculations

Summary

This paper presents an unconventional way of converting waste heat energy in a building into electricity that is then used to power wireless IoT sensors. Using experimental energy harvesters installed on windows at two locations, their ability to directly power sensor platforms was estimated. Based on the analysis of data acquired during experiments conducted during the winter for harvesters realized on the basis of the TEC1-12710 thermopile, quantities of energy were estimated that would theoretically allow for 32 to 115 complete measurement cycles to be realized and data to be sent via radio to the gateway via a remote sensor platform with LoRa connectivity.

Preliminary tests carried out using an ultra-low-voltage EM8900 DC-DC converter show that it will be possible to realize a battery-free thermal energy harvester on the basis of such a solution, effectively powering the wireless sensor platform.

Comparing the measurement data for the system installed on the external side of the window with the results obtained for the system installed on the internal side of the window, the system installed inside the building showed more favorable results. Under similar environmental conditions, confirmed by comparing the key values for harvester operation (system surface temperature, ambient air temperature), the harvester inside the building had a higher voltage output, resulting in more than 3.5 times higher total daily energy generated.

Literature

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TIKTOK SOCIAL NETWORKING PLATFORM AND ITS INFLUENCE ON GENERATION Z USERS

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Abstract:

This study investigates TikTok's influence on generation Z users and their use of the app. Due to the sudden growth of the app's reach, there is a lack of scientific resources on this subject. The popularity of the platform among exceptionally young people induces relevance for understanding the mechanisms of TikTok. This paper includes 3 hypotheses: users of the platform are not aware of the types and amount of data gathered by TikTok, the app influences its users' behaviour, views and/or beliefs and Generation Z users are exposed to non-entertainment content. To verify the hypotheses, the author used a quantitative research method and conducted a survey among participants between the ages 12 to 27. Results confirmed all of the hypotheses. Respondents were not acquainted with types of personal data gathered by the app. The study also shows that TikTok might influence its users and they are exposed not only to entertainment content, but also informational and educational videos.

Keywords:

TikTok, generation Z, social media influence

Introduction

TikTok's growth in the past few years made it one of the biggest social media platforms, along with Facebook, Instagram and Twitter. In 2021 it reached over 1 billion users [1]. Most of its users are young people, with almost 40% of them between the ages of 12-24 [2]. TikTok, mainly among the generations of Baby boomers, Generation X and Millennials, was and still is considered an entertainment platform that includes immature content, made primarily for children. Nonetheless, the latest research shows that TikTok contains educational, informational and even political content [3, 4, 5]. Some of the studies suggest that the platform can potentially influence and radicalise its users [6]. It is especially significant due to the mostly young target audience, whose cognitive development and critical thinking skills are still in progress [7].

Another disturbing fact is the controversy around the safety of the app. Penetrum, a cyber security organisation, in their 2020 report [8] indicates that TikTok's policy establishes unlimited sharing of all of the users' data. Report also points out that the app has a high security risk, ranked as an 8.8 CVE score.

According to media, such as Huffington Post [9] and Insider [10], TikTok struggles with moderating far-right messages, racist and homophobic videos. The spread of hateful content and its

massive scale is alarming, particularly in the modern world reality. While Tiktok has issues with managing its abusive users, it does not appear to have the same problem regarding videos that could be considered progressive or inclusive. Some of newspapers report [11] that TikTok is banning body positivity content and disabled creators. The platform explains the regulations were meant to look after vulnerable users, whilst the reality seems to be the opposite. Journalists also point out a questionable relationship between the company and the Chinese government. One of the worrisome examples could be Tiktok's censorship of videos regarding pro-democracy protests in Hong Kong [12].

Unfortunately, there is a lack of accessible scientific literature on this subject. Due to the Internetrelated content, this study is based mostly on media reports and press articles.

In connection with the above circumstances and controversies, research on TikTok seems crucial. This study investigated the platform and its influence on Generation Z users (age 12-27) and their declarative ways of using the app.

Hypotheses:

- 1. Users of the platform are not aware of the types and amount of data gathered by TikTok.
- 2. TikTok influences its users' behaviour, views and/or beliefs.
- 3. Generation Z users are exposed to non-entertainment content on TikTok.

Methodology

Characteristics of participants

In this section, the author's own research will be presented - its methodology, participants, experimental setup, data collection, data analysis.

Questionnaires were used to investigate declarative ways of using the app by its generation Z users. Survey consisted of 14 closed questions and metrics (age, sex) and was titled "TikTok app among young people" to preserve noninterference of the participants. Participants were first provided with a guarantee of anonymity. Survey was conducted online through Qualtrics and intramurally in one of the elementary schools in Subcarpathian Voivodeship in Poland from 11.04.2022 to 31.05.2022.

There were 1,934 participants in this study, of which 1,446 identified as women, 428 as men and 60 have chosen the option "other gender". In this study, participants were between ages 12 and 27, which - based on the 2019 Provident report [13] - circumscribes members of generation Z. The average age of the respondents was 22. School-age participants (aged 12-19) accounted for 17% of all respondents.

Results

First question - "Do you have a TikTok account?" was meant to divide respondents into three groups: subjects currently having TikTok accounts, subjects who have had accounts in the past and subjects who have never created an account or used the app. 1,358 (70.22%) participants stated that they currently have a TikTok account, 404 (20.89%) never have had it and 172 (8.89%) have had it

in the past. Subjects who have never used the app were excluded from further questions and finished the questionnaire at this point. Respondents stating that they used to have a TikTok account were then asked for the reasons for ceasing to use TikTok. Of 172 subjects, 119 (69.19%) stated that they felt like they waste too much time on TikTok, 35 (20.35%) stated that content was not interesting for them and 11 (6.40%) stated that they found videos on TikTok disturbing. 7 participants selected "other reasons" which allowed for a text entry. Responses were mainly concerning low content quality, information overload while using the app and concerns about personal data security.

The rest of the survey was addressed to 1,358 respondents who indicated that at the moment of participating in the survey, they had an account on TikTok. They were asked how often they use the app - over 65% stated they use it every day, 25.55% use it a few times a week, 6.04% use it a few times a month and only 2.87% use TikTok less often than that.

Next multiple-choice question was meant to determine the type of content each participant encounters while using TikTok. Of 1,358 respondents, vast majority (1,049) stated they encounter content regarding animals. Other most popular answers were as follows: "Cooking" - 915 respondents, "Mental health" - 887, "Dancing, singing" - 885, "Humour, pranks" - 873, "Fashion, beauty" - 828, "Politics" - 771. The frequencies of other responses are presented in Fig. 1. This question also provided space for a text entry - 157 participants stated there are other types of content they see on TikTok, e.g. "Anime", "Science", "History", "Pop Culture", "Photography", "TV series", "Trivia", "Books", "Education" and "LGBT+".



Fig. 1. Most popular types of content on TikTok Source: own research

Next question raised the subject of personal data collection. Participants were asked what types of information, in their opinion, does TikTok gather about them. Most popular answers are presented in Fig. 2. The majority of respondents stated that the app collected the following data about them: "Gender" - 1,298 participants, "Age" - 1,246, "Hobby" - 1,240, "Email address" - 1,182, "Online traffic" - 1,073. In optional text entry space 26 participants listed other types of information, such as "Location", "Sexual orientation", "Favourite drugs", "Advertisement preferences", "Daily cycle", "Every text entry", there were also responses expressing concern - "I think TikTok is listening to everything I say, like Facebook or Instagram" and "I think I'm not aware of a lot of it".





Fig. 2. Types on information gathered by TikTok according to the participants Source: own research

The next part of the questionnaire revolved around the perceived reliability of TikTok's content and information verification. Only 17% of participants declared always verifying the authenticity of information presented to them on TikTok. 40% claimed they do it often, 28% sometimes do it and 11% rarely do it. Only 4% admitted to never have done it. Additionally, the majority (57%) of respondents stated they don't think of TikTok as a reliable source of information. Other tendencies are presented in Fig. 3.



Fig. 3. Perceived reliability of TikTok's content Source: own research

Over 85% of respondents, when asked about their For You Page (TikTok's main page), claimed it has well or rather well matched their hobbies, interests and views and only 4% denied it, while 11% were indecisive. Furthermore, almost 85% of participants declared liking that fact, while only 4% claimed to dislike it. Moreover, almost 77% of respondents claimed that, in their opinion, content presented on their For You Page was unique and significantly different from other users' For You Pages' contents. Only 10% disagreed with that statement.

Fig. 4. presents participants' responses to a question whether or not TikTok influences their worldviews and beliefs. Although 41% of respondents claimed that such occurrence does not apply to them, as much as 38% of respondents agreed that TikTok does in fact influence their views.





Fig. 4. TikTok's influence on views and beliefs Source: own research

Of those who agreed that TikTok influences their worldviews and beliefs or were not sure about it, 41.4% admitted that their views have become more expressive and articulate due to their activity on the app, while 40,3% stated that they haven't. The responses are presented in Fig. 5.



Fig. 5. TikTok's influence on perceived expressiveness of participants' views and beliefs Source: own research

The next questions also applied only to participants who agreed that TikTok influences their worldviews and beliefs or were not sure about it. They were asked to determine the purposes of their TikTok use. The majority (62%) claimed to use TikTok for entertainment purposes. The second most popular choice (43%) was "all of the above" which consisted of entertainment, information and education. Other responses are presented in Fig. 6. In optional text entry space 7 participants stated they use TikTok for purposes such as "Dissociation", "Debraining" or "Killing time, e.g. while on public transport".



The last question regarded the respondents' willingness to learn due to TikTok's content being accessible. Almost 84% participants stated that TikTok's content's accessibility positively impacts their willingness to learn and get new information, also worldview related. All responses are presented in Fig. 7.



Fig. 7. Impact of content's accessibility on the willingness to learn new information Source: own research

Discussion

A possible limitation of the study's quantitative research could be a significant disparity between age groups, in favour of respondents above the age of 19. A more representative Generation Z sample, consisting of a higher number of school-age respondents with as diverse upbringing as possible, could provide a more generalised view of the results and examine actual trends within the whole population. It is also important to point out that the method of an in-person questionnaire (conducted in a classroom) that most of the 12-15 year-old respondents took part in, may have played a role in quality and objectivity of the final results compared to respondents who participated in an online survey. The circumstances of the in-person study may have caused constraint and lack of ease in self-reflection due to the presence of teachers and classmates.



Conclusions

After analysing the data, hypotheses have been verified:

- 1. Users of the platform are not aware of the types and amount of data gathered by TikTok.
- 2. TikTok influences its users' behaviour, views and/or beliefs.
- 3. Generation Z users are exposed to non-entertainment content on TikTok.

The results of the study confirm all of the hypotheses. Participants were not aware of all the types and amount of data gathered by TikTok. Taking into consideration the controversy around the cyber security of the app, this conclusion is specifically disconcerting. Almost 40% of the participants stated that the app influences their beliefs, even though the vast majority considered the platform an unreliable source of information. The further data demonstrates over 15% of 1,358 participants declared that due to activity on the app their views have become more expressive, which potentially might indicate radicalization. Even though most of the respondents (62%) said that they use TikTok just for entertainment, the second most popular choice (43%) consisted of entertainment, information and education.

The data also revealed that based on participants' declarations, there are several distinct types of content which do not include entertainment, such as: politics, religion, mental health, art or daily news.

Specificity of Tiktok and its moderation rules can make Generation Z users particularly vulnerable to the influence of disturbing trends and ideologies. Further in depth research on Tiktok's mechanisms and the content it provides would be a meaningful and thought-provoking subject in the academic discourse. Research data proves the importance of the shift in thinking among Generation X and Y, who still strictly perceive Tiktok as a medium of entertainment and view its content as childish and immature. TikTok could be used as a political marketing tool, which can shape the climate of opinion and beliefs. The consequences of Generation Z growing up in a digital reality will influence the future of the society as a whole. That is why the quality of Internet content, which has an unlimited potential of shaping a young person's views, seems crucial.

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SEARCH FOR THE ARTISTIC COMPASS. IN THE FOOTSTEPS OF TADEUSZ ZIELIŃSKI (1859-1944)

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Abstract:

Tadeusz Zieliński (1859-1944) was an undisputed authority on the Antiquity, an outstanding classical philologist, researcher and educator. He devoted his entire life to his great passion - the ancient culture, which interested him the context of modern times, both as a research field and as a school subject. His main goal, however, was propagating the ideas of the Antiquity among young people, among other things, by encouraging them to read classical literature in the original. A thorough knowledge of Latin was a necessary requirement for this purpose, but the classical languages were losing their status in school education and were taught less and less. That was why Zieliński strongly supported educational reforms within the humanities. He often emphasised that building a future would only be possible on the basis of ancient values, first of all, on the basis of truth, which is the essence of beauty.

Keywords:

Antiquity, classical philologist, Latin, educator, orator

Introduction

Tadeusz Zieliński is known as a famous scientist and remarkable classical philologist who devoted his entire life to his great passion – the Antiquity. He described his explorations of the secrets of the Ancient World in his numerous scientific publications, for which he was nominated to the Nobel Prize, among other distinctions. His works about Sophocles, Cicero or ancient religion still remain relevant to today's classical scholars. Zieliński's course of lectures *The Ancient World and Us*, delivered in 1901 in Saint Petersburg, is growing in popularity in Italy, among other countries, which proves that his ideas of have not become obsolete despite the considerable progress in related research. He was and still is highly acclaimed, though his fame may have slightly faded. Kazimierz Kumaniecki described Zieliński as "the most outstanding figure in the history of Polish classical philology and one of the most outstanding and original researchers of the Ancient World ever [1]." Marian Plezia characterised Zieliński in a similar manner, as "one of the most outstanding Polish classical philologists, if not the greatest among them all" [2]. Tadeusz Sinko even called him a "genius" [3] and in certain respects valued him higher than Ulrich von Wilamowitz-Moellendorff, who was undoubtedly considered the highest authority on ancient culture at the time.

Tadeusz Zieliński as a great educator and classical philologist

These are just a few of the plethora of highly positive opinions about Tadeusz Zieliński who was an expert of international renown. He was an unquestionable authority on the Antiquity, which he proved many times by his publications and lectures. In particular, he was a passionate and skilled lecturer and although he needed time to attract the interest of his students — who were not always particularly keen on classical philology — but he did not let that discourage him. Instead, he focused on finding the best solution despite his imperfect command of the Russian language. As he mentioned in his autobiography: "I knew that the main requirement for success was a free lecture. At first, I was still struggling with the language, so I could not speak freely during my early lectures. I had to write down each lecture in full and learn it by heart, which made me pay more attention to its composition and my train of thought. Later — even after my Russian had improved — I continued to use this method. I had the notes right in front of me of course, but I tried to look at the audience instead of reading them. I was soon doing it better and better, and my lectures appeared to be genuinely spontaneous" [4]. For Zieliński, a lecture was a success if he had a good contact with his audience. Soon he became a master orator.

A breakthrough in his academic career occurred when he was offered a teaching chair at the University of Saint Petersburg in 1885, after the renowned professor Piotr Nikitin resigned from this post, having lost his belief in the rebirth of classical philology. Zieliński did not intend to give up on this idea easily. His series of lectures on classical Greek language and his course on Greek tragedy helped this academic discipline regain some of its former splendour. His lecture on *The Bacchae* by Euripides was received with open enthusiasm: "As usual at the beginning, the lecture room was full. When I finished, there was loud applause. No classical philologist has been honoured in this way in Saint Petersburg since time immemorial [...]. The applause proved to me that I finally found what I had been searching for so long – myself, i.e. the key to the hearts of my audience. In that academic year and many more to come, I no longer saw the number of my students shrinking" [4].

He was widely admired and respected for his lectures, even among those who did not share his views. In addition, there was something about his appearance that resonated with his ideas. Jan Parandowski recalled him as "one of those personalities that in all places and times rise above the crowd, even if they are not among the crowd in the popular sense of the word. Before he opened his mouth, before he imposed the power of his knowledge or intelligence on others, before they knew who he was, his mere presence already commanded the keenest attention. I do not believe he could hide in shadows even if he had wanted to [...] It is hard to pin down what exactly made him so remarkable, since his conduct was so quite simple: was it his stately appearance, some peculiar detail, the gaze of his wise, always young eyes, or was it his very nature, so out of place in the modern life that at certain times one saw in him a remnant of the classical period" [5]. Michael von Albrecht discerned in Zieliński's life "parallels to ancient heroes. Just like Aeneas, he only discovered the unknown homeland of his ancestors at a mature age. Like Ovid, whose Heroides he translated and commented [...], he had an extraordinary and successful career, followed by old age and death in exile. Like Cicero — whom he admired so much — he mourned the death of his daughter and as an intellectual, he lost his political fight. Both Zieliński and Cicero believed that education was a real foundation of our existence and tried to foster the values of kindness, beauty and truth, even in the hardest of times" [6]. In some inexplicable way, Zieliński seemed to personify the ancient times.

Witold Klinger, in turn, perceived him as an outstanding scientist, "representing the Hellenic balance and moderation" [7]. According to Jerzy Axer, he was "a denizen of the Ancient World, specifically a citizen of Athens" [8]. The last remark may refer to the fact that Zieliński did not fully belong to any nationality. His culture was partly Polish, partly German and partly Russian. He once stated that "his body was Polish, his mind was German and his soul was Russian" [8]. In the view of Hanna Mortkowicz-Olczakowa, he was a citizen of the entire world: "Engrossed in the problems of the Antiquity, out of touch with the present, writing his books for readers of all nations, this old professor, shaped by the liberal decades of the end of the 19th century, was a typical cosmopolitan" [9], unfamiliar with the Polish reality despite his Polish origins. However, multiculturalism was not an obstacle in the academic world. On the contrary, it even seemed to open broader research perspectives. Besides, "there was something spiritual about him, as if he were a prophet or a clairvoyant" [7].

All of the above qualities made Tadeusz Zieliński an excellent classical scholar who focused on "propagating the idea that the Antiquity, far from being out of date, remained alive in modern culture" [8]. It was not an easy task, requiring a huge effort at first, as remarked by another acclaimed classical philologist Gustaw Przychocki: "Those great spirits of the past will not speak to you until you feed them with your own blood, honest work and true devotion. Only after this sacrifice of work and heart has been made, will you hear the Antiquity speak to you" [10]. Beyond doubt, it did speak to Tadeusz Zieliński. Another very important matter remained – sharing this knowledge, so that it would enter the hearts and minds of the young generation and beyond. This task was all the harder in the times of new exciting discoveries, when the ancient culture seemed to be a relic of the past: "A body of knowledge so thoroughly examined that it no longer posed any challenges to human creativity; [...] as an element of the modern culture, it is utterly meaningless because it was surpassed by modern progress a long time ago; [...] it is a strange relic of unknown purpose and use, still preserved by modern schools, a relic that ought to be removed soon and hopefully once and for all!" [11].

Zieliński - who considered the Antiquity to be the foundation of our culture - believed it was not possible to renounce the past and to only follow the latest fashion instead. In his opinion, humanity had lost its purpose by rejecting the legacy of the ancient thinkers and exchanging it for modern views. Zieliński put it this way: "We had lost the compass that guided our ship, and now it is at the mercy of capricious winds - fashion" [12]. Such state of affairs had to be changed, because in the eyes of Zieliński, it was a cul-de-sac. His search for the ancient compass meant returning to the ancient times, which were a measure of everything, including beauty, visible in each sphere of life or — as Zieliński called it - "biological aesthetics" [12]. As Gustaw Przychocki put it: "He was trying to discover and to understand the people from the Antiquity, the way they thought and behaved [...]" [10]. This beauty is unchangeable and eternal because it was born by the ancient culture: "What was created beautiful, will remain so for ever" [12]. This beauty is to be understood as the entire legacy of the ancient civilisation, which - rooted in human consciousness - is not so much a model, but a source of inspiration to later generations. Zieliński was far from encouraging mindless simulation: "The Antiquity should be for us more like seed than norm, i.e. not something to emulate, but a source of inspiration for our minds today that helps us address the challenges of our times" [12]. This "creed as a scientist and teacher" [12] reveals, though indirectly, Zieliński's mission - propagating knowledge about the Antiquity, especially among young people, doing research work and initiating educational reforms within the humanities. There are many aspects to his research because "in the



figure of Zieliński the scientist met the teacher, and the thinker met the artist in a way unattainable today" [13].

Tadeusz Zieliński as a propagator of ancient ideas and a master orator

As a propagator of ancient ideas, Zieliński enjoyed his role of lecturer which enabled him to reach a very wide audience, both young and old. He had no difficulties in capturing the goodwill of his listeners by using the rhetorical technique of *captatio benevolentiae*, which – according to Mirosław Korolko – "is achieved by speakers whose orations are supported by their general intellectual and moral qualities. Their authority, opinions, social standing etc. all play an important role [...] Apart from those general personal qualities of the speakers [...], it is recommended to apply certain conventional patterns, regarded as *locci communis* of the oratory art, such as the topoi of humility, conciseness and dedication, by using the appropriate words and common phrases [...]" [14]. His lectures and speeches were prepared according to the ancient oratory rules, but rather than limiting him, they offered him tools he could use according to his needs: "The best orator is one whose words move, teach and please the audience. Teaching is an obligation, pleasing is an honour, and moving a necessity for the speaker" [15]. In those two sentences, Cicero summed up the basic rules of an exemplary orator, such as Tadeusz Zieliński.

Achieving oratory perfection required not only a suitable training, but also a particular attention to language use, as the spoken word played a crucial role for Zieliński. In the Antiquity, the spoken word "used to be [...] highly praised and identified with reason [...]". The mystical idea expressed in the opening verses of the Gospel of John that logos ruled the world was shared by Zieliński and grew deeper and more compelling for him with age. He considered it to be a true apotheosis of the word as a superior and life-giving principle. At the end of the ancient period, the word was considered both powerful and divine" [15]. Owing to its divine nature, the word was elevated even higher, becaming even more influential. According to this concept, the speaker was not only a teacher, scholar or propagator of the classical culture, but even a kind of prophet whose visions were soon to come true. And they did, to some degree, though "one might dismiss his views and visions as anachronistic. However, for all his anachronism, he was actually shaping the future while trying to save humanity from the disasters of Bolshevism and Nazism. And even after they struck, he persisted on his old path" [8]. Zieliński, with his versatile education and open mind, knew perfectly well that there could be no future without the past, that the future was the result of the processes and laws that had existed since the beginning of time. He thought that the experiences of the ancients could be useful for later generations in helping them to avoid dangers known from history, which - as the saying goes - has the tendency to repeat itself.

One of the best ways to learn the ancient culture is through ancient monuments and texts, especially Greek or Roman literature. Knowledge of Latin and Greek is a requirement here because translations often do not fully reflect the qualities of the originals, as he himself emphasised: "Any translation of an ancient text into a modern language will be related to the original in a similar way as a wooden model used by students of anatomy relates to the actual human body: translation offer some general concept of the structure and content of the original, but one can hardly expect to find the subtle nuances of the original in them" [11]. In other words, translations have no artistic value. Only the original language can fully convey "the ancient metre and rhythm, its poetic and rhetorical

qualities" [10] and reveal its beauty. Zieliński considered Latin to be the essence of beauty. Zieliński wrote that an intellectual understanding of Latin brought us closer to the culture of the Antiquity. It helps us grasp those illusive truths that would get lost even in the best translation. Another famous German classical scholar, Wilfried Stroh, agreed with him when he write: "The reason we learn Latin is precisely to understand [...] major Greek and Latin philosophers such as Lucretius and Seneca [...] [17], but first of all Cicero who was admired by both scholars. "[...] Cicero, who was a *homo novus*, or a man without any social standing, reached the pinnacles of political power. It is to him that we owe the concepts of humanity (*humanitas*) and human dignity (*dignitas hominis*) which remain one of the common achievements of the human civilisation" [17].

However, Latin has many more qualities, as Zieliński often highlighted. As "mother of languages" it gave birth to Italian or French, among other modern languages. It is present in many spheres of life, as the great philologist remarked. Most importantly, however, it teaches clear and logical thinking through its grammatical structures, which Zieliński described as "logic tests" [11]. The fact that "its pronunciation matches the spelling" [11] is of great help in the learning process, too. Besides, knowledge of Latin facilitates learning other languages.

The advantages of learning classical languages cannot be overestimated, so that Zieliński was in favour of reforms in the classical education and "insisted on strengthening the only true middle school, by which he meant the German *Gymnasium* or grammar school, teaching classical languages. Zieliński was famous for the following opinion on education: "An easy school is a social crime" (i.e. a crime against society). Drawing a clear line between empty imitations of the classics and the creative ancient culture which he perceived as still very much alive, he taught his students that the Antiquity is not the norm, but rather seed that needs fertile soil to grow" [13].

The atmosphere of Saint Petersburg, a fashionable European metropolis of that time, seemed the right place to pursue his plans: "Focussing on the Antiquity is a priority, classicism in all kinds of art, classical education in the best schools" [13]. Zieliński actively participated in attempts to improve the teaching standard in schools. "Excellent commentaries to ancient texts for grammar schools, school visits, speeches to graduates" [13] were only some aspects of his social work.

The great philologist was not always received enthusiastically by other researchers and teachers, but in the eyes of his students, he was always their Master. Teaching in any form was his mission, regardless of whether he taught small children, high school or university students. His books and articles had lifted the readers' spirits and helped them survive many hardships, e.g. when the students and collaborators of Adrian Piotrowski, "the son and heir of Zieliński's legacy" [6]. Zieliński's short stories, written during his years in Saint Petersburg and inspired by Greek and Roman mythology, "helped a group of young people survive their murderous march to the Caucasus Mountains. Many of them threw away their heavier belongings they were no longer able to carry. But not even once was the one who carried books by Zieliński tempted to do away with them" [6]. The short stories by Zieliński not only encouraged, but even saved lives. A parallel to the "uplifting literature" by Henryk Sienkiewicz can be drawn here.

Summary

Not only was Tadeusz Zieliński a talented author and speaker, but he also knew how to win people over, which guaranteed that his lessons would not be forgotten. He repeatedly emphasised that



the Antiquity was still alive, as best evidenced by the existence of our civilisation. Ignoring the achievements of the ancient culture would be tantamount to "ignoring the entire modern European culture"[11]. Despite popular assumptions, the ancient culture still has not been fully explored and – for all the advanced research – remains full of riddles to this day. Hopefully, there will be no shortage of scholars of Zieliński's stature, for whom exploring such secrets will be a mission and passion alike, and for whom truth will be the highest virtue. As the outstanding philologist highlighted, "there is only one true path [...], but countless false ones" [11].

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THE PROBLEM OF STORING LIQUID FUELS

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Abstract:

Liquid fuels are currently the basic energy carrier necessary to power motor vehicle engines. It is very important to keep liquid fuels in the best possible qualitative and quantitative condition. Any loss of liquid fuels is associated with costs and may result in a loss of quality. The storage of liquid fuels is one of the key links in the supply chain. Proper storage of fuels allows to reduce the emission of hydrocarbons to the atmosphere. As a result, the losses of petroleum products are limited and the emission of toxic substances to the atmosphere is reduced. Currently, the most effective methods of reducing evaporative losses of petroleum products during storage are the use of a floating roof and a combination of containment techniques with vapor recovery.

Keywords:

liquid fuels, storage, fuel losses

Introduction

The storage of liquid fuels is a necessary element of the functioning of the supply chain. Unfortunately, it is a fuel operation in which liquid fuels evaporate due to various factors. It is also not the case that the liquid fuels evaporate only during the storage process, but nevertheless the losses due to evaporation during storage are relatively high. Moreover, hydrocarbons that get into the atmosphere are very harmful both to the natural environment and to human health and life. The vapors emitted to the atmosphere contain volatile organic compounds (VOCs). According to [1], volatile organic compounds are "any organic compound having a vapor pressure at 293,15 K (20 ° C) not less than 0,01 kPa , or having such volatility under specific operating conditions". During the storage of liquid fuels in the tank, gas exchange takes place. Hydrocarbon vapors accumulated inside the tank may be emitted to the atmosphere as a result of changes in atmospheric conditions, various types of manipulation operations and the physical and chemical properties of a given type of liquid fuel. Of great importance in the case of vapor formation is the free evaporation surface, the larger it is, the more vapors are generated under the given ambient and operating conditions of the tank.

Storage of liquid fuels

Liquid fuels are stored differently depending on needs and location. Liquid fuels can be stored in above-ground, underground and semi-underground tanks . They can be vertical or horizontal, drop



-shaped or spherical tanks. In addition, in terms of the operation of the tanks, they can be non-pressure, low-pressure and pressure. The division of the tanks is presented in Fig. 1.



Fig. 1. Division of storage tanks

In the case of vertical above-ground tanks, they currently have an additional curtain wall, which is to protect the surroundings in the event of a leakage of the inner shell of the tank. In the fuel depots and terminals, there are still bunded tanks in use, which perform the same function as the curtain wall. Tanks can also be thermally insulated. Above-ground, cylindrical and vertical tanks have a fixed roof or a floating roof. The use of a floating roof is largely related to the aspect of limiting evaporation of liquid fuels. The use of a floating roof or an internal membrane installed in tanks with a fixed roof allows to reduce the emission of hydrocarbons to the atmosphere. Vertical tanks are mainly used in fuel bases and terminals, where they are usually located above the ground. They are responsible for the storage of large amounts of petroleum products. Horizontal tanks are an essential element of petrol station equipment. They are usually double-walled and consist of one or two chambers [2].

The storage of liquid fuels also takes place during the transport of petroleum products by various types of transport. Although the oil product is transported, the liquid fuel contained in the transport tank is stored, it can be said here about storage in a short period of time. Fuel storage also takes place in a filled product pipeline, both long-distance and technological. In this case, when the product is not pumped, the fuel in the pipeline is stored. Additionally, it is also possible to store liquid fuels in salt caverns. Storage of petroleum products in rock salt deposits is very advantageous due to the fact that this type of storage technology is not complicated in terms of construction, cheap and safe. The structure of the salt deposits makes them very tight. Salt caverns are used for long-term storage of large amounts of liquid fuels and crude oil.

During the liquid fuel storage operation, although the product is not moved, there is a loss of products due to evaporation. Evaporation of liquid fuels always occurs and largely depends on the physicochemical properties of petroleum products, however, it is not only the properties that determine the evaporation and the resulting losses.

Evaporation losses of liquid fuels result from three groups of factors, such as [3]:

- 1) physical -and chemical properties:
 - evaporation tendency, i.e. volatility resulting from vapor pressure and fractional composition;
 - surface tension forces;
 - the density of the petroleum product in question;



- diffusion;
- 2) Atmospheric conditions:
 - atmospheric pressure;
 - ambient temperature;
- 3) organizational aspects:
 - size of the evaporation area;
 - air-tight sealing of storage tanks, pipelines and handling devices;
 - smooth functioning of the inhalation-exhalation valves;
 - the capacity of the tanks;
 - the degree of filling the tanks;
 - pressure of the gas space in the tank;
 - the location of the reservoir and its location in relation to the earth's surface, the direction of the wind gusts and the direction of the sun's rays;
 - storage time;
 - number of tank filling and emptying operations;
 - proper maintenance by personnel.

The above-mentioned factors, to a greater or lesser extent, are responsible for the intensity and quantity of liquid fuel vapors generated during storage. There are various methods and techniques that are able to a greater or lesser extent to reduce the emission of hydrocarbons to the atmosphere.

Vapor emission during storage

The emission of hydrocarbon vapors during storage depends on the vapor pressure inside the tank, tank structure, operating conditions, filling method, meteorological conditions, and the amount of liquid in the tank [4]. For the calculation of the emissions of total hydrocarbons (THC - total hydrocarbons) from tanks and fuel installations, a method based on the mass balance of production and turnover is used. Another method is to estimate emissions on the basis of general factors for individual groups of elements located at the refinery, fuel depot, fuel terminal and service station, however, this method is imprecise and does not reflect real emissions as it is based on global figures. Continuous monitoring of hydrocarbon emissions is also possible, which is very accurate, but also very expensive. Yet another method is to estimate the hydrocarbon emissions from frequent measurements. This method can be performed systematically or randomly. It is a cheaper method than the continuous monitoring of hydrocarbon emissions, but the problem may be the correct interpretation of the obtained results and determination of the emission factor. For the calculation of the annual emissions of hydrocarbons from a fixed roof tank, the operating emissions and the emissions from storage must be calculated. Working emission is related to "big breath", ie tank filling and emptying operations. In this case, the volume of liquid stored in the tank for a year, the turnover factor, the density of the emitted vapors of the product at the storage temperature and the vapor pressure of the vapor are taken into account. Warehouse emission refers to "little breaths", that is, the change in tank temperature as a function of time per day. In the case of a fixed roof tank with an internal floating lid, the storage emissions and the emissions received in kg/year are added together to calculate the annual hydrocarbon emissions. Emissions during storage occur due to vapor diffusion



through the peripheral seal and the inner seal of the floating cover and its seams. Pick-up emission refers to the evaporation of the liquid layer adhering to the inner walls of the tank after a certain volume of liquid has been pumped out. The emission of hydrocarbon vapors from tanks with an external floating roof results from leaks in the roof structure and perimeter seals. There is a gap of several centimeters, a gap, between the roof of the tank and the wall. The sum of the storage and offtake emissions is used to calculate the annual emissions of hydrocarbons from this type of tank. The storage emission refers to the leakage of the flexible ring sealing the space between the tank roof and the shell. This emission depends to a large extent on the strength of the wind. The discharge emission depends on the amount of evaporated hydrocarbons from the liquid film layer, adhering to the tank walls after a certain amount of the product has been pumped out [5]. The wind has a very large influence on the formation and amount of losses, but it depends on the type of reservoir. In the case of a floating roof tank, the wind creates a suction force, especially when the roof is low. The inner walls of the tank and the remaining fuel are dried up. Additionally, hydrocarbon vapors can be sucked in through the gaps between the roof and the tank shell. The destruction of the tank shell also affects the amount of losses. A tank with a damaged or corroded coating heats up faster, which leads to increased evaporation of petroleum products and greater losses [6]. In order to reduce losses from storage, it is necessary to keep the tank as low as possible through painting, thermal insulation and cooling. A white painted tank shows twice less losses than a black painted tank. Tanks painted with reflective paints heat up less than with matt paints. In order to cool the tank, it is possible to pump water onto the tank roof, keep water on the tank roof thanks to the use of roofs with raised edges (it has a corrosive effect on the tank roof structure - faster roof destruction) and the circulation of the cooling medium in the tank diaphragm or coil. Another way is to carry out storage operations at night and in low ambient temperatures and to fill the tank with petroleum product as much as possible. Additionally, the pumped product can be refilled with another medium, eg water, but it is disadvantageous because a large amount of contaminated water remains and needs to be cleaned [7]. There are different types of floating roof waterproofing. A distinction is made between primary and secondary seals, which can be of different types. According to the simulation in the "TANKS" program, the smallest losses arise for the primary, non-metallic seal that comes into contact with the liquid in the tank with the secondary seal installed on the edges of the floating roof. On the other hand, the largest for the primary non-metallic seal that does not come into contact with the liquid in the tank. The simulation results depend on the climate, tank location, storage time, number of revolutions and the type of liquid stored. The destruction of the tank shell also affects the amount of losses. A tank with a damaged or corroded coating heats up faster, which leads to increased evaporation of petroleum products and greater losses [6].

Methods of reducing the emission of hydrocarbon vapors to the atmosphere during storage

There are many ways to reduce hydrocarbon emissions during storage in tanks. The methods currently used to reduce the emission of vapors of petroleum products to the atmosphere, i.e. to reduce natural losses due to the evaporation of petroleum products during their storage, are based on [8-12]:

• minimizing the gas space in the tank by using floating roof tanks;

- the use of a surfactant additive which lowers the vapor pressure and reduces the surface tension of the fuel;
- creating a buffer capacity for petroleum product vapors by connecting gas spaces from several tanks;
- the installation in fixed roof tanks of an internal floating roof, diaphragm, membrane covering or a layer of balls of artificial material;
- increasing the overpressure in the reservoir;
- forcing into a gas sphere in an inert gas tank at a specific pressure;
- insulating the external walls and the roof of the tank with a suitable coating;
- painting the tanks from the outside with a suitable paint that reflects solar radiation.

The reduction of emissions during the storage of liquid fuels relates mainly to the isolation of the gas zone of the tank from the atmosphere and the limitation of the influence of the ambient temperature on the liquid fuels in the tank. Referring to the issues related to the reduction of hydrocarbon emissions to the atmosphere, one should mention the encapsulation of fuel operations. Encapsulation can be of three types [13, 14]:

- simple containment, in which excess hydrocarbon vapor is transferred directly to the vapor recovery system;
- simple containment using a buffer tank, whose task is to temporarily store the vapors before it goes to the recovery installation;
- air-tight sealing based on the gas pendulum principle, in which hydrocarbon vapors are forced from the filled tank to the emptied tank, and the resulting excess vapors are sent to the recovery installation.

There is also another solution in which the types described above are used simultaneously. In this case, we can speak of a comprehensive encapsulation system.

The air-tight sealing system is used at bases, fuel terminals and petrol stations, both when unloading tankers and refueling motor vehicle tanks. Encapsulation in fuel depots is based on connecting all storage tanks with a network of pipelines. Additionally, railway and car fronts are connected to this network. Such a connection also functions in port terminals, where tankers are filled and emptied. Currently, vapor recovery installations are used in most of the bases and fuel terminals, both onshore and offshore.

Simple encapsulation is related to the collection of vapors during the loading of storage tanks, tanker tanks, railway and road tankers. The collected vapors are transferred directly to the vapor recovery installation. In addition, the simple containment system can be extended with a buffer tank, also known as a gas tank, and when the tank is filled with the correct amount of gas, the vapors are transferred to the vapor recovery unit. If a buffer tank is used, on the one hand, the cost of building such an installation is increased, but on the other hand, energy savings can be achieved, because the vapor recovery unit only works when a sufficient amount of medium is collected for processing. Then there is no situation in which the vapor recovery installation is turned on each time the tank is filled, and only when the appropriate amount of gases is collected. In simple containment, both in the basic version and with a buffer tank, on the one hand, vapors are recovered, but on the other hand, new batches of hydrocarbon vapors are created. A negative pressure is created in the emptied tank,

and then the breathing valve takes air from the atmosphere in order to stabilize the pressure inside the tank, and thus subsequent batches of hydrocarbon vapors are created. Therefore, the best solution seems to be the use of an air-tight sealing system with the use of a gas pendulum and a buffer tank. Such a comprehensive encapsulation system is quite complex, but it allows for the highest possible level of safety and environmental protection at fuel depots and terminals. It should be mentioned here that hydrocarbon vapors are flammable and the installation related to their transfer and processing should be performed in accordance with the rules necessary for the use of equipment located in the explosion hazard zone [13, 14].

There are many techniques for treating hydrocarbon vapors within the operation of an encapsulation system. These techniques fall into two groups: destructive and recovery. Destructive techniques include thermal oxidation, catalytic oxidation and biofiltration. Regarding the techniques based on recovery, mainly adsorption, absorption, condensation and membrane technology can be distinguished [15, 16, 17].

Conclusions

The presented analysis shows how important it is to properly protect the storage tanks intended for the storage of liquid fuels. Petroleum products in the storage tank evaporate as long as they are stored in it. An increase in the ambient temperature causes excessive evaporation and then a relatively large amount of hydrocarbon vapors are released into the atmosphere. Summarizing the aspects discussed in the study, the following conclusions can be made.

- 1. Vapors of petroleum products are created by many factors, the most important of which are the ambient temperature, pressure and the free evaporation surface.
- 2. During the process of storing liquid fuels, a huge amount of hydrocarbon vapors can escape into the atmosphere, which will be emitted into the atmosphere during filling and emptying and the daily temperature change.
- 3. The methods currently used to reduce the evaporation losses of petroleum products are relatively well developed and continuously improved. The question of choosing the right method is very often dictated by economic aspects.
- 4. Estimating the emission of hydrocarbon vapors to the atmosphere is a very important task. The obtained information allows to determine whether a given method of limiting evaporation is effective and to what extent the natural environment may be polluted.
- 5. Currently, the best solution to reduce evaporative emissions is the use of floating roofs and the encapsulation of fuel operations.

The presented considerations were intended to show what the storage of liquid fuels looks like today, which is one of the most important operations in the logistics chain of liquid fuels. It should be noted that the currently used methods have been functioning for a long time and there is a clear lack of new solutions that would use more advanced and modern techniques and technologies.

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CYBERSECURITY OF APPLICATIONS WITH THE MVARMOR TOOL

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Abstract:

This article introduces MvArmor, an MVX system that uses hardware-assisted process virtualization to monitor variants in an efficient but secure way. To provide comprehensive protection against memory error exploits, MvArmor relies on a new variant generation strategy taking into account MVX. The system supports configurable by the user of the security policy in order to reach a trade-off between performance and security. The experiments were divided according to the type of tests performed: safety and performance. The security tests were carried out to verify the correct operation of the MvArmor system, while the performance tests allowed for the measurement of the performance cost caused by the use of MvArmor.

Keywords:

cybersecurity, MvArmor, cyber-attacks, IT

Introduction

In the world of constant technological development and constantly emerging proposals for new solutions, security systems have to face new problems more and more often. One of the most serious application security problems is memory errors in programs. Even the smallest of gaps can compromise users' private data. Over the years, operating systems and special software are trying to implement newer and newer solutions to protect against the use of memory errors, but these safeguards can still be bypassed. The need for defense mechanisms to protect against arbitrary attacks has led to the fight for more comprehensive solutions - primarily Multi-Variant eXecution (MVX) [1].

Multivariate Execution Systems (MVX) increase the effectiveness of software diversity techniques. The key idea is to run multiple and different copies of a program (called variants) in lockstep, providing them with the same input and monitoring their run-time behaviour for discrepancies [1]. Therefore, attackers must simultaneously compromise all variants of the program in order to successfully launch an attack. Many solutions have been proposed, including distributed, heterogeneous MVX systems that use different techniques to further increase the diversity between program variants. However, existing MVX distributed system designs suffer from high overhead costs associated with time-consuming network transactions for multi-variant execution system operations [2, 3].
This article presents the implementation of the MVArmor tool in an experimental environment in order to test the effectiveness of the tool as well as to identify its more detailed advantages and disadvantages. The currently available literature presents a rather modest description of the use of the above-mentioned solutions in information systems. The first proposal for this solution can be found in Koning et al. review from 2016 [1]. Then, that was mentioned in 2019 and 2020 by Liu et al. [4], Dao et al. [5], and Z. Zhang et al. [6]. It should be noted that in each of the above-mentioned cases, the authors described the Multi-Variant execution, but did not focus on a specific tool, and their articles were rather illustrative. The exception is the article from 2016 in which the authors carefully checked the tool's performance on selected servers that may be vulnerable to attacks. In the present article, we would like to focus on MVArmor, checking whether the development of this tool could be useful in the development of cybersecurity in modern IT systems.

Cybersecurity innovation

Cyber Attackers are a group of people who take advantage of people's or systems' mistakes for their own benefit, but admittedly, they have a lot of creativity. Defense against newer and newer attacks forces administrators and users to keep up with new technologies, trends, and their further development. Innovations in cybersecurity result primarily from the need to defend against the creativity of attackers, which in some way enables the development of the entire field [7]. Additionally, due to the Covid-19 pandemic, digitization has become an inseparable part of many areas of social life, and the role of cybersecurity has become even more important than before. The need to accelerate digital transformation, as well as the development of innovative technologies, have influenced the current situation, constantly increasing the number of cyber-attacks [8]. Attackers benefit from every vulnerability, and unfortunately, it seems that this trend will continue to worsen. Nevertheless, it is important to constantly improve security by introducing new security tools.

There are many different sources of information in the field of cybersecurity. One of them is the Survey of Cyber Moving Targets [9], which provides an overview of different cyber moving-target techniques. There is much information about their threat models and technical details. The moving target cyber technique tries to defend the system by making the system more static and less homogeneous. That survey describes the technical details of individual techniques, identifies the appropriate risk model associated with a given technique, and additionally shows its implementation and operation costs. Moreover, the survey describes the weaknesses of individual techniques based on already known attacks and bypassing exploits, but also proposes opportunities for future research in these areas. One of possible solutions is MVArmor [1, 9].

Tools

MvArmor

MvArmor is an MVX system that uses hardware process virtualization to monitor discrepancies between system calls in parallel variants of the program. The use of hardware virtualization enables efficient discrepancy tracking between variants, as it avoids the frequent context switching associated with traditional MVX implementations. In addition, given that the process virtualization layer can provide MVX with monitoring access to privileged processor functions, the design is particularly susceptible to optimization.

The project was first published at the DSN'16 conference in the article Secure and Efficient Multi-Variant Execution Using Hardware-Assisted Process Virtualization [1]. The original implementation of the solution is available on the Github platform [10]. It consists of a shared library that provides functions for synchronizing system calls, as well as two versions of the module intercepting system calls while the program is running and calling functions from the shared library to synchronize and compare the status of variants. When conducting this research on the MvArmor solution, we relied on its original implementation, using a hardware process virtualization tool called Dune [11].

Environmental Requirements:

- Linux 64-bit x86;
- Intel VT-x virtualization enabled;
- Linux kernel version 3.0 or later.

Dune

Dune is a system that provides applications with direct but secure access to hardware functions, while maintaining existing operating system interfaces for processes. It consists of a small kernel module that initializes the virtualization hardware and mediates interactions with the kernel, and user-level libraries that help applications manage privileged hardware functions [12]. The experiments used Dune for the 64-bit x86 version of Linux.

Ptrace

Ptrace is a Linux mechanism by which a parent process can observe and control the execution of another process. It can inspect and change its core image and registers, and is mainly used to implement breakpoint debugging and system call tracing [13]. Ptrace was used in the original MvArmor implementation as a simpler and less efficient alternative to the Dune utility, mainly used for debugging purposes.

Httpd

Daemon HTTP is software that runs in the background of a web server and waits for incoming server requests. Daemon automatically responds to the request and handles hypertext and multimedia documents over the Internet using the HTTP protocol [14]. The CGI protocol works with it, which adds scripts with the request based on which the content is delivered instead of the static content being returned. The CGI protocol is not necessary, but HTTPd and CGI are used together to deliver dynamic content [15, 16]. During the experiments, an implementation of the HTTP server from the Apache project (httpd) was used.



Experiments

Experimental environment

Experiments were performed in the Linux Ubuntu 14.04.1 64-bit version with the use of components:

- CPU: Intel i7-5600U 2,6GHz;
- RAM: 4GB.

Implementation

Koning, Bos, & Giuffrida [1] created C libraries with approximately 5000 lines of code. Having access to the address space of the monitored application, the software is able to determine how memory is allocated between the variants, as well as monitor the state of the application memory in order to detect a potential attack. The project is split into two implementations: Sandbox Dune, which allows running and monitors any application, and ptrace, which is used for development and debugging. In order to test the effectiveness of the solution, the authors used then popular server programs that could be exposed to remote attacks. They have chosen nginx (v0.8.54), lighttpd (v1.4.28), bind (v9.9.3), and beanstalkd (v1.10) for their experiments.

Security experiments

In order to verify the effectiveness of MvArmor in terms of detecting and preventing attacks using memory errors, a simple C program was written containing a vulnerability allowing for a buffer overflow attack. The program contained several lines of code in which a string of arbitrary length, passed as an argument of the program call, was copied to a fixed-length buffer.

To enable a successful buffer overflow attack, the program was compiled with gcc compiler safeguards disabled, such as disabling stack execution, and detecting and terminating stack overflow attempts. The ASLR (Address Space Layout Randomization) mechanism built into the Linux system, consisting in the randomization of memory addresses allocated to processes (which is a separate technique of the Moving Target Defense type), was also deactivated.

The attack consisted in overwriting the return address from the function with the address pointing to the area belonging to the program stack, where the code running the program /bin/dash was placed. Attempts were made to attack the version of the program without MvArmor protection, as well as the version launched using MvArmor.

In the case of the program version without additional protection, the introduction of malicious data resulted in unexpected behaviour of the program and the launch of the /bin/dash program. However, the program with the MvArmor protection working was terminated before the stack contents were executed, and the MvArmor logs could read information about a discrepancy in the content of system calls, indicating an attack. Therefore, it was possible to confirm the ability of the MvArmor solution to detect and prevent simple buffer overflow attacks based on overwriting the return address from the function.

Performance experiments

In order to measure the performance cost of using MvArmor, the HTTP server from the Apache project was launched and its response latency was measured as well as the number of completed



requests per unit of time. Experiments were performed for the server version without MvArmor protection and with a different number of parallel variants launched by the MvArmor utility. The autocannon tool [17] was used to perform the experiments. It allowed to set up many parallel connections with a given server and send requests to it for a specified number of seconds.

The conducted experiments investigate the impact of the increase in the number of parallel connections on selected configurations, such as the average delay, the average number of requests, and the number of errors returned by the HTTP server. The experiments were performed 4 times and the results were averaged in order to obtain the most optimal results.

Number of	Without	MVArmor with	MVArmor with	MVArmor with
parallel	MVArmor	2 variants	3 variants	4 variants
connections				
100	8488ms	7971ms	7501ms	7259ms
101	7776ms	8051ms	7498ms	7089ms
10 ²	6901ms	7151ms	7110ms	7168ms
103	6612ms	7120ms	3861ms	2871ms

Tab	1	Average	delay
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Source: own calculations

Source: own calculations

Fig. 1. shows the average values of response delays with a different number of parallel connections to the server, for different versions of the server (without MvArmor protection and with MvArmor protection, with a different number of variants running).

Average latency drops for MvArmor with 2 and 4 variants. This is because the increase in the number of parallel connections makes the system unable to handle them. In the case of experiments for a system without MvArmor defence and for MvArmor with two variants, a general downward trend in the average delay can also be seen, but it is not as marked a decrease as in the case of the 2 and 4 variant configurations.



Interestingly, the latency for the version with MvArmor protection is often lower than for the unprotected server.

Number of	Without	MVArmor with	MVArmor with	MVArmor with
parallel	MVArmor	2 variants	3 variants	4 variants
connections				
100	69	92	31	28
101	258	236	227	201
10 ²	239	238	261	238
10 ³	315	240	260	209

Tab. 2. Average number of requests

Source: own calculations

Fig. 2 shows the average number of completed requests for the same configuration options. The average number of completed requests is generally lower for the version of the server with MvArmor protection than for the version without protection. However, these differences are not big. Again, these are not big differences, and it can be explained to some extent by the lower number of requests for servers with MvArmor protection. Average number of requests for 10-1000 parallel connections varies between 201 and 261 for all server version.





Number of	Without	MVArmor with	MVArmor with	MVArmor with
parallel	MVArmor	2 variants	3 variants	4 variants
connections				
10^{0}	0	0	0	0
101	0	0	0	0
10 ²	2	0	0	0
10 ³	548	1320	464	1602

Tab. 3. The number of errors returned by the HTTP server

Source: own calculations



Fig. 3. The number of errors returned by the HTTP server Source: own calculations

Fig. 3 shows the number of errors returned from the server in response to a request for different configurations. The errors returned by the HTTP server do not appear until 1000 concurrent connections. This coincides with the average delay, which for the same number of parallel connections suddenly drops drastically for a MvArmor configuration with 2 and 4 variants.

During the experiments, a performance study was also conducted based on CPU and RAM utilization. For each type of experiment, RAM consumption remained around 20-30% all the time. In the case of the processor, consumption was almost always below 10%, small jumps were not related to the experiments performed. The exception was the test of the number of errors returned by the HTTP server. For 10³ parallel connections, the CPU was above 70%, and on one attempt, the system became unresponsive.

Discussion

PROMOVENDI

The presented solution has some limitations, mainly hardware. According to the authors [1], Linux kernel version 3.0 or newer is required to run the tool, however, experiments show that the solution cannot be built with kernel version 4.0 or newer.

The use of implementation used requires a very specific version of the operating system. The authors [1] indicate that the solution was successfully evaluated on Ubuntu version 14.04. The Linux kernel version requirements are also met by Ubuntu 14.10, however, it was not possible to build and run the solution on this version of the system due to bugs and missing libraries. Problems with running MvArmor also occurred on Ubuntu version 14.04.06 (LTS); finally, the solution was built and run on Ubuntu version 14.04.01. The issues listed are likely due to specific Dune requirements.

An important limitation is also the fact that Dune works only for processors from the Intel family.



Conclusions

MvArmor is an effective solution, but it generates many compatibility problems. The solution has been tested on many different versions of the Linux Ubuntu operating system, however, the only version that has successfully run the presented implementation is Linux Ubuntu 14.04.01 64-bit x86.

The tests performed did not reveal a clear performance overhead caused by the use of MvArmor. However, a more accurate assessment of the cost of using the MvArmor solution requires further research.

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THE NOVEL DELIVERY SYSTEMS FOR NEW ACTIVE SUBSTANCES BASED ON NATURAL RAW MATERIALS

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Abstract:

Organogels, the novel vehicles for active substances based on natural raw materials are semi-solid systems with an organic liquid phase immobilized by a three-dimensional network composed of self-assembled fibers. Application of organogels are various, including chemistry, pharmaceuticals, cosmetics, and biotechnologies. In pharmacology, they are used as drug and vaccine delivery platforms for active ingredients via diverse routes such as transdermal and oral. More recently, the synthesis of more biocompatible organogels has strengthened the development of several biomedical and pharmaceutical applications. In this review an emphasis is placed on recent vehicles, especially organogels, used in the potential controlled delivery systems of active substances.

Keywords:

gels, organogels, formulation vehicle, controlled release, active substance delivery systems

Introduction

As a complex organ designed to isolate the organism from the environment, the skin is a barrier limiting the penetration and absorption of active ingredients and thus represents a challenge to the pharmaceutical and cosmetic development of carrier. In principle, it is essential to choose the appropriate delivery vehicle for each active ingredient, depending on its physicochemical properties and the targeted site. Besides, the desirable properties of a formulation for cutaneous application are the acceptability and non-toxic. Typical formulations are gels, creams, lotions, ointments or emulsions. In this review describes the vehicles used as potential controlled delivery systems of active substances [1-8].

Microemulsions

Microemulsions are clear, stable, isotropic mixtures of oil, water and surfactant, frequently in combination with a cosurfactant. These systems are currently of interest to the pharmaceutical scientist because of their considerable potential to act as drug delivery vehicles by incorporating a wide range of drug molecules. Microemulsions are defined as 'a system of water, oil and amphiphile which is a single optically isotropic and thermodynamically stable liquid solution. In practice, the key



difference between emulsions and microemulsions are that the former, whilst they may exhibit excellent kinetic stability, are fundamentally thermodynamically unstable and will eventually phase separate. Another important difference concerns their appearance; emulsions are cloudy while microemulsions are clear or translucent. In addition, there are distinct differences in their method of preparation, since emulsions require a large input of energy while microemulsions do not [9-15].

Gels

Gels are three-dimensional (3-D) networked structures that have the ability to immobilize a liquid phase. Such systems are used in various personal care products and for biomedical applications, for example, drug delivery systems, toothpastes, shampoos. Gels are composed of two components, namely a liquid solvent phase (either polar or apolar) and a gelling agent (often referred to as a gelator), responsible for forming the 3-D networked structure. Depending on the polarity of the liquid immobilized within the networked structure, gels may be regarded either as hydrogels (polar solvent) or organogels (organic solvent). Gels are vehicles that have been proved to be favorable for topical active substance delivery. Recently, gels have become more and more popular because they are often characterized by a simple composition content and high biocompatibility with skin cells [16-19].

Hydrogels

Hydrogels are a type of gel formulations with water-based solvents as a continuous phase and are capable of absorbing large quantities of water or biological fluids. The distinctive nature and characteristics, i.e., water-affinity, dispersibility as colloids, and soft texture, endow hydrogels with appreciable hydrophilicity, biocompatibility, and flexibility [16, 20, 21].

Since the advent of hydrogels, they have generated a great deal of interests in scientific research and provide a wide range of practical applications as one of the most important soft matters. The high hydration ability of hydrogels contributes to their biocompatibility and bioactivity with biological organisms as well as avoiding mechanical and biological mismatch to bio-tissues. Besides, combining with the response to external stimulus, hydrogels are capable of attentively demonstrating versatile functions and have shown promising applications in versatile applications including sensors, actuators, optics, flexible devices, soft robotics, water harvesters and coatings. Nevertheless, most hydrogels are not durable under dry conditions due to the significant evaporation of the continuous phase in their network structure. Therefore, most hydrogels are only suitable to serve in a wet environment or used for a short time. Additionally, liquid (i.e., water) immobilized within the hydrogel may be inevitably frozen at subzero temperature, leading to the loss of softness and biocompatibility [22-24].

Many substances, both natural and artificial, meet the concept of hydrogels, and can be classified based on the source of origin, either synthetic or organic. An important class of hydrogels known as multipolymer interpenetrating polymeric hydrogels which is composed of two independent cross-linked of synthetic or natural polymer components that are arranged in a network structure. A hydrogel is nothing more than a hydrophilic polymeric network that has been somehow cross-



linked to create stretch like structure. Therefore, a hydrogel can be produced using any method that can be utilized to manufacture a cross-linked polymer [25-27].

Organogels

An organogel may be defined as a non-glassy thermoreversible semi-solid system composed of an organic liquid entrapped within a 3-D network. Organogels may be categorized either as physical or chemical gels depending on the type of chemical interactions involved during the gelation process. Organogels, can be distinguished from hydrogels by their predominantly organic continuous phase and can then be further subdivided based on the nature of the gelling molecule: polymeric or low molecular weight (LMW) organogelators [28-30].

Organogels are inherently biodegradable, especially the latest formulations based on biomolecules (lecithin-soy being highly biocompatible with amphiphilic character facilitating dissolution of active substances) and biocompatible solvents (isopropyl myristate enabling substrates with better emollient and spreading properties) constituting the continuous phase. In addition, organogels, due to their unique properties (lower sol-gel transition temperature and higher gel strength leading to the formation of supramolecular cross-linked gelation points), have the ability to carry active compounds to various target sites in the body and control the degree of their release [31-33].

Soy lecithin, which is the main component of soybeans (widely used as an organo-gelator), is the general term used to describe the group of phospholipids most abundant in biological systems. Lecithin does not have an irritant effect and promotes the disorganization of skin lipids, increasing the penetration of active substances, but is itself characterized by a low activity profile. The specificity of lecithin is related to its isotropic nature, sufficiently high purity, and the presence in its structure of unsaturated bonds present in the fatty acid chain. The ability of lecithin to increase the penetration of substances through the skin naturally promotes its use in topical preparations as a biocompatible enhancer of the penetration of new active substances [34-36].

The rational design of new organogelators as stimuli-responsive materials with tuned properties requires the control of the non-covalent forces directing the self-assembly, involving not only gelator–gelator but also gelator–solvent interactions. The review [34] presents a perspective on the abilities and properties of carbocycle-based organogelators, from simple cycloalkane derivatives to complex polycyclic compounds, with emphasis on the influence that chirality, conformational bias, and molecular rigidity have on their self-assembly mode and properties. Nevertheless, it is not easy, if not impossible, to predict with precision if a given compound will be able to gelate a liquid based on simple qualitative structural features [17, 24, 34, 36, 37].

Organogels are semi-solid systems; their liquid phase is fixed in a thermo-reversible threedimensional network using various oleogelators which lead to the formation of lipid structures with obvious macroscopic properties (such as oil binding capacity, rheological properties, and thermostability). As a substitute for saturated fatty acids, and because of their properties, organogels have been widely applied in the food industry and for shaping food products such as cakes, biscuits, meat products, chocolate, and ice cream. Additionally, organogels can be utilized to stabilize and control the release of nutraceuticals and medicines [35-38]. The physical organogels are more commonly used than the chemical organogels because they can provide a network structure to vegetable oils and are edible. However, as physical organogels have only recently been investigated, detailed information on gelation phenomena and intermolecular interactions is not yet available. Moreover, the types of physical oleogelators are limited, mainly including natural waxes, fatty acids, fatty alcohols, and compounds of sterols and glutamine [37-39].

Low Molecular Weight Organogelators

Organogels have currently occupied a significant place in research, especially those called low molecular weight gelators (LMWGs) have a special place application in active substance release. LMWG's are a class of organogels with an interesting molecular structure, with less than 1000 Da molecular weight. They are self-assembled supramolecular structures with distinct stereochemistry due to weak hydrogen bonds and Van der Waals forces. Gel formation takes longer time to complete compared to Lecithin Organogels (LO), critical parameters including pH variation, trigger conditions and temperature change are considered during synthesis. Contents consist of a significant amount of liquid phase and minute amount of solid phase (about 1 %) and the transformation process is triggered by an external stimulus which entangle its molecules leading to networks that can immobilize the solvent [38-40].

Polymers immobilize the organic solvent by forming a network of either crosslinked or entangled chains for chemical and physical gels, respectively. The latter is possibly further stabilized by weak inter-chain interactions such as hydrogen bonding, van der Waals forces, and π -stacking. Likewise, the self-assembly of LMW organogelators depends on physical interactions for the formation of aggregates sufficiently long to overlap and induce solvent gelation. Depending on the kinetic properties of aggregates, an important distinction amongst LMW organogels is made between those composed of solid (or strong) versus fluid (or weak) fiber networks [38-40].

Gelatin-Based Organogels (GBO's) is another interesting class of organogels

These type of organogels is obtained by solubilizing gelatin in water phase of water/oil microemulsion, studies were initially conducted in 1984. It was proposed that while such organogels can be synthesized from different gelatin structures, there is a unique macroscopic hydrophobic continuous phase that is a connected gelatin network which can be solubilized easily by oil when it is induced by a single layer of surfactant. The most interesting property of GBO's is its electrical conductivity which make them an excellent choice for iontophoretic drug delivery method [41-44].

Depending on the intermolecular interaction such organogels can be formed in two types. Solid fiber network is formed when heated polar solvent is made to cool down at room temperature, below the solubility threshold of the organogelators. The resulting structure contains an alignment of organogelators in bundles. Fluid fiber is achieved when polar solvent is added with a solution exhibiting both hydrophobic and hydrophilic properties. Such molecules behave as reverse micelles with the addition of small amounts of water. Due to the ability to modify the gelator structure using straightforward synthetic processes, the availability of materials with various properties, and the versatility of the gels, LMWGs are generating a lot of interest [38, 43-45].



Conclusions

The understanding of the relationships between composition, structure, and physicochemical properties of the synthesis of vehicles used in the potential controlled delivery systems of active substances is still very limited. The contribution of the chemical structure and active components, in the properties of vehicles is still a field to be explored.

This review presents a general description of the recent vehicles - especially organogels, used in the potential controlled delivery systems of active substances. Organogels are a very diverse and fascinating class of soft materials that, over the last 30 years, have evolved to be one of the most interesting subjects in materials science. This fact is clearly reflected by the number of references found through any web search engine, which retrieves an average of 7 references on organogels in 1990 vs. 190 references in 2021 [46].

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POISONOUS HOUSEPLANTS FOR DOGS AND CATS

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Abstract:

Poisonous plants commonly grow in our nearest environment and are responsible for many poisonous events in cats and dogs. Having knowledge about morphology, the toxic profile of most often kept houseplants and symptoms of poison, could make diagnoses and treating patients much easier. In addition, spreading knowledge and increasing awareness among animal owners could prevent poisonous cases in small animals.

Keywords:

dogs, cats, poisonous houseplants

Introduction

In Europe, due to climate conditions, we can find much less poisonous plant species, compared to their occurrence in continents like Africa and South America. Unfortunately, according to data received from European poison centers, still more than 10% identified poison cases in domestic animals are related with exposure to plant toxins. Additionally, the research by the Poison Center of Milan showed that more than 50% plant poison in dogs and cats is caused by houseplants [1].

On the basis of the survey conducted for the needs of this article among 185 owners of small animals results that 60% respondents have in their house at least one houseplant with toxic effect on their companion animal. Furthermore, 30.6% respondents answered that they have more than one poisonous plant in their nearest environment. The most common kept plants with harmful influence are *Ficus benjamina, Kalanchoe spp. and Euphorbia pulcherrima*.

Generally, dogs and cats poisoning by plants occurs due to eating leaves, stems, flowerings and seeds. Indoor animals show behaviour to eat plants as a result of getting bored, curiosity and dentination [2].

In most cases symptoms occur few hours after consumption and most often they come from: digestive system (vomiting, diarrhea, sialorrhea), nervous system (asthenia, ataxia, mydriasis, hallucinations, hypertonia, convulsions), cardiorespiratory system (arrhythmias, bradycardia, hypotension, dyspnea) [1].



DON'T HAVE ANY POISONOUS PLANTS	40%
RHODODENDRON SPP.	11,90%
LILIUM SPP.	7,50%
KALANCHOE SPP.	24,20%
FICUS BENJAMINA	26,30%
EUPHORBIA PULCHERRIMA	21%
DIEFFENBACHIA SPP.	16,10%
CYCAS REVOLUTA	6,50%

Fig. 1. Poisonous plants owned by small animals owners Source: survey from own source

The course of poisoning is influenced by factors belonging to plants (concentration of toxins in each part, growth stage, climate and soil) and factors belonging to animals (natural immunity, acquired immunity, alimentary system, breed, age, gender, nutrition) [2].

Dieffenbachia spp.

Dieffenbachia belongs to the family *Araceae* and naturally grows in tropical forests of Central and South America. In Europe, it is kept as an ornamental houseplant. Most popular species are Dieffenbachia picta oraz Dieffenbachia maculata. In a house environment, it can reach from several dozen centimeters to 1,5 meters. Dieffenbachia is characterized by huge spiky leaves in color combination with white and green [3].



Fig. 2. Dieffenbachia spp. Source: own source

All parts of this plant are toxic and the most common way of poison is through the alimentary system or direct contact with the eyeball. Dieffenbachia has sap with strong toxic influence, which is composed of saponins, alkaloids, cyanogenic glycosides, proteolytic enzymes, calcium oxalate crystals and oxalic acid [2]. These substances act irritating to mucosal membranes and after

consumption cause swelling of the oral cavity, tongue hypertrophia, sialorrhea, ulceration, vomiting and difficulty in eating. Toxins could affect kidneys causing acute renal tubular necrosis. Respiratory tract is also exposed to progressing edema and as a result dyspnea. Contact with the eyeball ends with inflammation in the cornea and the conjunctiva and temporary blindness which leads from several hours to several days.

Treatment in asymptomatic cases is based on decontamination of the alimentary system by causing vomiting. In case of symptoms occurring treatment should focus on mitigation of edema and pain by giving antihistamines, antispasmodic and painkillers [4]. In addition, reasonable will include fluid and oxygen therapy [2]. During eyeball injuries, it should be rinsed with a physiological solution. Locally application of antibiotics is also correct [4].

Cycas revoluta

Sago palm (*Cycas revoluta*) belongs to the class of Cycadopsida in the family Cycadaceae. It is native to southern Japan but is also popular in Europe as a houseplant. Under natural conditions it grows to a height of 6-7 meters whereas as an indoor plant it reaches about 1 to 1.5 meters. Cycads have short and thick trunk with plume of leaves on top. Its dark green leaves grow 50 to 60 centimeters long and have fine spikes on top [5].



Fig. 3. Cycas revoluta Source: own source

All parts of the plant are toxic, however, the highest concentration of toxins are in the seeds as well as in the roots [6, 7]. The essential chemicals responsible for the toxicity are glycosides - cycasin and macrozamin. These glycosides are not toxic itself, although they become hepatotoxic and gastrotoxic after they are metabolized [8]. *Cycas revoluta* also contains neurotoxins, such as β -methylamino-L-alanine and unidentified neurotoxin [9].

Gut microbiota play the most important role in the metabolism of cycasin and macrozamin, nevertheless, part of these chemicals are converted by animal enzymes - β -glucosidases.

Hydrolysis of glycosidic bond results in release of toxic aglycone - methylazoxymethanol (MAM) [9-11].



Methylazoxymethanol (MAM) disintegrates spontaneously into reactive particles, including free radicals, which have DNA damaging potential. As a result of reactions with nucleic acids a great number of N-7-methylguanine (N7-mG) and O6-methylguanine (O6-mG) are produced. Accumulation of DNA lesions is the reason for the hepatotoxic effect of cycasin, however, it may also indicate its mutagenic, teratogenic, carcinogenic and neurotoxic properties [11].

It has been proven that neurotoxins contained in *Cycas* are responsible for neurologic disease in cattle. Unidentified neurotoxin causes axonal degeneration and demyelination in brain, spinal cord and dorsal root ganglia [9].

Dogs, among all companion animals, are the most often intoxicated by *Cycas revoluta* [12]. Clinical signs after ingestion of the toxic plant may include vomiting, diarrhea and abdominal pain. Sometimes neurological signs, like ataxia, depression, proprioceptive deficits, seizures and coma, are also observed [8]. Progressive depression, icterus, ascites and excessive bleeding are signs of ongoing liver damage. Laboratory tests show elevated liver enzymes, hyperbilirubinemia, hypoglycemia and hypoalbuminemia [8].



Fig. 4. Euphorbia pulcherrima Source: own source

Treatment of *Cycad* intoxication is mostly symptomatic and focused on protection of damaged liver. In the early stage of toxicosis, gastrointestinal decontamination is the most crucial. Induction of emesis, gastric lavage and administration of activated charcoal can be performed. Supportive fluid therapy is also essential for successful therapy [6].

The prognosis in the case of *Cycas revoluta* intoxication depends on amounts of ingested toxins along with intensity of supportive treatment. According to reports, mortality varies between 32% and 58% [8].

Euphorbia pulcherrima

Euphorbia pulcherrima belongs to the huge family *Euphorbiaceae*. Originally, it comes from Mexico and Guatemala, where in its natural environment it takes the form of shrub or short tree of height from 1 to 3 meters. In the half of XX century it became very popular as an ornamental plant, as a result of bred species which were adapted to climate in temperate zone. Nowadays, it is known



as one of the most common houseplants. Species kept indoors achieve height to 50 centimeters and have elliptic, spiky leaves in dark green color. Furthermore, Euphorbia pulcherrima is characterized by presence of the apical sub-inflorescence leaves, gathered in rosette, surrounding small flowers. Sub-inflorescence leaves have intense color, red,pink or white thanks to what they attract insects. Plants become poisonous when the sub-inflorescence leaves start their growth [5].

Euphorbia pulcherrima has milky sap which include diterpenoid euphorbol esters and steroids with saponin-like properties. These substances are responsible for irritating influence on mucous membranes [2].

Companion animals after consumption of this plant show symptoms like fever, hypersalivation, vomiting and diarrhea. Contact with skin results with local irritation, erythema and itching. Direct contact with the eye could induce conjunctivitis and lacrimation [2]. In most cases symptoms are mild and not life threatening. Prolonged vomiting leads to dehydration and electrolytes disturbance.

Treatment in the first place is focused on decontamination of the alimentary system to limit toxic influence on animal organism. Necessary is also constant control of animal hydration and administration of antihistaminic drugs. In cases of contact sap with the eye is needed to rinse the eyeball with plenty of water or physiological solution [2].

Ficus Benjamina

Ficus benjamina is the best known and most popular houseplant of the genus *Ficus*. This plant belongs to the family *Moraceae*. In their natural environment it takes the form of a tree of height up to 30 meters with delicate, hanging down branches. It grows in south Asia, north Australia and islands of Oceania. Ficus benjamina under house breeding condition reach 2 meters height. It has small, leathery, suspended down leaves in light green color with white border [5].



Fig. 5. Ficus Benjamina Source: own source

The leaves, cortex and fruits of Ficus benjamina contain many bioactive substances such as cinnamic and caffeic acids, naringenin, quercetin, and stigmasterol. These substances have anti-inflammatory, antioxidant and antibacterial properties thanks to what this plant has for medical use.

However, despite positive influence on health, plant sap has toxic compounds such as ficin which is a proteolytic enzyme and furocoumarins and psoralen. It is known that these substances are cytotoxic and develop irritation of skin and mucous membranes [12].

Based on research by Veterinary Toxicological Assistance Service in France, Ficus benjamina is one of the major causes of plant poisoning in cats and dogs [12]. There is no specific treatment and is based on decontamination of the alimentary system, fluid therapy and constant monitoring of life functions of exposed animals.

Kalanchoe spp.

Kalanchoe is a genus consisting of approximately 150 to 200 species of succulent plants in the family Crassulaceae. They are native to southern Africa, Madagascar and Australia [16]. Great diversity is observed within this genus, but most of the species occurs in the form of shrubs or herbaceous plants. Dark green and thick leaves are highly variable in shape. Some of the plants in this genus produce clonal plantlets from the base or along the leaf margins [15]. Kalanchoes are often seen as ornamental houseplants, mostly because of their ease of flowering in various colors even in low light conditions. The most common species grown indoors include *Kalanchoe blossfeldiana*, *Kalanchoe pinnata* and *Kalanchoe daigremontiana*.



Fig. 6. Kalanchoe spp. Source: own source

All species of the genus Kalanchoe are poisonous. The highest levels of toxic chemicals are located in the flowers, however, all parts of the plant have significant amounts of them [16].

Kalanchoe intoxication is often seen in livestock in south Africa and Australia when there is scarcity of feed. Toxic doses of these plants have been determined only for birds and livestock. Amongst companion animals dogs are considered the most sensitive to a cardiotoxicity of Kalanchoe spp. [17].

The main chemicals responsible for Kalanchoe toxicity are cardiotoxic bufadienolides, including bryotoxins, bryophyllins and bersalgenins [16]. These substances are related to the compounds

responsible for toxicity of toads from the genus Bufo and have similar activity to cardiac glycosides [17].

Bufadienolides inhibit sodium-potassium ATPase activity in cardiomyocytes, thereby intracellular concentration of sodium ions increases and extracellular concentration of potassium ions decreases, leading to reduction of the resting membrane potential. Disturbances in the distribution of ions restrain electrical conductivity together with activity of the cardiac conduction system. Complete loss of electroconductive function in myocardium may eventually induce asystole [17].

The most common signs after ingestion of Kalanchoe spp by dogs and cats include vomiting, depression and diarrhea [17]. Cardiac signs, such as bradycardia, arrhythmia and heart blocks are related to the presence of cardiotoxic agents. Neurologic signs have been observed in intoxicated dogs and include nystagmus, delirium, tetany and mild seizures [16]. There have not been any fatal cases of intoxication described [17].

It is crucial to monitor the pulse, rhythm, blood pressure and electrolyte levels of intoxicated animals. Hyperkalaemia may occur due to potassium ions shifting out of cardiomyocytes. Serum biochemistry tests should be performed to evaluate liver and kidney functions. Occasionally, hypotension may arise, leading to impaired kidney activity. Hypoglycaemia in the course of Kalanchoe spp. intoxication also has been described [17].

Digoxin immunoassays cross-react with plant-derived cardiac glycosides and may be used for definite diagnosis. These tests are effective only when a patient has not been exposed for cardiac glycosides from other origins [17].

In the treatment of Kalanchoe spp. intoxication gastrointestinal decontamination is the most important. Patients should then be monitored for gastrointestinal and cardiac symptoms. If necessary, symptomatic treatment and appropriate fluid therapy should be instituted. Fluids with calcium ions need to be used with caution as they may enhance the cardiotoxicity of bufadienolides. Intoxicated animals should be provided with a quiet environment to reduce the stress, which can put more strain on the heart [16]. Beta-blockers or atropine can also be used for treating different types of arrhythmias [17].

The prognosis in the case of *Kalanchoe spp*. intoxication depends on severity of patients symptoms. For animals with mild gastrointestinal symptoms the prognosis is good, however, for patients exhibiting arrhythmias and hyperkalaemia it is guarded [17].

Lilium spp.

Lilium is a genus of herbaceous flowering plants of the family Liliaceae. They are native to temperate areas of the northern hemisphere. Lilies have an erect, unbranched stem that grows severally from the underground bulb. Narrow leaves are placed densely on the stem which end with solitary or clustered flowers [18]. The flowers vary in shapes and colours depending on species. Plants from this genus usually reach 50 to 200 centimetres in height [5]. Lilies have gained popularity as ornamental house plants mostly because of their impressive inflorescences and long flowering period. Hybrid lilies, formed from the crossing of many Japanese species, are most often grown indoors due to their adapting ability.





Fig. 7. Lilium spp. Source: own source

The first documented case of lily toxicity was in 1992 and involved *Lilium longiflorum* [19]. Further observations proved that all species of *Lilium* should be considered nephrotoxic. Noteworthy is the fact that the only animal susceptible to nephrotoxicity is the domestic cat [20]. Toxic agents are located in all parts of the plants. Ingestion of even a small amount of *Lilium* may be dangerous for cats. Mortality caused by consuming as little as 2 to 3 leaves or flower fragments has been noted [20].

Toxins responsible for lilies' nephrotoxicity still have not been identified. It is known that they are placed in the water-soluble fraction of the plant. Rapid onset of clinical symptoms is proving that toxic chemicals are quickly absorbed by the organism. Toxins are probably eliminated from the animal's body within 48 hours after intoxication, however, clinical effects last for a few more days after removal [20].

Nephrotoxicity cannot be recreated in rats, mice or rabbits even after giving them lilies in amounts bigger than 1,5 their bodyweight. The application of water-soluble fraction of lilies does not have any toxic effect on feline renal tubular epithelial cell culture [21]. All things considered, it is very likely that differences in metabolism of toxins may be the reason for cats' exceptional sensitivity for the plant from the *Lilium* genus.

Toxins contained in *Lilium spp*. damage the renal tubular epithelium which results in the subsequent renal failure [21]. Based on clinical cases of lilies intoxication, two necessary components have been identified to cause acute renal failure. The first one is the direct effect of the toxic agents on the renal tubular epithelium which causes initial renal failure with concomitant polyuria. The second element is the development of severe dehydration due to polyuria [20].

The clinical picture is changing during the course of intoxication. First signs develop within 1 to 3 hours after ingestion and include vomiting, salivation, anorexia and depression. Polyuria is observed after 12 to 30 hours after exposure and leads to dehydration. The next is anuric phase which occurs 24 to 48 hours after the intoxication. Renal failure causes accumulation of waste products which leads,



in 30-72 hour of the syndrome, to the recurrence of vomiting along with weakness. Deaths are reported 3 to 7 days after lilies ingestion.

Changes in blood biochemistry in the course of intoxication include increased levels of urea nitrogen, creatinine, phosphorus and potassium. The most significant sign, that may help identify Lilium poisoning, is a disproportionate elevation of creatinine levels in comparison to urea levels. In many clinical cases, concentration of creatinine was at the level of 15-20 mg/dL or even 30 mg/dL, while concentration of urea was only 75-200 mg/dL [22].

Abnormalities in the urinalysis are observed 12 hours after ingestion of the toxic plant and include proteinuria, glycosuria and presence of renal casts. Isosthenuria will occur due to the complete loss of the kidneys ability to concentrate urine [21].

In the treatment of *Lilium spp*. intoxication gastrointestinal decontamination procedures should be implemented first, to minimize the amount of absorbed toxins. The most effective treatment for cats without anuria is adequate fluid therapy to force diuresis. When anuria occurs due to the action of toxins, treatment options are limited. There are cases of cats with lilies-induced renal failure that have undergone dialysis, however, the dialysis are not always effective [21].

The prognosis needs to be based on severity of clinical signs at the beginning of treatment. In case of an early diagnosis combined with decontamination of the alimentary tract followed by fluid therapy and forced diuresis, the prognosis is excellent. In cases where renal failure with anuria already occurred, the prognosis is guarded to poor [21].

Conclusions

In case of plant poisoning in cats and dogs, fast recognition of plant species and its toxic profile is very important to start appropriate treatment as soon as possible. In most cases plant toxins do not have any specific antidote and it is necessary to implement treatment which is focused on protecting most exposed systems.

It is needed to attract the attention of small animal owners to prevent occurrence of poisoning companion animals. Fulfilment of animal behaviour needs by assurance of appropriate environmental stimuli will work to lower the tendency of eating plants. Additionally, it is very important to inform small animal owners about the danger of keeping poisonous houseplants species in the environment of the animal.

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