Assen Zlatarov University
Burgas, Bulgaria

ANNUAL

VOLUME LII, 2023

TECHNICAL AND NATURAL SCIENCES

SOCIAL SCIENCES

ASSEN ZLATAROV UNIVERSITY
BURGAS, BULGARIA

ANNUAL

Vol. LII, 2023

TECHNICAL AND NATURAL SCIENCES

SOCIAL SCIENCES

Assen Zlatarov University

Assen Zlatarov University
Annual, Vol. LII, 2023

Technical and Natural Sciences
ISSN 2603-3968

Social Sciences
ISSN 2603-3976

Burgas 8010, Bulgaria

ASSEN ZLATAROV UNIVERSITY
BURGAS, BULGARIA

ANNUAL

Vol. LII, 2023

TECHNICAL AND NATURAL SCIENCES

SOCIAL SCIENCES

BURGAS ● 2023

VOLUME LII. CONTENTS

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

CEREMONIAL SPEECH OF RECTOR PROF. DR HRISTO BOZOV AT THE CELEBRATION OF THE 60th ANNIVERSARY OF PROF. DR ASSEN ZLATAROV BURGAS STATE UNIVERSITY ON 09.10.2023

Dear Mr President
of the Republic of Bulgaria,

Dear Mr Deputy Minister,

Dear Ms Consul and dear Honorary Consuls,

Dear Mr Regional Governor,

Dear Ms Mayor of Burgas,

Dear Rectors,

Dear Members of the Expert Group of the National Evaluation and Accreditation Agency,

Dear Members of the Academic Management,

Dear colleagues, lecturers and employees (current and former) of Prof. Dr Assen Zlatarov University,

Dear students,

Dear guests from all spheres of the public, political and business sectors,

Our Alma Mater was founded in October in the now distant 1963 with a Decree of the Council of Ministers as the Institute of Chemical Technology and began training 270 students in 5 specialties. Today, education is carried out in five faculties, three colleges and two departments.

The University now provides education in 83 subjects for Professional Bachelor, Bachelor and Master educational qualification degrees and 13 doctoral programmes. Tens of thousands of students from Bulgaria and the world have attained their university degrees at our university (1,350 students graduated it this year). Having acquired knowledge and skills, and not only diplomas, our graduates have achieved success on all continents and brought glory to our University, Burgas and our country.

Over these six decades Prof. Dr Assen Zlatarov University has become a symbol of quality in education. Our students are our greatest asset. Their persistence and ambitions inspire us to continue teaching them with dedication and responsibility.

Our 60th anniversary is a cause of joy and pride because it is not just a number. It is a testament to our long-standing commitment and ongoing dedication to education and the development of our community, for which I most heartily thank all current and former academics and staff.

Today, we are not only proud of our past, but also focused on our future. Times change, but our goals remain the same: to continue to provide high quality education, to promote research and innovation, to train our students for a successful career and life.

Our University has effective cooperation with dozens of universities from Bulgaria and all over the world, we have numerous joint participations in international projects, and we encourage student and faculty mobility.

We achieve our success thanks to more than 300 teachers and researchers, some of whom have won national awards, such as the Pythagoras Prize for Science, as well as prestigious international awards.

We encourage the young people among us to think for themselves, to make informed and courageous decisions about their lives. Our students

need to know that they have a great responsibility, because the future belongs to them.

We do not stop setting new, higher goals.

In two years' time, we are going to take leave of the first medical graduates of Prof. Dr Assen Zlatarov Burgas State University. Although the Faculty of Medicine is still young, it has become the most popular among students. We have achieved a national record for those wishing to study Medicine for the academic year 2023/2024 (25 girls and 13 boys competed for one place). Soon, the first foreign students of Medicine are to be admitted. It is a fact that in recent years Burgas has become the city with the most investments in the field of health care, and the basis of this growth is the development of the two new faculties of the University, the Faculty of Public Health and Health Care and the Faculty of Medicine. We are also going to help with providing the staff for the realization of the Children's Hospital project.

We are also actively negotiating the opening of the first branch of the University outside the Region of Burgas. On the 6th of October, at a ceremonial session the newly elected Academic Council took several important decisions, one of which is to open a branch for the training of nurses in Kardzhali. The second one is to start a procedure for accreditation of the Faculty of Pharmacy. As the last point in the agenda, it approved my proposal for the establishment of a Museum of the history and development of Prof. Dr Assen Zlatarov University. I am extremely pleased that the Museum of Chemistry was opened on 5 October, the Museum of Pedagogy is to be opened on 30 October and the Museum of Medicine will be opened soon. So, our University will be also known as the University with many museums. I had a talk with Prof. Dr Assen Zlatarov's granddaughter, Evdokia Zlatarova, who promised to donate some of his books and belongings to our new museum. Prof. Ivan-Assen Hristov Zlatarov was born in Haskovo soon before the Unification of the Principality of Bulgaria with Eastern Rumelia. He was named in honour of the victory of the great Bulgarian king Ivan-Assen II near Klokotnitsa. He was a man of very wide scientific and social interests and personified the brightest expression of Bulgarian academic history. He graduated in chemistry in Geneva, but specialized in food and forensic medicine in Munich. He holds a "doctorate in physics and chemistry" from the University of Grenoble. During the Balkan Wars and World War I he helped in several military hospitals. From 1924 he was a "professor" of organic chemistry at the University of Sofia, but most of his 600 scientific publications were related to biochemistry. He was a well-known public figure, a charming lecturer, and a much-loved teacher of his students. His heart stopped beating at the age of only 51 in Vienna on 22.12.1936 after two cancer operations. In my view, he was wisely chosen as the patron of our University in 1967, because his brilliant personality combines chemistry, physics, medicine, pedagogy, literature, art, and economics, all of which are taught at the University that was named after him.

Remembering our experience in the past, we look confidently to the future. As Henryk Sienkiewicz said, "Quo vadis?". Where are we going? We will continue to support the development of the Faculty of Natural Sciences, the Faculty of Technical Sciences, the Faculty of Social Sciences, the College of Tourism, the College of Medicine and the Technical College, as well as the two departments. In a few days, we will issue a tender for the design of a new building which will house the Faculty of Pharmacy, a new state-of-the-art University Library and a Student incubator. The government has already granted us 220 thousand leva for the project, thanks to the efforts and support of the Ministry of Education and Science, the local government and all members of Parliament from the region. We will also pay serious attention to the development of sports, culture, creativity and student initiative.

Why is our University very important for the Republic of Bulgaria?

We give priority to training students in state-protected specialties that are key to the development of many sectors of Bulgarian society and the national economy: chemistry, history and philosophy, Bulgarian language and literature, ecology and protection of the environment. It is well known that there are not enough people interested in studying chemistry and engineering, but the medical and pedagogical specialities are in great demand. It is highly possible that this trend will change in a few years' time. Why? Because we are part of a large and rich union with nearly 500 million consumers and whoever produces for and sells in this huge market will develop successfully. So we will retain and develop all the personnel who can help the industry. This is why we are a state university: to help the state, and we expect the state to support us.

How will we help our city, Burgas? We will strive to increase the number of students and train them better, so that they are ready to start

work immediately upon graduation (many of them even work while they are still studying). This year we have admitted 10% more students than last year. We are throwing a bridge to high school education and we have already started active cooperation with high schools whose profiles match our professional fields, so that, even while still at high school, school students in Burgas could find the specialty in Burgas University to continue their education in their chosen field. Dear school directors, we will rely heavily on your collaboration so that Burgas sets an example of a perfect link between high school and higher education. We will also encourage the exchange of staff between the two. With the opening and development of the Faculty of Pharmacy, we do not merely want to train students, but also to provide personnel as well as an impetus for the development of the pharmaceutical industry in the Southeast Region. We will strive to attract an increasing number of international students, and our idea is that they are not only medical students. The implementation of this strategy will not only bring more income to those working at the University, but also to the citizens of Burgas, because it involves accommodation, food, flights, culture, and business.

2,500 years ago, a Chinese thinker said, "There are three paths that lead to knowledge: the path of reflection, which is the noblest; the path of imitation, which is the easiest; and the path of experience, which is the bitterest." Even in his lifetime, Confucius was believed to be the teacher of 10,000 generations. I believe that for 60 years, we have gone through all three.

I wish to thank all who have joined us along our scientific path all these years: my predecessor rectors, lecturers, former and current students, collaborators and friends. Your support and inspiration have been immeasurably precious to us!

Dear Mr President, thank you for being here and supporting us, despite your very serious engagements in the present tense situation. I would like to assure you that Prof. Dr Assen Zlatarov Burgas State University will continue to be a pillar of higher education in the Republic of Bulgaria! Our broad profile and huge potential are our capital. We know that it is up to us to make the most of it! We will also rely on help from the state when necessary!

Finally, I will conclude with another of Confucius's sayings: "Three things never come back - time, word, and opportunity." Therefore, dear colleagues and friends, let us not waste time, keep our word and not miss the opportunities for the development of our University.

Let Prof. Dr Assen Zlatarov Burgas State University live forever and, as a next step, have a successful accreditation this week!

Congratulations on our holiday!

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

STUDY OF THE NUTRITIONAL REGIMEN OF DIABETIC PATIENTS

Galina Grigorova, Galina Yordanova, Ruska Nenkova
E-email: galinakirova@abv.bg

ABSTRACT

This article examines what the diet for overweight diabetics should include and what approaches are used to achieve good results. The composition and energy content of the appropriate products and meals are essential for diabetics. Body mass index and the amount of fat tissue in diabetic patients are evaluated.

Keywords: *rational nutrition, body mass index, diabetes*

INTRODUCTION

Since diabetes is a disease which continues during one's lifetime, proper therapy methods with special emphasis on diet should be used by healthcare providers in a way to control the disease, reduce its symptoms, and prevent the appearance of complications. Patients should also have good knowledge about the disease and appropriate diets. For this purpose, healthcare providers must inform patients what changes in their nutritional habits and food preparation are required. Active and effective dietary education may prevent the onset of diabetes and its complications [1]. A rational diet is the basis of the correct treatment of diabetes. The correct diet for diabetes should be well-balanced and tailored to each patient's individual needs. Nutritionists say that nutrition is very important in managing diabetes: it is not only the type of food but also its quantity that influence blood sugar. Meals should be consumed at regular times with low fat and high fibre contents including a limited amount of carbohydrates. Excess weight and physical inactivity are also associated with an increased risk of developing various diseases, particularly type 2 diabetes [2-4].

The body mass index (BMI) is an indicator that serves to determine a healthy weight in patients and to diagnose obesity. BMI allows to distinguish conditions associated with underweight, overweight, and obesity in the elderly. Measuring waist circumference is an important indicator of health risks associated with body fat accumulation.

The purpose of the present study is to conduct a questionnaire survey among diabetics and to make recommendations for a healthy diet. The normal body mass and the amount of fat tissue in diabetic patients are to be evaluated.

$$\text{BMI} = \frac{\text{Weight in kilograms}}{(\text{Height in meters } 2)}$$

Underweight < 18.5
Normal weight $18.5 – 24.9$
Overweight $25\text{-}29.9$
Obesity $30\text{-}39.9$
Extreme obesity ≥ 40

EXPERIMENT

Body mass index in 46 diabetic patients has been determined and recommendations for dietary regimens have been given. Waist circumference has been measured in a standing position, along the mid-axial lines, midway between the lowest part of the chest and the iliac crest. The permissible value of waist circumference is ≤ 90 cm for men, ≤ 80 cm for women. Significant deviations over these values increase the risk of developing obesity-related diseases.

RESULTS AND DISCUSSION

The article examines the diabetic diet, makes assessment of body mass index and what the diet for overweight diabetics should include and what approaches are used to achieve this. Basic recommendations have been made: adequate fluid intake including clean water, tea, vegetable soups and vegetable smoothies; daily consumption of fresh and seasonal vegetables such as cucumbers, tomatoes, mushrooms, carrots, cauliflower, cabbage, collard greens, green beans, and other local

vegetables; daily intake of fresh fruit except sugar-rich fruits such as grapes. The diet must include carbohydrate foods rich in ballast substances, brown rice, oatmeal, and legumes such as lentils and beans. Low-fat milk and dairy products such as cottage cheese and yogurt can be included. Meats can include lean chicken without skin, rabbit meat such as fillet and breast, fish and beef. The unsuitable products for a diabetic diet include cream, mayonnaise, processed and smoked cheese, sausages, and fried foods. Ravussin et al. [5] showed that when the diet-derived fat intake is increased, fat storage within and around other tissues and organs including liver, skeletal muscle and pancreatic b-cells, which under normal conditions do not store lipids, takes place. This in turn results in excessive mitochondrial production of toxic reactive lipid species that cause organ-specific oxidative damage and cellular dysfunction, leading progressively to the development of insulin resistance, impaired glucose metabolism and finally to diabetes [6]. The accumulation of toxic metabolites within the pancreatic islet β-cells in particular affects insulin secretion and enhances b-cell apoptosis accelerating the progression to overt diabetes [7]. Fats in the diet should be limited to a minimum amount. All these could be achieved through the following: excluding from the dietary regimen of fatty foods. The intake of mayonnaise and cream should be kept to a minimum. When preparing nutritional regimens, it is necessary to take into account the person's health status, gender, and physical activity. Energy sources in food fats, carbohydrates, and proteins, their values are important when preparing a dietary healthy food regimen. It is accepted that the mandatory information on the nutritional value should be indicated for 100 g or 100 ml [8]. Dairy products with the lowest fat content, such as goat and cow milk are recommended [9]. The study evaluated the diet of 46 people with diabetes. In 74% of the patients, it is reported that they follow a diet related to the disease, and 26% do not strictly follow their prescribed diet. The data are presented in Figure 1.

The study assessed the normal body mass and the amount of fat tissue in diabetics. The body mass index in 46 diabetic patients was determined. The result of the conducted test was that 25% of the examined patients had an above-normal level of BMI and amount of body fat. 65% had normal weight and 10% were obese II degrees.

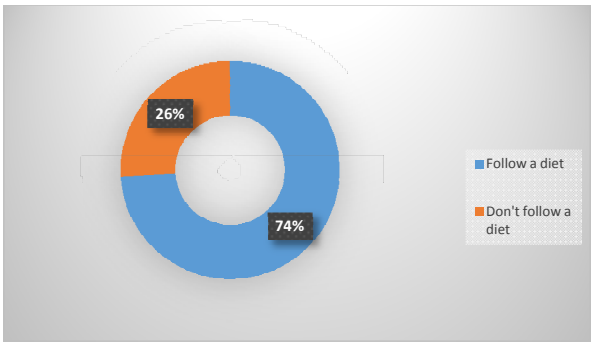


Fig. 1. Dietary compliance in diabetic patients

Obesity II degree has a very high risk of obesity, accompanied by concomitant diseases such as type 2 diabetes, hypertension, and cardiovascular diseases. The data are presented in Figure 2.

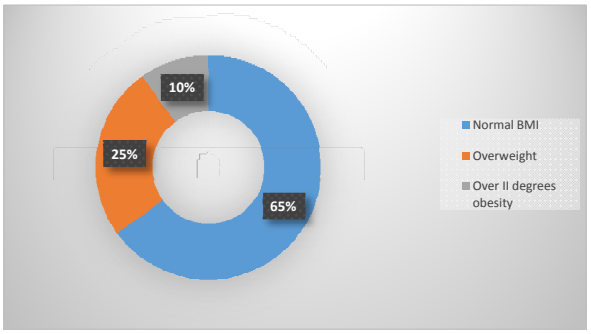


Fig. 2. Body mass index and the amount of fat tissue in diabetic patients

When asked if they take long walks daily, 62% of the respondents say that they do sports and take daily walks. 38% do not have time for sports in their daily routine. A good dietary regimen should always be combined with sufficient physical activity and lifestyle changes. Regular physical activities, determined individually, contribute to a permanent reduction of excess weight and control of diabetes. The increased physical activity may increase the risk of early or late hypoglycaemia up to 24 hours. Moderate physical efforts such as walking and gardening are met with an additional intake of 1 bread unit before and after the physical activity. Intense physical activities such as sports, mountain excursions, agricultural work require an additional intake of 1 bread unit before and after the exercise for short activities of up to 30 minutes. Longer activities require an additional 2.5 units of bread for each hour of physical activity. Blood sugar values below 4 mmol/l in people with diabetes are undesirable. If the blood sugar value drops below these units, a quick recovery is required with an immediate intake of 15 grams

of sugar (3-4 lumps, 3-4 sugar candies, but not chocolate). If the signs of hypoglycaemia have not disappeared within 15 minutes, another 15 grams of sugar must be taken. If there is no meal or breakfast within 1 hour, additional slow carbohydrates should be taken: one apple or a slice of whole grain bread. Most often, the cause of hypoglycaemia is dietary mistakes and incorrect diet. All recommendations are general recommendations. Each patient with diabetes needs an individual dietary regimen, tailored to his or her age, nutritional status, exercise regimen, work regimen, and accompanying diseases. An individual diet is prepared with the participation of an endocrinologist and a nutritionist. A proper diet for diabetics contains what people without diabetes should also eat. Modern recommendations for rational nutrition look the same.

CONCLUSION

Reducing excess weight is important because it improves metabolic disorders present in diabetes. Losing even a few kilograms leads to favourable changes. Dietary regimen should always be combined with adequate physical activity.

REFERENCES

1. Sami1, W., T. Ansari, N. Butt, M. Hamid. Effect of diet on type 2 diabetes mellitus: A review, *International Journal of Health Sciences*, **11**, Issue 2, (2017), pp. 65-71.
2. Sullivan, P.W., E. Morrato, V. Ghushchyan, H. Wyatt, J. Hill. Obesity, inactivity, and the prevalence of diabetes and diabetes -related cardiovascular comorbidities in the US 2000-2002, *Diabetes Care*, **28** (2005), pp. 1599-1603.
3. Jung, H-S., Y. Chang, K. Yun, C-W Kim, E-S Choi, M-J Kwon, J. Cho, Y. Zhang, S. Rampal, D. Zhao, HS Kim, H. Shin, E. Guallar, S. Ryu. Impact of body mass index, metabolic health, and weight change on incident diabetes in a Korean population. *Obesity*, **22**, Issue 8 (2014), pp. 1880-1887.
4. Rudra, C.B., T. Sorensen, W. Leisenring, E. Dashow, M. Williams. Weight Characteristics and Height in Relation to Risk of Gestational Diabetes Mellitus, American Journal of Epidemiology, **165**, (2007), pp. 302-308.
5. Ravussin, E., S. Smith. Increased fat intake impaired fat oxidation, and failure of fat cell proliferation result in ectopic fat storage, insulin resistance, and type 2 diabetes mellitus. *Ann NY Acad Sci*, **967**, (2002), pp. 363-378.
6. Lewis, G.F., A. Carpentier, K. Adeli, A. Giacca. Disordered fat storage and mobilization in the pathogenesis of insulin resistance and type 2 diabetes. *Endocr Rev*, **23**, (2002), pp. 201-229.
7. Lois, K., S. Kumar. Obesity and diabetes. Endocrinol Nutr, 56, Issue 4, (2009), pp. 38-42.
8. Gogov, Y., S. Chomakova, D. Popova, P. Lilova, H. Yurukov. *Labelling the nutritional value of meat products* (ppractical guide), Association of Meat Processors in Bulgaria, 2015.
9. Grigorova, G.,Determination of food and energy of dairy products. Requirements reglamint EU 1169/2011. *Industrial Technologies*, **4**, Issue 1, (2017), pp. 80-84.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

APPLICATION OF COFFEE GROUNDS FOR THE GROWTH OF DIFFERENT TYPES OF MICROORGANISMS

Galina Yordanova
E-mail: burdelova@abv.bg

ABSTRACT

The growth of selected bacteria, yeasts and fungi on coffee grounds obtained by brewing, from espresso coffee and from capsules was investigated. The results obtained show that mainly fungi are able to grow on coffee grounds, with the greatest growth observed in A. niger and A. oryzae, regardless of how the grounds were obtained. Fungi have also been found to grow persistently on brewed coffee, espresso coffee and coffee capsules. These studies prove the possibility of using coffee grounds as a nutrient medium for the development of microorganisms, and the high resistance of fungi to coffee and coffee grounds.

Key words: *coffee ground, microorganisms, coffee*

INTRODUCTION

Intensive coffee production is accompanied by several environmental problems, soil degradation, loss of biodiversity and pollution due to the extensive use of agrochemicals, raw materials and waste generated from coffee processing. In addition, climate change reduces the suitability of cultivated areas, while potentially increasing the spread and impact of pests and diseases. In this regard, the coffee microbiome has been increasingly studied in recent decades to improve the sustainability of coffee production. Microorganisms associated with coffee have been isolated and characterized to highlight their beneficial characteristics and explore their potential for use as beneficial alternatives. Despite numerous studies highlighting the potential of coffee-associated microorganisms grown on nutrient media, the lack of such benefits under field conditions is highlighted.

Nowadays, sequencing technologies allow the study of coffee-associated microorganisms with metabarcoding. This strategy, which does not require the cultivation of microorganisms, now provides a deeper insight into coffee-associated microbial communities and their impact not only on the fitness of the coffee plant, but also on the quality of the final product. The ability of the microbiota to promote coffee plant growth and control its pests and diseases is reviewed, and the potential of the microbiota to improve coffee quality and sustainability for waste management is highlighted [1].

Some authors have investigated the antimicrobial activity of regular and decaffeinated Arabica coffee extract and evaluated it against three different gram-positive bacteria and two gram-negative, including pathogenic strains of staphylococci. Antimicrobial activity has been shown to be independent of caffeine content and is mostly expressed against Gram-positive strains. The common coffee extract showed a significant bacteriostatic effect against *Staphylococcus aureus* and *Staphylococcus epidermidis* at short exposure time and bactericidal after prolonged exposure. These results highlight the potential of coffee extracts as a naturally active and non-toxic antibacterial compound suitable for biomedical applications.

The rise of antimicrobial resistance in bacterial populations raises the question of an urgent response in terms of new antimicrobial molecules [2]. However, the development of new antibiotic molecules is time-consuming and expensive in terms of both human and financial resources, so the preferred strategy is to optimize already existing antimicrobial drugs or to combine multiple antibiotic compounds to improve their antimicrobial activity. efficiency. In addition, public concern over the safety of synthetic molecules has led to increased interest in naturally occurring molecules.

Some studies have reported antimicrobial properties of coffee [3, 4, 5, 6], but the antibacterial components responsible for the activity and mechanisms of action are still not fully understood [7].

For the future use of coffee derivatives as antibacterial compounds, it is important to reveal the mechanisms driving their antimicrobial properties, as well as to expand the number of tested strains to determine their spectrum of activity. There are many methods for testing total microbial counts [8], as well as verification of methods for the study of microorganisms [9].

Other authors investigated the potential cytotoxicity of coffee extracts against eukaryotic cells and tissues [10]. The authors' aim was to investigate the antimicrobial activity and cytotoxicity of Arabica coffee extracts. The results contribute to the evaluation of the potential of these coffee derivatives as antimicrobial agents or preservatives [11].

Another application of coffee grounds is that spent coffee grounds can affect wastewater treatment processes due to the high consumption of coffee worldwide. The influence of the main chemical compounds present in coffee grounds on the respiratory activity of sewage sludge was investigated. Increasing the respiratory activity of microorganisms in the presence of inexpensive waste materials such as coffee grounds can help improve wastewater treatment. The study showed the possibility of improving wastewater treatment due to the respiratory activity of microorganisms in the presence of inexpensive waste materials such as coffee grounds [12].

Coffee is one of the most popular and consumed products in the world, generating tons of solid waste known as spent coffee grounds containing several bioactive compounds. Antifungal activity of ethanolic extract of caffeinated and decaffeinated coffee capsules was evaluated against yeasts and filamentous fungi. These extracts have antifungal activity against *Candida krusei*, *Candida parapsilosis*, Trichophyton mentagrophytes and Trichophyton rubrum, all skin fungal agents. In addition, the sludge has fungicidal activity against T. mentagrophytes and T. rubrum. This confirms the antifungal activity of spent coffee grounds, representing a potential increase in the life cycle sustainability of coffee grounds as a source for the development of new antifungal formulations, especially for skin or mucosal fungal infections [13].

A medium for cultivating microorganisms using sludge was also investigated. Microorganism culture medium using coffee grounds is very economical as it can reduce costs by using the discarded coffee grounds. Meanwhile, the treatment of coffee waste generated worldwide largely depends on landfilling or incineration, which affects soil and other organisms due to caffeine, tannin, and other constituents of coffee. Combustion can generate combustible gases and cause air pollution, therefore there is an urgent need for a coffee grounds recycling method which is industrially useful and can efficiently reduce the generation of waste [14].

The present study aims to investigate coffee grounds as a suitable nutrient medium for different types of microorganisms and those that are most resistant were tested for resistance on coffee.

MATERIALS AND METHODS

Materials

Coffee grounds were collected from capsule coffee machines, espresso machines and brewed coffee. They were then dried at room temperature to a constant weight.

Microorganisms: Various microorganisms were used, namely: Bacteria - *Brevibacterium flavum, Pseudomonas aeruginosa, Micrococcus spp., Pseudomonas fluorescens*. Yeast - *Saccharomices cerevisiae, Candida utilis, Rodotorula spp., Trichosporon cutaneum, Candida tropicalis.* Fungi - *A. niger, A. awamori, Penicillium spp., A. oryzae*. They were provided by the Department of Biotechnology, Faculty of Technical Sciences, Burgas, Prof. Dr. Assen Zlatarov University, Bulgaria. Cultures of the investigated strains were maintained on Beer agar at 29-30^{0}C in order to obtain dense sporulation and stored at 4°C in a refrigerator.

Methods

Culture conditions: The nutrient medium was just coffee or coffee grounds. 2 grams of the dried material was weighed in Petri dishes and autoclaved at 121°C for 15 minutes. After cooling to room temperature, wash (5 ml of sterile water) of the respective microorganism was introduced into the Petri dishes under sterile conditions. The Petri dishes thus inoculated were placed in a thermostat at 29-30°C for development. The samples were observed every 24 hours.

RESULTS AND DISCUSSION

First, the bacteria *Brevibacterium flavum, Pseudomonas aeruginosa, Micrococcus spp., Pseudomonas fluorescens* were tested for growth on coffee grounds obtained in three ways: from brewed coffee, from coffee capsules and from espresso coffee. The results show that there is no bacterial growth on the sludge obtained in all three ways (Fig. 1).

Fig. 1 Coffee grounds with different types of bacteria

Then the yeasts *Saccharomices cerevisiae, Candida utilis, Rodotorula spp., Trichosporon cutaneum, Candida tropicalis* were tested for growth on coffee grounds obtained in three ways: from brewed coffee, from coffee capsules and from espresso coffee. The results show that there is no growth of the selected yeasts on the sediment obtained in all three ways (Fig. 2).

Fig. 2 Coffee grounds with different types of yeast

Finally, the fungi - *A. niger, A. awamori, Penicillium spp., A. oryzae* were studied for growth on coffee grounds obtained in three ways: from brewed coffee, from coffee capsules and from espresso coffee. Table 1 presents the results of the three types of coffee grounds. They show that there is growth in some of the fungi on the sludge obtained in all three ways (Fig.3). Namely, *A. niger* and *A. oryzae*, already on the second day of their sowing, reproduction was observed on the coffee grounds obtained in all three ways (Fig. 4).

Fig. 3 Growth on coffee grounds of different types of fungi

1

2

Fig. 4 Growth on coffee grounds of the fungi *A. niger* – 1 and *A. oryzae* - 2

Table 1. Results of fungi growth on coffee grounds obtained in different ways

Microorganism	Fungi growth, espresso coffee grounds, days				
	1	4	5	6	12
A. niger	-	+	+	+	+
A. awamori	-	-	-	-	-
Penicillium spp.	-	-	-	-	-
A. oryzae	-	+	+	++	++
	Fungi growth, grounds from coffee capsules, days				
	1	4	5	6	12
A. niger	-	+	+	+	+
A. awamori	-	-	-	-	-
Penicillium spp.	-	-	-	-	-
A. oryzae	-	+	+	+	+
	Fungi growth, brewed coffee grounds, days				
	1	4	5	6	12
A. niger	-	+	+	+	+
A. awamori	-	-	-	-	-
Penicillium spp.	-	-	-	-	-
A. oryzae	-	+	+	+	+

Accordingly, experiments were made with these two fungi on pure brew coffee, from coffee capsules and espresso coffee. The results show that both microorganisms are able to multiply on pure coffee (Fig. 5).


1


2

Fig. 5. Growth on coffee of the fungi *A. niger*-1 and *A. oryzae* – 2

In this way, the good resistance of the two fungi on pure coffee for brewing, from coffee capsules and espresso coffee was confirmed.

CONCLUSION

After the experiments, it was found out that the selected bacteria and yeasts are not able to grow on coffee grounds, regardless of the method of preparation. But of the selected fungi, two are capable of growing on coffee grounds. And these are *A. niger* and *A. oryzae*, which have been found to be able to grow on pure coffee as well. These results confirm the ability of fungi to use coffee grounds as a sole carbon source, and their ability to utilize waste from the food industry.

REFERENCES

1. Duong, B., P. Marraccini, J-L. Maeght, P. Vaast, M. Lebrun and R. Duponnois. Coffee Microbiota and Its Potential Use in Sustainable Crop Management. A Review. *Frontiers in Sustainable Food Systems*, www.frontiersin.org, **4**, (2020), Article 607935.
2. Zell, B. L., D. A Goldmann. Healthcare-associated infection and antimicrobial resistance: moving beyond description to prevention. *Infection Control and Hospital Epidemiology*, **28** (3), (2007), pp. 261-264.
3. Almeida, A., A. Farah, A. Silva, D. A. Nunan, E. A., M. B. Gloria, Antibacterial activity of coffee extracts and selected coffee chemical compounds against enterobacteria. *Journal of Agricultural and Food Chemistry*, **54** (23), (2006), pp. 8738-8743.
4. Daglia, M., A. Papetti, P. Grisoli, C. Aceti, V. Spini,, C. Dacarro, et al. Isolation, identification, and quantification of roasted coffee antibacterial compounds. *Journal of Agricultural and Food Chemistry*, **55** (25), (2007), pp. 10208-10213.
5. Rurian-Henares, J. A., F. J. Morales. Antimicrobial activity of melanoidins against Escherichia coli is mediated by a membrane-damage mechanism. *Journal of Agricultural and Food Chemistry*, **56** (7), (2008), pp. 2357-2362.
6. Tiwari, B. K., V. P. Valdramidis, C. P. O'Donnell, K. Muthukumarappan, P. Bourke, P. J. Cullen. Application of natural antimicrobials for food preservation. *Journal of Agricultural and Food Chemistry*, **57** (14), (2009), pp. 5987-6000.
7. Mueller, U., T. Sauer, I. Weigel, R. Pichner, M. Pischetsrieder. Identification of H(2)O(2) as a major antimicrobial component in coffee. *Food & Function*, **2** (5), (2011), pp. 265-272.
8. Grigorova, G. Study of total microbial count in raw milk. *Annual Of Assen Zlatarov University*, ISSN 2603-3968, **47** (1), (2018), pp. 89-93
9. Grigorova, G. Verification of a method for the detection of Listeria monocytogenes in food. BDS EN ISO 11290-1:2017. Microbiology of the food chain. Horizontal method for the detection and enumeration of Listeria monocytogenes and Listeria spp. Part 1: Method of detection. *Industrial technologies*, ISSN 1314-9911, **7** (1), (2020), pp. 67-70.
10. Hegele, J., G. Munch, M. Pischetsrieder. Identification of hydrogen peroxide as a major cytotoxic component in Maillard reaction mixtures and coffee. *Molecular Nutrition & Food Research*, **53** (6), (2009), pp. 760-769.
11. Runti, G., S. Pacor, S. Colomban, R. Gennaro, L. Navarini, M. Scocchi. Arabica coffee extract shows antibacterial activity against Staphylococcus epidermidis and Enterococcus faecalis and low toxicity towards a human cell line. *LWT - Food Science and Technology*, **62**, Issue 1, Part 1, (2015), pp. 108-114.
12. Vít˘ezová, M., S. Jan˘cíková, D. Dordevi´c, T. Vít˘ez, J. Elbl, N. Hanišáková, J. Jampílek and I. Kushkevych. The Possibility of Using Spent Coffee Grounds to Improve Wastewater Treatment Due to Respiration Activity of Microorganisms. *Appl. Sci.* **9**, (2019), 3155.

13. Calheiros, D., M. I. Dias, R. C. Calhelha, L. Barros, I. C. F. R. Ferreira, et. al. Chantal Fernandes and Teresa Gonçalves. Antifungal Activity of Spent Coffee Ground Extracts. *Microorganisms*, **11**, (2023), p. 242.

14. Method for preparing medium for microbial culture using coffee ground and producing method for L(+) lactic acid using the same, Republic of Korea Patent. 2014, Application No. 10-20007-00300.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

PHYTOCHEMICAL COMPOSITION OF EXTRACTS OF THE *SIDERITIS SYRIACA L.* ENDEMIC PLANT

A. Veli, R. Nikolova, Z. Mustafa, K. Yaneva, G. Rusev, L. Gonsalvesh
E-mail: anife_veli@abv.bg

ABSTRACT

Lamiaceae Lindl. family is one of the most diverse and widespread in the world, including about 200 genera and more than 7,000 species. The genus Sideritis belongs to the Lamiaceae family and has found application in traditional medicine due to its anti-inflammatory, anti-rheumatic and antimicrobial properties. Sideritis syriaca is an endemic plant also found on the territory of Bulgaria and included in the national legislation and in the Red Book of the Republic of Bulgaria, Volume 1 in the critically endangered category, among other 112 plant species in the Strandzha mountain. Although a lot of literature regarding the composition of the genus Sideritis is available, research on Bulgarian Sideritis syriaca is scarce. The present study aims to elucidate the phytochemical composition and total phenolic content of extracts from the cultivated Sideritis syriaca plant.

Key words: *Sideritis syriaca, phytochemical composition, total phenolic content*

INTRODUCTION

Herbal plants are gaining increasing popularity worldwide as they are an important source of natural compounds that offer the chemical diversity important for the pharmaceutical industry [1, 2]. The scientific interest in plants has also been greatly stimulated by the discovery of natural antioxidants which replace the synthetic ones and are very effective in the prevention of the destructive processes caused by oxidative stress [3]. Herbal plants contain a large number of phytochemicals which provide additional benefits to human health since they have strong antioxidant effect and exhibit antimicrobial, antiallergic, and antiviral properties [4, 5].

Lamiaceae Lindl. family is one of the most diverse and widespread in the world, including about 200 genera and more than 7,000 species [6]. The genus *Sideritis* belongs to the *Lamiaceae* family and has found application in traditional medicine due to its anti-inflammatory, anti-rheumatic and antimicrobial properties [7]. Research on the phytochemical composition of *Sideritis* species reveals a high variability in the chemical constituents, which is generally attributed to the environmental conditions under which the plant is grown, the time of harvest, the type/origin of the plant material, and the extraction method [8]. As reported, species of this genus are rich in polyphenols, flavonoids, monoterpenes, sesquiterpenes, and terpenoids with prominent pharmacological effects [7, 9, 10]. Phenolic compounds are among the most valuable functional components produced by plants, since they are involved in activities such as the formation of colour, taste and aroma, and are building blocks of defence systems in plants [11]. The variety of different properties and biological effects of polyphenols defines their broad-spectrum applicability also in the prevention of cardiovascular, neurodegenerative diseases and cancer [12].

Globally, there is a lot of literature regarding studies on ethnopharmacology, phytochemical content, and pharmacological activities of plants of the genus *Sideritis*. Nevertheless, most of the publications cover populations inhabiting Spain, Italy, Greece and Turkey [7, 8, 11, 13, 14]. In Bulgaria, the species *Sideritis syriaca* is included in the national legislation and in the Red Book of the Republic of Bulgaria, Volume 1 in the critically endangered category, among other 112 plant species in the Strandzha mountain. However, Bulgarian Sideritis populations, especially *Sideritis syriaca L.*, have not been studied enough. Therefore, the aim of the present work is to elucidate the phytochemical composition of non-polar and polar derivatized extracts from the cultivated plant *Sideritis syriaca* and determine the content of total phenolic compounds. An in-depth study of plant extracts and their products will reveal their potential as a source of new phytochemical compounds that can find application in medicine for the prevention and treatment of a number of diseases, and in the food-flavour and cosmetic industries.

EXPERIMENTAL

Plant material

Air-dried aerial parts (stem, leaves and flower) of the cultivated plant *Sideritis syriaca L*. were provided by "KIPRO" OOD. The plant was grown in a small bio-tea plantation located in the village of Varovnik, Sredets Municipality, on light and alkaline soils with pH~7. Prior to analysis, the dry plant material was ground to a powder size < 0.2 mm and an aliquot was used for extraction.

Extraction procedure

As extraction agents four solvents were considered, i.e. ethanol (EtOH), methanol (MeOH), hexane (He) and acetone (Ac). The extraction procedure was as follows: 2.0000±0.0700 g of homogenized powder of the *Sideritis syriaca* plant was weighed in a glass-stoppered Erlenmeyer flask and subjected to ultrasonic extraction for 120 minutes with 150 ml of the appropriate solvent at a temperature not exceeding 35°C. Each extraction was carried out in triplicate. After extraction, the samples were filtered, then concentrated using a rotary vacuum evaporator at a temperature of 50°C and completely dried via nitrogen purging. The extracts were weighed on an analytical balance to evaluate the yields (Re, %) and stored in the dark in a desiccator until their analysis. The extraction yields were calculated as follows:

$$Re\ (\%) = \frac{m_{extract}}{m_{plant\ material}} x100 \qquad (1)$$

Determination of total phenolic content

The total phenolic content in the obtained plant extracts was determined by the Folin – Ciocalteu (FC) method [15, 16] using a Thermo Scientific Evolution 300 two-beam UV-VIS spectrophotometer and cuvettes with thickness of 1 cm.

Aqueous solutions of gallic acid with concentrations ranging from 20 μM to 1,000 μM were used as standard solutions for construction of a calibration curve.

The extracts were dissolved with 300 μL of the corresponding solvent. Thereafter, the solutions were further diluted with distilled water so that the measurements could be within the calibration range. The standard and sample solutions were processed according to the FC method as follows: 50 μl of standard (gallic acid) or sample solution, was mixed with 0.25 ml of the FC reagent and diluted with 3 mL of distilled water. After 7 minutes of incubation period, 0.75 ml of a 20% w/w solution of Na_2CO_3 was added and topped up with distilled water to a total volume of 5 ml. The reaction mixtures were incubated in the dark at room temperature for a specified period of time, and then the absorbance was measured at different wavelength of 760, 765 and 770 nm against a blank.

The concentration of total phenolics in the extract was expressed as milligrams of gallic acid equivalent (GAE) per 1g of sample (mg GAE/g).

Analysis of the phytochemical composition of Sideritis syriaca extracts

The determination of the phytochemical composition was performed by the method of gas chromatography coupled to mass spectrometry (GC-MS, Thermo Scientific Trace 1300/TSQ 8000). Separation of individual components of *Sideritis syriaca* extracts with a concentration of 600 μg ml^{-1} in DCM was carried out using a capillary column with a non-polar stationary phase (5% diphenyl, 95% dimethylpolysiloxane, 30 m × 0.25 mm × 0.25 μm). Helium with high purity (99.999%) was used as the carrier gas at a constant flow of 1.2mL min^{-1}. A volume of 1μL was injected in the splitless mode at inlet temperature of 250°C. Initial column temperature was 40°C with 3 min hold, then increase up to 300°C at ramp rate of 5°C min^{-1} and held for 5 min at the final temperature. The mass spectrometer was operated in electron impact (EI) ionization mode with an electron energy of 70 eV. The ion source temperature was 250°C and the transfer line temperature was 270°C. The mass spectra of compounds were acquired in the mass range from 40 to 550 amu as the identification was performed by comparing the mass spectra of individual compounds with the spectral database of NIST library.

For quantitative analysis, a deuterated internal standard acenaphthene (d10–Ace) with a concentration of 0.2 μg ml^{-1} was added to each extract. The concentration of individual compounds in the extract was calculated using the formula:

$$C_i = \frac{C_{d10-Ace} A_i}{A_{d10-Ace}} \qquad (2)$$

where C_i and A_i are the concentration and area of the i^{th} component, respectively; $C_{d10\text{-}Ace}$ and $A_{d10\text{-}Ace}$ are the concentration and area of the internal standard, respectively.

Prior to chromatographic analysis, the extracts were derivatized according to the following procedure: 1mg of each *Sideritis syriaca* extract was dissolved in 1ml of dichloromethane and 0.1 ml of N, O-Bis(trimethylsilyl)trifluoroacetamide (BSTFA) was added to each of the solutions.

After full homogenization, the solutions were heated up to 70°C for 15 minutes and cooled down to room temperature.

The resulting products after derivatization were less polar, therefore more volatile, allowing chromatographic analysis.

RESULTS AND DISCUSSION

Sideritis syriaca extraction yields

The extraction yields derived from the cultivated plant are arranged in the following descending order: MeOH (20.70±2.54 %), EtOH (9.88±0.66 %), Ac (7.30±0.38 %), He (1.79±0.32 %). It can be seen that the yields of extracts increased with increasing the polarity of the solvent used. The results obtained in the present study are comparable to the literature data and it is observed that, regardless of the species of the studied plants of the genus *Sideritis*, the highest yields were obtained with MeOH [17].

Total phenolic content (TPC) in the studied extracts

Determination of TPC was performed by using a seven-point (each point analyzed in triplicate) calibration curve in the concentration range of 20 µM to 1000 µM. The linearity of the calibration curve was evaluated at different reaction times (one and two hours) and different wavelengths (760, 765 and 770 nm, Fig. 1). The constructed calibration curves and the derived regression equations show that in the selected concentration range, the dependence between absorbance and gallic acid concentration is highly linear and is described by coefficients of determination $R^2 > 0.998$. However, sole use of R^2 is not recommended as a means to demonstrate linearity and therefore the analysis of variance (ANOVA) was employed for testing the statistical significance of the regression model and acceptability of the linearity of the calibration function. The performed analysis of variance (ANOVA) shows that the Significance $F<0.05$ (Significance $F=6.7\times10^{-14}$), which means that the relationship is statistically significant at the chosen significance level of 0.05.

The data presented in Fig. 1 indicates that neither the reaction time, nor the absorption wavelengths significantly influence the results. Therefore, the extracts were analyzed after reaction time of 1 hour at wavelength of 760 nm. The results are summarized in Table 1. The data in Table 1 indicates that the values of total phenolic content of the studied extracts are comparable.

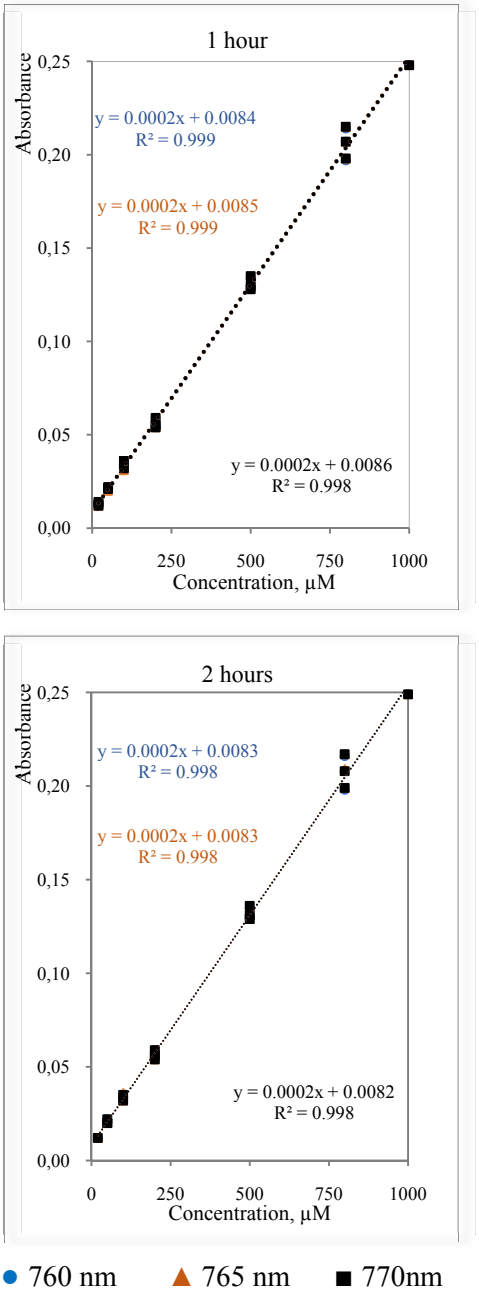


Fig. 1. Calibration curves for the determination of TPC with gallic acid standard

Table 1. TPC in the studied extracts

Solvent	Gallic acid equivalent	
	µM	mg/g
MeOH	381692.2	71.8
Ac	380105.1	70.6
EtOH	363484.1	68.4

Yanchev et al. [18] determined that the total polyphenols in different solvents (distilled water, acetone, 20, 50, and 70% ethanol), obtained after various extraction procedures of *Sideritis scardi-*

ca Griseb. varied from 4.0 to 32.2 mg GAE/g dry plant material. TPC values reported by Sevindik et al. [11] for MeOH extracts of some Sideritis species (*Sideritis rubriflora, S. libanotica subsp. violascens, S. erythrantha var. cedretorum, S. congesta, S. brevidens and S. vuralii*) ranged from 35.5 to 366.9 mg GAE/g dry plant material. On the other hand, Alipieva et al [19] reported 28.9 mg caffeic acid equivalent/g for MeOH extract, derived via ultrasonication. The large variations of the values in TPC found by different studies could be explained by the variety of plant material, soil structure, habitat, climatic, seasonal characteristics and non the least applied extraction procedure and the chosen solvent.

Phytochemical composition of the studied extracts

In order to better understand the results of extraction by different solvents, the constituents of the extracts were further elucidated via GC-MS analysis. The chemical classes identified in the corresponding extracts obtained from *Siderites syriaca* are listed in Table 2.

The GC-MS analysis revealed 21.8 wt. %, 13.0 wt. %, 40.0 wt. % and 20.0 wt. % of the phytochemical composition of He, Ac, MeOH and EtOH extracts, respectively. Previous studies of the authors (not published) have identified significantly lower amounts of constituents of the underivatized extracts, incl. 19.2 wt. %, 4.6 wt. %, 0.42 wt. % and 1.35 wt. % of composition of He, DCM, MeOH and EtOH extracts, respectively. It is clearly seen that derivatization played its important role, especially in the analysis of the polar extracts.

Various classes of phytochemical compounds were registered in the analyzed extracts, including terpenes and terpenoids, alcohols and phenolic compounds, long-chain carboxylic acids (saturated and unsaturated) and their esters, aldehydes and ketones, saturated hydrocarbons and sterols. Of the analyzed compounds, diterpenes and saturated hydrocarbons were in the highest content in the non-polar extract, a total of 63.6% of the registered compounds, followed by sterols (27.6%), while in the polar extracts the most abundant were carbohydrates varying in the range of 46.0 – 71.4%, followed by carboxylic acids in the range of 6.1 – 24.6%, and alcohols and phenols 6.2 – 14.2%. The high content of diterpenes even in the polar extracts is related to the fact that most of the registered compounds are polar diterpenoids.

The following peculiarities of the studied extracts were observed:

- A mixture of alcohols and phenolic compounds was registered in all extracts except for He extract. The highest content was glycerol, which is an end product of photosynthesis in plants and can also be derived from the breakdown of lipids. The relatively high glycerol content can also be associated with destruction reactions of thermally unstable compounds in the injector system of the chromatograph;
- The distribution profile of the saturated hydrocarbons in the He extract was as follows: the registered hydrocarbons have a number of carbon atoms from C_{21} to C_{33}; the odd homologues are preferentially represented with a maximum at C_{31};
- Carboxylic acids and esters were found in all extracts. The registered carboxylic acids have an even number of carbon atoms, incl. $C_{14} – C_{18}$ (saturated) and $C_{18:2} – C_{18:3}$ (unsaturated with 2 and 3 double bonds, respectively, with the maximum content of unsaturated for $C_{18:3}$). Carboxylic acid esters were recorded only in the EtOH extract. Benzyl Benzoate (Ascabin) used as a medicine and insecticide occurred in relatively high content in all extracts. Hydroxycarboxylic, dicarboxylic acids and hydroxy-dicarboxylic acids were also recorded in the derivatized extracts;
- Triterpenes (squalene and β-Amyrin) and sterols (γ-Sitosterol) were mainly registered in the He extract. Mono- and sesquiterpenes, were observed in He and MeOH extracts with the main identified compounds being Camphenol, trans-(-)-Pinocarveol, cis-Verbenol, Pinocarvone, Myrtenol, Kumaran, (Z,E)-α-Farnesene, (E)-β-Famesene, D-Germacrene, Bicyclogermacrene, Benzofuran-2-carboxaldehyde, 2(4H)-Benzofuranone, 5,6,7,7a-tetrahydro-4,4,7a-trimethyl and Spathulenol;
- Carbohydrates were registered in all polar extracts. Carbohydrates were represented by 8 monosaccharides, including furanoses and pyranoses, and 4 disaccharides incl. sucrose and isomaltulose. The content of sugars in a pure state in the studied extracts was atypical and was associated with the presence of glycosides - phenolic, flavonoid, anthocyanin, anthraquinone, cardiac and other glycosides. Glycosides are a large group of plant substances made up of a sugar and a non-sugar (aglycone) part. A number of phenylethanoid glycosides (over 10 in number) and flavonoid glycosides (over 17 in number) have been recorded in extracts of different

Sideritis species [10, 20]. It is possible that these compounds destroy and release simple sugars during the analysis or that they cannot be analyzed under the applied mass spectral conditions. For further clarification, the mass spectrometer scans ions with m/z 550 Da, a silylated monosaccharide has a molecular weight of 540 Da, and the recorded glycosides in *Sideritis* have a molecular weight of over 600 Da in the unsilylated state.

Table 2. GC-MS analysis of *Sideritis Syriaca* extracts

Chemical class	Number compounds	He	Ac	MeOH	EtOH
		μg g^{-1} sample			
Mono- and sesquiterpenes	13	33.32	-	111.94	-
Diterpenes	*9*	1118.24	619.27	3936.87	2932.04
Carboxylic acids	*12*	205.72	4666.72	5191.39	2350.02
Esters	*5*	19.55	19.2	16.7	410.28
Alcohols and phenols	*10*	-	2706.54	2367.77	3655.66
Aldehydes and ketones	*10*	2.77	78.83	52.7	121.95
Carbohydrates	-	-	8729.72	25757.13	27610.11
Saturated hydrocarbons	13	1237.88	335.54	-	593.91
Triterpenes	*2*	64.04	2.35	-	-
Sterols	2	1023.54	1835.86	1037.99	1005.95
Total Identified	76	3705.06	18994.03	38472.49	38679.92

CONCLUSIONS

In the current study the phytochemical composition and total phenolic content of He, Ac, MeOH and EtOH extracts of the cultivated plant *Sideritis syriaca* were elucidated. Extract yields obtained from the plant sample with extractants EtOH, MeOH, He and DCM were arranged in the following descending order: MeOH (20.70±2,54 %), EtOH (9.88±0,66 %), Ac (7.30±0,38 %), He (1.79±0,32 %). GC-MS analysis of the samples revealed 21.8 wt. %, 13.0 wt. %, 40.0 wt. % and 20.0 wt. % of the phytochemical composition of He, Ac, MeOH and EtOH extracts, respectively.

Different classes of organic compounds and biologically active substances characteristic of plants of the genus *Sideritis* were registered in the analyzed extracts, including terpenes and terpenoids, alcohols and phenolic compounds, long-chain carboxylic acids (saturated and unsaturated) and their esters, aldehydes and ketones, saturated hydrocarbons and sterols.

With regards to the total phenolic content, the highest value was registered for MeOH extract, followed by EtOH and Ac extracts.

REFERENCES

1. Fitzgerald, M.; Heinrich, M.; Booker, A. Medicinal Plant Analysis: A Historical and Regional Discussion of Emergent Complex Techniques. *Front. Pharmacol.*, **10**, (2020), p. 1480.
2. Bauer, A.; Brönstrup, M. Industrial Natural Product Chemistry for Drug Discovery and Development. *Nat. Prod. Rep.*, **31**, (2014), pp. 35-60.

3. Saeed, N.; Khan, M.R.; Shabbir, M. Antioxidant Activity, Total Phenolic and Total Flavonoid Contents of Whole Plant Extracts Torilis Leptophylla L. BMC Complement. *Altern. Med*., **12**, (2012), pp. 221.
4. Yadav, R.N.S.; Agarwala, M. Phytochemical Analysis of Some Medicinal Plants. *J. Phytol.,* **3**, (2011), pp. 10-14.
5. Kumar, A.; P, N.; Kumar, M.; Jose, A.; Tomer, V.; Oz, E.; Proestos, C.; Zeng, M.; Elobeid, T.; K, S.; et al. Major Phytochemicals: Recent Advances in Health Benefits and Extraction Method. *Molecules*, **28**, (2023), p. 887.
6. Stanoeva, J.P.; Stefova, M.; Stefkov, G.; Kulevanova, S.; Alipieva, K.; Bankova, V.; Aneva, I.; Evstatieva, L.N. Chemotaxonomic Contribution to the Sideritis Species Dilemma on the Balkans. *Biochem. Syst. Ecol.*, **61**, (2015), pp. 477-487.
7. Kaparakou, E.H.; Daferera, D.; Kanakis, C.D.; Skotti, E.; Kokotou, M.G.; Tarantilis, P.A. Chemical Composition of the Essential Oils of Three Popular Sideritis Species Cultivated in Greece Using GC-MS Analysis. *Biomolecules*, **13**, (2023), pp. 1157.
8. Chrysargyris, A.; Tomou, E.-M.; Goula, K.; Dimakopoulou, K.; Tzortzakis, N.; Skaltsa, H. Sideritis L. Essential Oils: A Systematic Review. *Phytochemistry*, **209**, (2023), 113607.
9. Romanucci, V.; Di Fabio, G.; D'Alonzo, D.; Guaragna, A.; Scapagnini, G.; Zarrelli, A. Traditional Uses, Chemical Composition and Biological Activities of Sideritis Raeseri Boiss. & Heldr. *J. Sci. Food Agric.*, **97**, (2017), pp. 373-383.
10. González-Burgos, E.; Carretero, M.E.; Gómez-Serranillos, M.P. Sideritis Spp.: Uses, Chemical Composition and Pharmacological Activities – A Review. *J. Ethnopharmacol.*, **135**,(2011), pp. 209-225.
11. Sevindik, E.; Gübeş, İ.; Murathan, Z.T.; Tümen, G. Determination of Total Phenolic Content, Total Flavonoid Content and Total Antioxidant Capacity in Some Endemic Sideritis L. (Lamiaceae), *Species Grown in Turkey*, **11**, (2021), pp. 260-266.
12. Bié, J.; Sepodes, B;Fernandes, P.C.B.; Ribeiro, M.H.L. Polyphenols in Health and Disease: Gut Microbiota, Bioaccessibility, and Bioavailability. *Compounds*, **3**, (2023), pp. 40-72.
13. Goulas, V.; Exarchou, V.; Kanetis, L.; Gerothanassis, I.P. Evaluation of the Phytochemical Content, Antioxidant Activity and Antimicrobial Properties of Mountain Tea (Sideritis Syriaca) Decoction. *J. Funct. Foods*, **6**, (2014), pp. 248-258.
14. Giuliani, C.; Bini, L.M.; Papa, F.; Cristalli, G.; Sagratini, G.; Vittori, S.; Lucarini, D.; Maggi, F. Glandular Trichomes and Essential Oil Composition of Endemic Sideritis Italica (Mill.) Greuter et Burdet from Central Italy. *Chem. Biodivers.* **8**, (2011), pp. 2179-2194.
15. Singleton, V.L.; Rossi, J.A. Colorimetry of Total Phenolics with Phosphomolybdic-Phosphotungstic Acid Reagents. *Am. J. Enol. Vitic.*, 16, (1965), pp. 144-158.
16. Agbor, G.; Vinson, J.A.; Donnelly, P.E. Folin-Ciocalteau Reagent for Polyphenolic Assay. *Int. J. Food Sci. Nutr. Diet.*, (2014), pp. 147-156.
17. Axiotis, E.; Petrakis, E.A.; Halabalaki, M.; Mitakou, S. Phytochemical Profile and Biological Activity of Endemic Sideritis Sipylea Boiss. in North Aegean Greek Islands. *Molecules*, **25**, (2020), p. 2022.
18. Yanchev, N.; Petkova, N.; Ivanov, I.; Delev, D. Total Polyphenolic Content and Antioxidant Activity of Different Extracts from Sideritis Scardica. *Trop. J. Nat. Prod. Res.,* **6**, (2022), pp. 1113-1118.
19. Alipieva, K.; Petreska, J.; Gil-Izquierdo, Á.; Stefova, M.; Evstatieva, L.; Bankova, V. Influence of the Extraction Method on the Yield of Flavonoids and Phenolics from Sideritis Spp. (Pirin Mountain Tea). *Nat. Prod. Commun.*, **5**, (2010), pp. 51-54.
20. Petreska, J.; Stefkov, G.; Kulevanova, S.; Alipieva, K.; Bankova, V.; Stefova, M. Phenolic Compounds of Mountain Tea from the Balkans: LC/DAD/ESI/MSn Profile and Content. *Nat. Prod. Commun.*. **6**, (2011), pp. 21-30.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

DEVELOPMENT AND APPLICATION OF VISUALIZATION SITUATION MODELS AS PART OF A METHODOLOGICAL TOOLKIT FOR DISASTER SITUATIONS AND PROTECTION

Plamena Atanasova, Sabina Nedkova, Tanya Krasteva
E-mail: pl.veleva@abv.bg

ABSTRACT

The scientific field of study of the Disaster Protection discipline is vast and includes knowledge and practical skills from various other fields that aim to protect people's lives, their health and working capacity in case of disasters. This knowledge is large-scale, wide-ranging, and interdisciplinary, primarily in the field of risks and hazards arising as a result of natural and man-made disaster situations which create the need to use a specific approach to transfer knowledge needed to solve a problem, i.e. a disaster situation of different origins, where the so-called active learning approach (method) can be appropriately applied. The principles of this method have been used to develop visual-situational models for the detection/recognition of dangerous and risky situations in case of a disaster scenario. Using the models, students have to apply the newly acquired knowledge, by considering the most appropriate solution for the specific disaster situation, presenting and justifying their strategy of action before their classmates and the teacher. By applying the principles of active learning, while using the visual-situational models, students develop skills aimed at solving problematic complex situations, think over the adequacy of applied knowledge and develop responsibility for the decisions made and their implementation.

Key words: *active learning, disaster protection, visual-situational models, conceptual drawings*

INTRODUCTION

Training in the subject of Disaster Situations aims to form interdisciplinary thinking necessary to identify, assess, control and manage situations caused by natural and man-made disasters. Studying the disciplines that underlie this field: Disaster Medicine, Disaster Protection, Technical Safety and Disaster Protection, gives students the opportunity to acquire knowledge and practical skills to protect and restore people's lives, their health and their ability to work in case of injuries as a result of disaster. The training courses deal with questions related to the taxonomy of the main dangers arising from the creation of disaster situations: natural (earthquakes, floods, etc.) and anthropogenic (ionizing radiation and accidents with the spread of toxic substances, fires and explosions). The main parameters and damage factors of natural disasters are studied, as well as the behavior and actions of the population in the endangered zones in the realization of critical situations. The main physical characteristics, properties and toxic effects of the most frequently used dangerous substances in the industry are presented. Questions about the biological effects of ionizing radiation and industrial toxic substances on humans, as well as methods of prevention and protection from them, are also considered. Regardless of its origin (natural or caused by human action), every disaster situation is characterized by several common features:

- Suddenness of the situation;
- Large scale of related losses including human casualties;
- Discrepancy between required and available resources to deal with the disaster situation;
- Destruction of infrastructure and logistics network;
- Contamination of the environment.

All these factors create a need for the application of multi-component knowledge, development of logical thinking, and the ability to take decisions in critical situations for the development of action strategies. The conceptual drawings and visual-situational models (VSM) designed for this purpose fully meet this need [1].

EXPERIMENT

Visual-situational models (VSM) are educational models of a specific disaster environment

visualized, with various situations depicted as right and wrong actions of its participants. VSMs aim to place the learner in the role of an active participant having to survive in a critical environment in which he/she must assess how to react, turning it into a situation whose mastery can be realized by him/her. While using the Visual-situational models, students apply the principles of active learning [2] through thinking, discussion, research and finding a solution, in a specific situation.

Visual situation models (VSM) are created as game picture models, in which several critical (incorrect) and several correct situations are set, which the learner must discover and explain (for example, Fig. 1).

Fig. 1 Visual situation model on the subject of "Earthquake"

In this way, the learner will think in the context of a multi-component situation in which, by the domino effect, one mistake leads to another and each of them is important and has a place in the realization of a risky situation that can lead to disaster. The engaging working model which involves observation and focus on details takes the learning process out of the university classroom and is easily internalized by the learners through their focusing on the creative way of solving the specific problem and applying what has been learned so far and thinking about the connection between signals, solutions and actions.

The visual situational models are conceptually developed by teachers/lecturers of the subject and are directed not only specifically to the lecture and practical training at Prof. Dr. Assen Zlatarov University, but also to students taking these courses at other universities in accordance with their profile. They are graphically designed by an artist on the basis of the conceptual ideas of the teachers of the subject and are in the form of worksheets for practical use after the respective lecture on the subject, developed in accordance with Art. 16, paragraph 1 of the Disaster Protection Act [3], for the mandatory conduct of disaster protection and first aid training in the higher education system.

RESULTS AND DISCUSSION

VSM on the subject of "Earthquakes" was presented to third-year Master degree students of Medicine as part of their practical training in the "Medicine of disaster situations" discipline. Applying the strategies for activation of learners, work with VSM aims at active participation of students in all its stages, namely:

- Monitoring/Observability;
- Research;
- Thinking;
- Solution;
- Discussion.

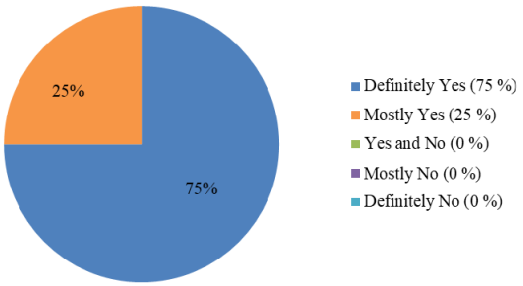


Fig. 2 Distribution of approval of surveyed students of visual situation model

After working with the VSM and in order to receive feedback on the level of understanding and applicability of the model, students were asked to fill out an anonymous survey expressing their opinion. The majority of them (75%) find the model very interesting, and a smaller part (25%) finds it interesting (Fig. 2)

The majority of the surveyed students (71%) believe that VSM provokes the development of skills aimed at solving complex situations (Fig. 3).

The majority of surveyed students (75%, Fig. 4) and (79%, Fig. 5) believe that the visual-situational model of the lecture material on the topic of "Earthquake" reinforces the acquired knowledge and helps to take in the information needed to respond in case of disaster and crisis.

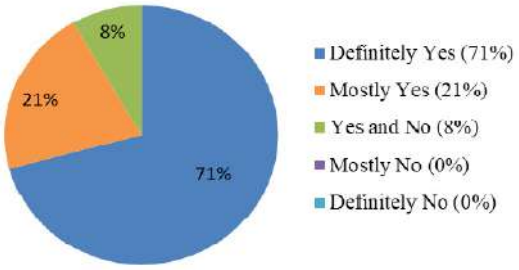


Fig. 3 Skills for solving complex situations

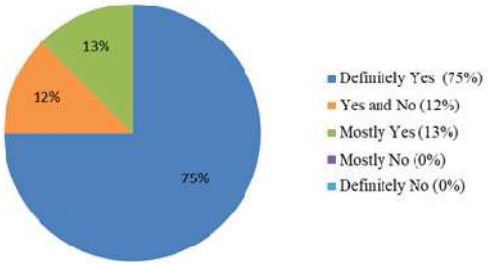


Fig. 4 Assessment of the reinforcement of the lecture knowledge on the topic

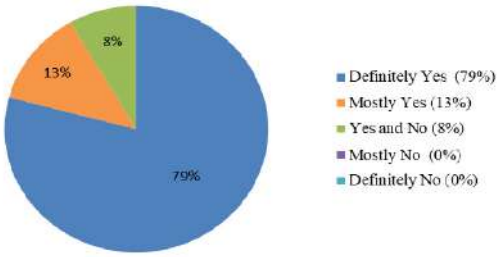


Fig. 5 Assessment of the assimilation of information necessary for disaster and crisis response

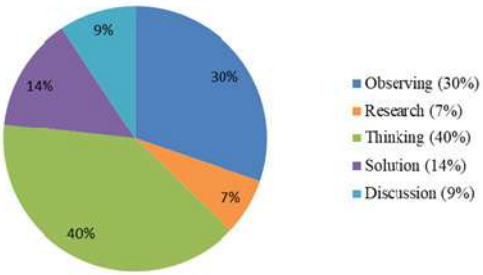


Fig. 6 Most used stages of active learning

The principles of active learning used in the process of creating of VSM combine information and knowledge by activating the processes of observation, thinking, discussion, research and decision-making, giving students the opportunity to apply the acquired knowledge and solve problems, think about a specific situation and defend their choice before the other students and the teacher. According to the respondents, all these stages of active learning are applied, but as a percentage, the ones mostly used are the provoking of thinking and the development of observation (Fig. 6)

The majority of students (71%) would definitely use VSM as part of their studies, and 25% would rather do so (Fig. 7).

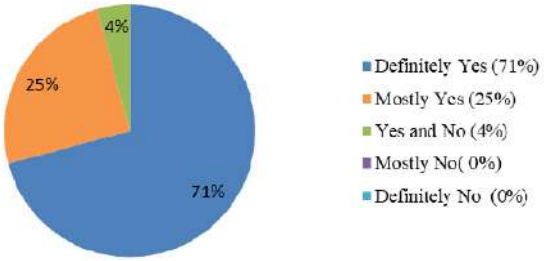


Fig. 7 Willingness to use VSM as part of the lecture training

CONCLUSION

The scientific contributions of the Visual Situational Models are aimed at understanding and making sense of the knowledge obtained so that the use of information to make an adequate decision in a given disaster situation becomes easy, regardless of the stress factors that are always present in conditions of danger and uncertainty. Here, efforts are focused on prevention and obtaining the necessary knowledge and skills before the disaster occurs, as one of the most successful ways to manage risk.

AKNOWLEDGEMENT

This work was supported by the Scientific research sector's NIS 490/2023 programme of Prof. Dr. Assen Zlatarov University, Burgas.

REFERENCES

1. Atanasova, P., Sabina Nedkova, Analysis of the preparedness of the population to respond to a critical situation of natural or technogenic origin, *Industrial Technologies*, **9**, (2022) pp. 115-121.
2. https://teaching.cornell.edu/teaching-resources/active-collaborative-learning/active-learning, Cornel University, Center for Teaching Innovation (Freeman et al., 2014; Theobald et al., 2020).
3. Zakon za zashtita pri bedstvia, 07.07.2020

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

STUDY OF THE TOXIC ACTION OF SOME SULFIDES AND THEIR OXIDIZED FORMS

Yana Koleva, Neli Koycheva, Elisaveta Todorova-Koynova
E-mail: *ykoleva@btu.bg*

ABSTRACT

Crude oil pollution is a serious problem in the petroleum industry. Various organic compounds predominate in oil. Determining the composition of heteroatom-containing compounds (N, O and S) in crude oil is important for solving pollution problems. The most common heteroelement in the composition of oil is sulfur, and the study of sulfur compounds in it is important. The presence of various types of sulfur are among the undesirable constituents in crude oil and therefore reduce the quality of oil products. Sulfur and sulfur compounds (thiols, sulfides, etc.) in crude oil can have a detrimental effect in crude oil contamination. The aim of the present work was to predict the possible toxic action (rodent organ-specific carcinogenicity) of three sulfides and their oxidized forms by ROSC-Pred.

Key words: *sulfides, sulfones, toxic action, organ-specific carcinogenicity, predict, software*

INTRODUCTION

The use of fossil fuels in various sectors for heat and power generation continues to threaten global stability and sustainability. Moreover, sulfur containing compounds present in gasoline and diesel cause an extra undesirable effect due to the emission of toxic gases [1]. In order to protect human health and reduce environmental hazards, environmental regulations that tend to limit the sulfur levels to very low levels, have already been introduced in many countries during the last few decades. Also, sulfur should be removed from the petroleum fractions as it causes poisoning of catalysts, corrosion of surfaces, and air pollution [2, 3].

Nowadays, hydrodesulfurization (HDS) is the main method for the removal of sulfur from petroleum distillates in a refinery [4]. Oxidative desulfurization (ODS) has been demonstrated to be a promising method for ultra-deep desulfurization technology because of its mild operation conditions, no hydrogen required and low cost of operation. During the process, the organosulfur compounds are oxidized to their corresponding sulfoxides or sulfones. The process is carried out in the presence of a catalyst and an oxidant agent, and the oxidized sulfur compounds are subsequently removed by extraction, adsorption, distillation, or decomposition [5, 6]. Potential oxidative routes to produce ultralow sulfur fuels include the use of various oxidizing agents such as nitric acid, nitrogen oxides, organic hydroperoxides and peroxide. The most promising oxidation systems in the terms of selectivity, product quality, safety, environmental impact and cost of effectiveness are those using hydrogen peroxide as an oxidizing agent [7].

The aim of the present work is to predict the possible toxic action (rodent organ-specific carcinogenicity) of three sulfides and their oxidized forms by ROSC-Pred.

EXPERIMENTAL

Compound. Organic sulfides are compounds with the general formula RSR′, where R and R′ are hydrocarbon radicals. These compounds can be considered analogs of ethers, generated by replacing the oxygen atom with sulfur. The two radicals, R and R′, can be identical or different, and they can be aliphatic, aromatic, unsaturated (with the carbon atom connected to the oxygen atom involved in a double bond), and combinations of the three previous possibilities [8-10]. Their CAS number, name of the compound and structural formula are presented in Table 1 [8].

A sulfone is an organosulfur compound containing a sulfonyl ($R{-}S(=O)_2{-}R'$) functional group attached to two carbon atoms. The central hexavalent sulfur atom is double-bonded to each of two oxygen atoms and has a single bond to each of two carbon atoms, usually in two separate hydrocarbon substituents [8-10]. Their CAS number, name of the compound and structural formula are presented in Table 1 [8].

Table 1. CAS number, name and structural formula of three sulfides

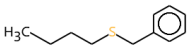
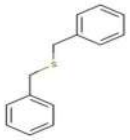
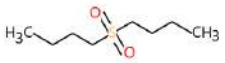
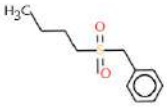
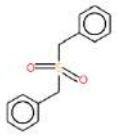
No	CAS number	Name of compound	Structural formula
1	544-40-1	Dibutyl sulfide	
2		Benzyl butyl sulfide	
3	538-74-9	Dibenzyl sulfide	

Table 2. CAS number, name and structural formula of three sulfones

No	CAS number	Name of compound	Structural formula
1	598-04-9	Butyl sulfone	
2		Benzyl butyl sulfone	
3	620-32-6	Benzyl sulfone	

ROSC-Pred. ROSC-Pred is a freely available web-service for rodent organ-specific carcinogenicity prediction on the basis of structural formula of organic compounds. Prediction is based on PASS (Prediction of Activity Spectra for Substances) technology and training sets created on the basis of data from Carcinogenic Potency Database (CPDB). The CPDB data are available on EPA Distributed Structure-Searchable Toxicity (DSSTox) Public Database Network [11-13].

P_a (probability "to be active") estimates the chance that the studied compound belongs to the sub-class of active compounds (resembles the structures of molecules which are the most typical in a sub-set of "actives" in PASS training set).

P_i (probability "to be inactive") estimates the chance that the studied compound belongs to the sub-class of inactive compounds (resembles the structures of molecules which are the most typical in a sub-set of "inactives" in PASS training set).

Only activities with $P_a > P_i$ are considered as possible for a particular compound.

Applicability domain. The number of new MNA descriptors for a tested molecule may be used for estimation of the applicability domain: the larger the percentage of new MNA descriptors, the less the molecule structure is appropriate for the model. The most accurate prediction is achieved for molecules without new MNA descriptors [12, 13].

RESULTS AND DISCUSSION

In the present work, ROSC-Pred. has been used to predict rodent (rat and mice) organ-specific carcinogenicity of the sulfides and their oxidized forms. The structure (Dibutyl sulfide) is in the applicability domain. The percentage of new MNA descriptors is 0 % (Pa >Pi). Data of prediction (organ-specific carcinogenicity (rat)) of Dibutyl sulfide are presented in Table 3.

Data of prediction (organ-specific carcinogenicity (mice)) of Dibutyl sulfide are presented in Table 4.

The structure (Benzyl butyl sulfide) is in the applicability domain. The percentage of new MNA descriptors is 0 % (Pa >Pi). Data of prediction (organ-specific carcinogenicity (rat)) of Benzyl butyl sulfide are presented in Table 5.

Table 3. Prediction of organ-specific carcinogenicity (rat) of Dibutyl sulfide

Rats					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.568	0.159	hematopoietic system	0.610	0.162	hematopoietic system
0.511	0.169	liver	0.538	0.206	uterus
0.368	0.276	stomach	0.402	0.176	thyroid gland
0.266	0.175	lung	0.258	0.108	oral cavity
0.325	0.292	nasal cavity	0.342	0.211	lung
0.161	0.142	Maltoni head cancers			

Table 4. Prediction of organ-specific carcinogenicity (mice) of Dibutyl sulfide

Mice					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.828	0.031	liver	0.533	0.212	thyroid gland
0.432	0.258	lung	0.405	0.153	pituitary gland
0.116	0.020	preputial gland	0.497	0.248	urinary bladder
			0.392	0.250	liver
			0.285	0.279	ovary

Table 5. Prediction of organ-specific carcinogenicity (rat) of Benzyl butyl sulfide

Rats					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.486	0.148	stomach	0.431	0.215	stomach
0.163	0.138	Maltoni head cancers			

Table 6. Prediction of organ-specific carcinogenicity (mice) of Benzyl butyl sulfide

Mice					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.441	0.178	liver	0.403	0.378	urinary bladder

Table 7. Prediction of organ-specific carcinogenicity (rat) of Dibenzyl sulfide

Rats					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.509	0.115	spleen	0.542	0.256	hematopoietic system
0.456	0.172	stomach			
0.294	0.020	Maltoni head cancer	0.464	0.190	stomach
0.484	0.248	hematopoietic system	0.390	0.197	thyroid gland
0.465	0.237	thyroid gland	0.478	0.317	uterus
0.380	0.199	ear Zymbals gland	0.425	0.298	kidney
0.381	0.200	oral cavity	0.237	0.136	oral cavity
0.315	0.307	nasal cavity	0.305	0.232	all tumor bearing animals
			0.206	0.173	clitoral gland

Data of prediction (organ-specific carcinogenicity (mice)) of Benzyl butyl sulfide are presented in Table 6.

The structure (Dibenzyl sulfide) is in the applicability domain. The percentage of new MNA descriptors is 8.3 % (Pa >Pi). Data of prediction (organ-specific carcinogenicity (rat)) of Dibenzyl sulfide are presented in Table 7.

Data of prediction (organ-specific carcinogenicity (mice)) of Dibenzyl sulfide are presented in Table 8.

The structure (Butyl sulfone) is in the applicability domain. The percentage of new MNA descriptors is 20 % (Pa >Pi). Data of prediction (organ-specific carcinogenicity (rat)) of Butyl sulfone are presented in Table 9.

Data of prediction (organ-specific carcinogenicity (mice)) of Butyl sulfone are presented in Table 10.

The structure (Benzyl butyl sulfone) is in the applicability domain. The percentage of new MNA descriptors is 17.4 % (Pa >Pi). Data of prediction (organ-specific carcinogenicity (rat)) of Benzyl butyl sulfone are presented in Table 11.

Data of prediction (organ-specific carcinogenicity (mice) of Benzyl butyl sulfone are presented in Table 12.

The structure (Benzyl sulfone) is in the applicability domain. The percentage of new MNA descriptors is 21.4 % (Pa >Pi). Data of prediction (organ-specific carcinogenicity (rat)) of Benzyl sulfone are presented in Table 13.

Table 8. Prediction of organ-specific carcinogenicity (mice) of Dibenzyl sulfide

Mice					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.450	0.249	urinary bladder	0.589	0.147	urinary bladder
0.367	0.267	vascular system	0.599	0.157	thyroid gland

Table 9. Prediction of organ-specific carcinogenicity (rat) of Butyl sulfone

Rats					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.668	0.072	spleen	0.642	0.121	hematopoietic system
0.625	0.102	hematopoietic system	0.527	0.224	uterus
0.417	0.207	stomach	0.390	0.197	thyroid gland
0.287	0.134	lung	0.244	0.124	oral cavity
0.365	0.239	nasal cavity	0.324	0.233	lung
0.180	0.109	Maltoni head cancers	0.359	0.315	urinary bladder

Table 10. Prediction of organ-specific carcinogenicity (mice) of Butyl sulfone

Mice					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.666	0.079	liver	0.606	0.130	urinary bladder
0.467	0.214	lung	0.582	0.170	thyroid gland
			0.439	0.113	pituitary gland
			0.358	0.234	ovary

Table 11. Prediction of organ-specific carcinogenicity (rat) of Benzyl butyl sulfone

Rats					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.674	0.070	spleen	0.470	0.332	hematopoietic system
0.460	0.169	stomach	0.350	0.282	stomach
0.203	0.070	Maltoni head cancers			
0.422	0.312	hematopoietic system			

Table 12. Prediction of organ-specific carcinogenicity (mice) of Benzyl butyl sulfone

Mice					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.453	0.167	liver	0.547	0.187	urinary bladder
			0.463	0.268	thyroid gland
			0.315	0.283	pituitary gland

Table 13. Prediction of organ-specific carcinogenicity (rat) of Benzyl sulfone

Rats					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.862	0.016	spleen	0.537	0.262	hematopoietic system
0.506	0.224	hematopoietic system	0.397	0.245	stomach
0.294	0.020	Maltoni head cancers	0.302	0.232	small intestine
0.443	0.184	stomach	0.346	0.277	thyroid gland
0.381	0.200	oral cavity	0.206	0.173	clitoral gland
0.408	0.308	thyroid gland	0.431	0.400	uterus
0.333	0.267	ear Zymbals gland	0.385	0.363	kidney
0.315	0.307	nasal cavity	0.205	0.194	oral cavity

Table 14. Prediction of organ-specific carcinogenicity (mice) of Benzyl sulfone

Mice					
Male			Female		
Pa	**Pi**	**Organs**	**Pa**	**Pi**	**Organs**
0.367	0.267	vascular system	0.665	0.083	urinary bladder
0.090	0.053	small intestine	0.595	0.160	thyroid gland
0.338	0.302	thyroid gland	0.481	0.172	ovary
0.351	0.341	urinary bladder	0.376	0.194	pituitary gland
			0.232	0.067	peritoneal cavity
			0.090	0.053	small intestine
			0.284	0.253	vascular system
			0.337	0.330	stomach

Data of prediction (organ-specific carcinogenicity (mice)) of Benzyl sulfone are presented in Table 14.

CONCLUSION

The oxidation of sulfides is a fundamental reaction as one of the most straightforward methods to afford sulfoxides and sulfones. Entering the environment, these substances would cause a number of toxic effects. Various SAR methods have been proposed to reduce the number of animal experiments. Identification of rodent carcinogens is an important task in the risk assessment of chemicals.

ACKNOWLEDGEMENT

This study was financially supported by Bur-
gas University through the Scientific Research Sector, Project number 483/2023.

REFERENCES

1. Battaglini, A., J. Lilliestam, A. Haas, A. Patt. Development of Super Smart Grids for a more efficient utilisation of electricity from renewable sources. *J. Cleaner Prod.* **17**, (2009), pp. 911-918.
2. Zhu, W., G. Zhu, H. Li, Y. Chao, Y. Chang, G. Chen, and C. Han. Oxidative desulfurization of fuel catalyzed by metal-based type

ionic liquids. *Molecular Catalysis A: Chemical*, **347**, (2011), pp.8-14.
3. Vardhaman, A. K., S. Sikdar, and C.V. Sastri. Oxidation of Desulfurization by Mononuclear Non-Heme Iron Compleexes: Abiomimetic Approach for Oxidative Desulfurization. *Indian Journal of Chemistry*, **50A**, (2011), pp. 427-431.
4. Ahmedzeki, N.S., B. J. Ibrahem. Reduction of Sulfur Compounds from Petroleum Fraction Using Oxidation-Adsorption Technique. Iraqi *Journal of Chemical and Petroleum Engineering*, **16** (1), (2015), pp. 35-48.
5. Garcia, E. T., A. Galano, and G. Rodriguez. Oxidative Desulfurization (ODS) of Organosulfur Compounds Catalyzed by Peroxo-Metallate Complexes of WOx-ZrO2: Themochemical, Structural, and Reactivity Indexes Analysis. *Journal of Catalysis*, **282**, (2011), pp. 201-208.
6. Lei, W., L. Shuzhen, C. Haijun, X. Yanyan, W. Xihui, and C. Yujing. Ultra-deep desulfurization of fuel with metal complex of chitosan Schiff base assisted by ultraviolet. *Fuel*, **94**, (2012), pp.165-169.
7. Filippis, P. D., and M. Scarsella. Oxidative Desulfurization: Oxidation Reactivity of Sulfur Compounds in Different Organic Matrixes.
Energy & Fuels, **17**, (2003), pp.1452-1455.
8. Tumula, V. R., S. Bondwal, P. Bisht, C. Pendem, J. Kumar. Oxidation of sulfides to sulfones with hydrogen peroxide in the presence of acetic acid and Amberlyst 15. *Reac Kinet Mech Cat*, (2012), 2012. DOI 10.1007/s11144-012-0491-8.
9. ChemIDplus Advanced: https://chem.nlm.nih.gov/chemidplus/
10. Zhecheva, H.. Health-Environmental Aspects of the Educational Chemical Experiment. *Management and Education*, **18** (3), (2022), pp. 92-101.
11. EPA Distributed Structure-Searchable Toxicity (DSSTox) Public Database Network: ftp://ftp.epa.gov/dsstoxftp/DSSTox_Archive_20150930/CPDBAS_DownloadFiles/
12. Way2drug predictive services: http://www.way2drug.com/ROSC/index.php
13. Lagunin A., A. Rudik, D. Filimonov, D. Druzhilovsky, V. Poroikov. ROSC-Pred: web-service for rodent organ-specific carcinogenicity prediction, **34** (4), (2017), pp. 710-712.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

DEVELOPING A PROGRAM FOR TESTING AND FORECASTING "CLASS FUEL INJECTOR"

Toncho Boyukov
E-mail: toncho_b@abv.bg

ABSTRACT

Modern technologies provide us with better opportunities for collecting, processing, and analyzing large volumes of data from various research sources. Based on obtained experimental results, we collected data regarding changes in the characteristics of fuel injectors for gasoline-powered cars. Subsequently, we organized this data into files, classifying and arranging them in a suitable format for use in a programming environment. After that, we generated a code for test models of the injectors. In the second part of the study, our goal was to create a new program capable of processing, testing, and analyzing the condition of the measured object while also providing predictive results for the future state of the observed system.

Key words: *fuel injectors, code for test models, testing and analyzing, measured object, future state, large data*

INTRODUCTION

Changes in voltage, pollution, wear, and pressure in the fuel system can impact the fuel delivery and its distribution in the cylinders [1-3]. Extracting information about the states of the observed objects is an important part of modern automotive system diagnostics. Through analytical methods, we are able not only to monitor processes but also detect anomalies in their early stages [4]. Creating new testing models and integrating them into a suitable and user-friendly software environment will provide us with greater flexibility and the necessary precision for subsequent analysis of the obtained results [5-10].

RESULTS AND DISCUSSION

Boundary Value Analysis

This type of analysis allows us to identify potential risks and problems in boundary situations. In our case, we can conclude that tests close to the lower and upper bounds of the operating range are especially important for detecting irregularities and errors in the system's operation.

For the purposes of the study, we created a test map of the measured values (Table 1).

The analysis used the following levels of boundary values:

1. No boundary values (level 1). Tests were performed under normal conditions without observing boundary values.
2. Boundary values above normal (level 2). In this case, anomalies in the measured values that exceed expectations were observed.

Table 1. Test map of the measured values

Injector	Test Point	Measured Flow	Published Flow	Error (%)	Evaluation
1	60,000 km	280 g/s	25.2 g/s	+1009%	Evaluation: No
1	60,000 km	380 g/s	25.2 g/s	+1409%	Passes
1	60,000 km	280 g/s	25.2 g/s	+1009%	Boundary
2	60,000 km	280 g/s	25.2 g/s	+1009%	Values
2	60,000 km	380 g/s	25.2 g/s	+1409%	
2	60,000 km	280 g/s	25.2 g/s	+1009%	
3	60,000 km	280 g/s	25.2 g/s	+1009%	
3	60,000 km	380 g/s	25.2 g/s	+1409%	
3	60,000 km	280 g/s	25.2 g/s	+1009%	
4	60,000 km	280 g/s	25.2 g/s	+1009%	
4	60,000 km	380 g/s	25.2 g/s	+1409%	
4	60,000 km	280 g/s	25.2 g/s	+1009%	
1	280,000 km	270 g/s	25.2 g/s	+971%	
1	280,000 km	375 g/s	25.2 g/s	+1389%	
1	280,000 km	280 g/s	25.2 g/s	+1009%	
2	280,000 km	230 g/s	25.2 g/s	+979%	
2	280,000 km	378 g/s	25.2 g/s	+1416%	
2	300,000 km	280 g/s	25.2 g/s	+1009%	
3	300,000 km	274 g/s	25.2 g/s	+986%	
3	300,000 km	380 g/s	25.2 g/s	+1389%	
3	300,000 km	278 g/s	25.2 g/s	+1002%	
4	300,000 km	280 g/s	25.2 g/s	+1009%	
4	300,000 km	380 g/s	25.2 g/s	+1409%	
4	300,000 km	280 g/s	25.2 g/s	+1009%	

3. Boundary values below normal (level 3). Here, anomalies in the measured values were also observed, but they were below expectations.

Here, we can adjust the boundary values and levels of boundary values according to specific requirements and data based on the observed object.

Generating a code for testing the "Injector" class

This code created an "injector" class that stores the published data for the injectors and their test information. Then, the code analyzes the measured values relative to the reference values and outputs the deviation for each test condition of the injectors.

```
class Injector:
    def __init__(self, name, published_g_s,
published_cc_min, resistance_ohm):
        self.name = name
        self.published_g_s = published_g_s
        self.published_cc_min = published_cc_min
        self.resistance_ohm = resistance_ohm
        self.tests = []
```

Fig. 1. "Injector" class code

Here, you can add more test data by continuing to append pairs (measured_g_s, measured_cc_min) to the test_data list.

Creating a program that combines testing, analysis, and forecasting based on the data provided by the study

For this purpose, it was necessary to create a new file (library) that includes multiple modules, which we named "data_comparison.py."

This code uses classes for data organization and functions for analysis and visualization. This module can be imported into the main program and used for convenient data organization and injector analysis (Fig. 1 and 2).

```
import numpy as np
import matplotlib.pyplot as plt
from scipy.optimize import curve_fit

# Data
mileages = np.array([60, 120, 180, 240, 300])
injector_data = {
    1: {
        'measured': np.array([280, 380, 280]),
        'published': np.array([25.2, 220.2, 158.4])
    },
    2: {
        'measured': np.array([280, 380, 280]),
        'published': np.array([25.2, 220.2, 158.4])
    },
    3: {
        'measured': np.array([280, 380, 280]),
        'published': np.array([25.2, 220.2, 158.4])
    },
    4: {
        'measured': np.array([280, 380, 280]),
        'published': np.array([25.2, 220.2, 158.4])
    }
}

# Regression function
def linear_func(x, a, b):
    return a * x + b
```

Fig. 2. Data organization and functions for analysis and visualization

```
import numpy as np
from scipy.optimize import curve_fit
import matplotlib.pyplot as plt
class InjectorData:
    def __init__(self, measured, published):
        self.measured = measured
        self.published = published

class DataComparison:
    def __init__(self, mileages, injector_data):
        self.mileages = mileages
        self.injector_data = injector_data
```

Fig. 3. Data_comparison.py

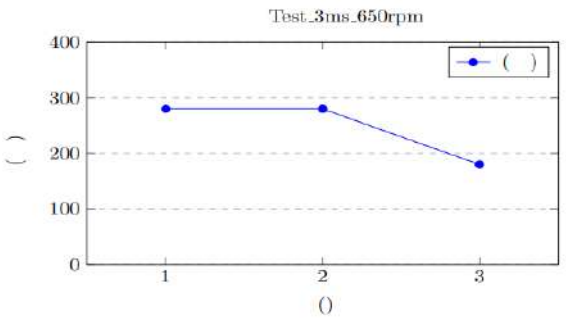


Figure 1:

Table 1: Test_3ms_650rpm

()	Test_3ms_650rpm	1	2	3	4
1	120000	280	380	280	280
2	180000	280	380	280	280
3	240000	180	380	280	280

Fig. 4. Visual representation of selected data

The above graph (Fig. 4) shows a visual representation of selected data from the model.

Then the complete code of the program was created, which combines data analysis and its graphical representation using the libraries created for this purpose (Fig. 5).

```
import numpy as np
from scipy.optimize import curve_fit
import matplotlib.pyplot as plt

def linear_func(x, a, b):
    return a * x + b

class Injector:
    def __init__(self, measured, published):
        self.measured = measured
        self.published = published
class DataComparison:
    def __init__(self, mileages, injectors):
        self.mileages = mileages
        self.injectors = injectors
    def analyze_injector(self, injector):
```

Fig. 5. Complete code of the program

CONCLUSIONS

In the first part of the research, we collected data from a number of cars with different mileage but with the same fuel systems. Then, we created suitable databases for storing, processing, and analyzing the data from our results and the published data from the manufacturer. In the second part, we used these libraries to create an appropriate model for testing, analyzing, and forecasting. These models will help us determine new service intervals for car systems and diagnose anomalies in the systems at an early stage. The goal for the next part of the research is to observe changes in the characteristics of car sensors and their influence on the management of the fuel system.

REFERENCES

1. Marino, B.D.V., Mincheva, M., Doucett, A. California air resources board forest carbon protocol invalidates offsets. *Peer J*, **2019**, (2019), p. 7606.
2. Yang, C., Zha, M., Wang, W., Liu, K., Xiang, C. Efficient energy management strategy for hybrid electric vehicles/plug-in hybrid electric vehicles: Review and recent advances under intelligent transportation system. *IET Intell. Transp. Syst.*, **4**, (2020), pp. 702-711.
3. Hannan, M.A., Azidin, F.A.; Mohamed, A. Hybrid electric vehicles and their challenges: A review. Renew. Sustain. Energy Rev., **29**, (2014), pp. 135-150.
4. Boyukov,T. Establishing Approaches for Analyzing and Forecasting Fuel Injectors, *Annual of Assen Zlatarov University*, **42**, (2023), in press.
5. Zarma, T.A.; Galadima, A.A.; Aminu, M.A. Review of Motors for Electrical Vehicles. *J. Sci. Res. Rep.*, **24**, (2019), pp. 1-6.
6. Ahmad, A.; Khan, Z.A.; Alam, M.; Rafat, Y.; Chabaan, R.C.; Khan, I.; Bharadwaj, A. A Bibliographical Review of Electrical Vehicles (xEVs) Standards. *SAE Int. J. Altern. Powertrains*, **7**, (2018), pp. 63-98.
6. Sun, Y.; Anwar, M.; Hassan, N.M.S.; Spiryagin, M.; Cole, C. A review of hydrogen technologies and engineering solutions for railway vehicle design and operations. *Railw. Eng. Sci.*, **29**, (2021), pp. 212-232.
7. Popa, M.E.; Segers, A.J.; Denier van der Gon, H.A.C.; Krol, M.C.; Visschedijk, A.J.H.; Schaap, M.; Röckmann, T. Impact of a future H2 transportation on atmospheric pollution in Europe. *Atmos. Environ.,* **113**, (2015), pp. 208-222.
8. Fang, Y.; Lu, Y.; Roskilly, A.P.; Yu, X. A review of compressed air energy systems in vehicle transport. *Energy Strategy Rev.*, 33, (2021), 100583.
9. Korbut, M.; Szpica, D. A Review of Compressed Air Engine in the Vehicle Propulsion System. Acta Mech. Autom., **15**, (2021), pp. 215-226.
10. Mazzoleni M, Di Rito G, Previdi F. Fault *Diagnosis and Condition Monitoring Approaches*. *Electro-Mechanical Actuators for the More Electric Aircraft*, Springer International Publishing, 2021, pp. 87-117, https://doi.org/10.1007/978-3-030-61799-8_3.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

ESTABLISHING APPROACHES FOR ANALYZING AND FORECASTING FUEL INJECTORS

Toncho Boyukov
E-mail: toncho_b@abv.bg

ABSTRACT

In a series of studies, we will examine the factors that influence the changes in the operating characteristics of fuel injectors and sensors during the operation of light vehicles. Changes in voltage, contamination, wear and tear, and pressure in the fuel system can affect the fuel delivery and its distribution in the cylinders. It is important to study and optimize these factors to achieve optimal performance of the fuel injectors and engine efficiency.

Key words: *factors, changes, characteristics of fuel injectors, sensors, operation of light vehicles, changes in voltage, contamination, wear and tear, pressure, fuel system*

INTRODUCTION

Fuel injectors in gasoline-powered cars possess specific characteristics that change over their operational lifespan due to various severity factors [1-3]. In this study, we will examine the alteration of these characteristics by creating statistical processing models that analyze, compare, and calculate values representative of the current state of the object or the respective quantity being observed. This will involve classifying the condition, predicting changes over time, or detecting anomalies. The use of these characteristics in statistical processing models will enable us to extract useful information and conduct precise analysis for decision-making, process control, or anomaly detection [4]. In the studies of fuel injectors in gasoline-powered cars, it has been discovered that the specific characteristics they possess change depending on various types and severity factors [5-10]. One of the significant aspects contributing to the alteration of fuel injector characteristics is the quantity of fuel injection.

Here, we will delve into a detailed examination of the changes in the characteristics of fuel injectors in gasoline-powered cars based on real-world data collected from previous studies. We will also investigate the wear and contamination of fuel injectors due to the accumulated mileage and the impact it has on fuel atomization. The investigation of changes occurring within the components of this system through measurements conducted with specialized equipment and the collection of statistical data through various methods is essential for determining the correct diagnostic and servicing methods for the system [11 - 16]. This provides the opportunity to optimize service intervals.

RESEARCH METHOD

The investigation of the changes occurring in the components of this system through measurements taken with specialized equipment and the collection of statistical data through various methods is necessary to determine the correct diagnostic and servicing methods for the system. This enables the optimization of service intervals. Based on the significant number of laboratory tests conducted on various fuel injectors, characteristic changes occurring during their prolonged operation have been identified. The flow rates of the fuel injectors mentioned below are based on testing with injector testing equipment provided for this purpose and may not necessarily reflect those of others. For this study, test cards were created to document each stage of the research accurately and precisely, which would later undergo analysis.

Equipment

The "HPMM" fuel injector diagnostic and cleaning station used in the conducted research has the following specifications:

- Power Supply: 220V / 50Hz
- Ultrasonic Bath Power: 150W
- Pressure Range: 0-90 psi / 0-6.2 bar
- Operating Temperature: -20°C~38°C

- Injector: 0-10,000 pulses / 0-10,000 rpm
- Cylinder Capacity: 120 ml

Methodology

1. Investigation of the structure and operation principles of the fuel injector;
2. Determination of a testing scheme for assessing the performance of fuel injectors using the "HPMM" testing bench;
3. Establishment of the dynamic response characteristics of the injector (see Table 1);
4. Re-evaluation and analysis of the fuel injection quantity in real-time under various mileage conditions;
5. Conducting a sensitivity analysis and assessing the contribution of sensor control parameters through measurements performed with an oscilloscope to study their sensitivity and sequence of changes concerning injection cycle quantity, injection duration, and other efficiency indicators as they evolve;
6. Subsequently, based on statistical methods and regression algorithms, conduct an analysis of the changes in quantity. The ultimate goal is to develop a scheme for optimizing the diagnostics and service intervals of the fuel system.

Table 1. Establishment of the dynamic response characteristics of the injector

PROCESS	RESULTS
Flow	
Comparison of results before and after	
Injection Model Analysis	
Verification of correct dispersion	
Static Flow Test	
Checking flow balance	
Dynamic Flow Test	
Simulates real driving conditions	
System Calculations	
Min./Max./Avg. flow and system balance	
Performance Calculations	
Determines fuel system limits	

Static Flow Testing of the Fuel Injector

Static flow testing of the fuel injector measures the amount of fuel that will flow through the injector when it is fully open. This test is conducted at a specific fuel pressure and for a defined duration.

Dynamic Flow Testing of the Fuel Injector

Injectors are tested at a specified pressure and across a range of RPM from 650 rpm to 10,000 rpm, using various injector duty cycles ranging from 1000 to 2000 pulses. The set of injectors should be able to deliver the same amount of fuel for each RPM range and each tested duty cycle. This type of testing not only shows whether the injectors flow consistently at every point of testing but also indicates if the latency values of the injectors are uniform. If an injector set delivers the same amount of fuel during static flow testing but not during dynamic flow testing, it is usually an indication that the injector set has varying latency values.

RESULTS AND DISCUSSION

All tests were conducted based on established testing procedures, measurement methods, and quantitative determination of measured parameters as specified by SAE J1832_200102. The obtained results were compared with the injector data published by the manufacturers (Tables 2 - 6).

Table 2. Published data for the injector

Published injector data			
Injector	Flow at 43.5PSI/3bar	Static flow–cc/min,3bar	Coil resistance
1	25.2	220.2/158.4	16Ω
2	25.2	220.2/158.4	16Ω
3	25.2	220.2/158.4	16Ω
4	25.2	220.2/158.4	16Ω

Table 3. Test data for the injector at 60,000 km static flow rate

Test data for the injector at 60,000 km.-Static flow			
Injector	Leak Test-Pass/Fail	Static flow–cc/min,3bar	Injection Pattern– Good/Fair/Poor
1	passing	220.2/158.4	good
2	passing	220.2/158.4	good
3	passing	220.2/158.4	good
4	passing	220.2/158.4	good

Table 4. Dynamic test

Dynamic Injector Test/60 000km/ 1000 - 2000 pulses				
Injector	Test–3ms,650rpm	Test–12ms,2400rpm	Test–6ms,3600rpm	Coil resistance
1	25ml	40ml	38ml	16Ω
2	25ml	40ml	38ml	16Ω
3	25ml	40ml	38ml	16Ω
4	25ml	40ml	38ml	16Ω

Table 5. Test Data for the Injector at 280,000km - Static Flow

Test data for the injector at 280,000km.-Static flow			
Injector	Leak Test-Pass/Fail	Static flow–cc/min,3bar	Injection Pattern– Good/Fair/Poor
1	passing	220.2/158.4	good
2	passing	218.3/154.4	poor
3	passing	223.2/160.4	fair
4	passing	220.2/158.4	good

Table 6. Test Data for the Injector at 280,000km - Dynamic test

Dynamic Injector Test/280 000km/ 1000 - 2000 pulses				
Injector	Test–3ms,650rpm	Test–12ms,2400rpm	Test–6ms,3600rpm	Coil resistance
1	25ml	40ml	32ml	16Ω
2	23ml	38ml	38ml	16Ω
3	28ml	38ml	32ml	16Ω
4	25ml	40ml	38ml	16Ω

Defining methods for analysis and prediction

Based on the obtained test results, considering the specificity of the data and the many parameters that need to be processed, Python code was generated for the goal of creating a program for processing, analyzing, and forecasting a large group of measured parameters and comparing them with the manufacturers' published data. For this purpose, a structure was created to include these data and model the tests of gasoline injectors, and then each user could add the logic for extracting and processing these data according to their specific needs *"injector_data.txt"* (Fig. 1).

```
Part Number Flow Rating @ Flow at 43.5 PSI / 3 Bar .52 BSFC - Projected HP Work Cycle BAR lbs/hour cc / min 80% 95% Feed Impedance Application
0-280-150-001 25.2 264.9 190.5 43.5 3 25.2 264.9 38.8 46 EV1 Low MB 3.5l, Saab 1.7l, VW 4-1.7l
0-280-150-002 25.2 264.9 190.5 43.5 3 25.2 264.9 38.8 46 EV1 Low -
0-280-150-003 36.15 379.9 273.3 43.5 3 36.15 379.9 55.6 66 EV1 Low Citroen
0-280-150-007 25.2 264.9 190.5 43.5 3 25.2 264.9 38.8 46 EV1 Low VW 1.6l, 4-1.7l, MB v8-3.5l
0-280-150-008 25.2 264.9 190.5 43.5 3 25.2 264.9 38.8 46 EV1 Low -
0-280-150-009 25.2 264.9 190.5 43.5 3 25.2 264.9 38.8 46 EV1 Low Porsche 914 1.7l
0-280-150-010 - - - - - - - - - - EV1 Low
```

Fig. 1. Creating a text file for the database "injector_data.txt"

Then, we created a new database file from the measured values, *"data.txt"* (Fig. 2).

Then, we generated a code for a testing model that generates results based on an input dataset, *"class Fuelinjector"* (Fig. 3).

This code will create two classes, FuelInjector and Engine, and will run tests for all injectors using the provided data. We should clarify that this model is demonstrative and is intended to create a graph showing how the tests change their duration depending on the mileage and RPM difference (Fig. 4).

Test Data at 60,000km and 280,000km

Injector	Test Point	Measured (g/s at 3 bar) 60,000km
1	60,000 km	280
2	60,000 km	280
3	60,000 km	280
4	60,000 km	280
Injector	Test Point	Measured (g/s at 3 bar) 280,000km
1	280,000 km	270
2	280,000 km	272
3	280,000 km	274
4	280,000 km	280

Fig. 2. Database file from the measured values, *"data.txt"*

```
class FuelInjector:
def __init__(self,
injector_number, leakage_test,
static_flow_rate, spray_model,
resistance):
self.injector_number =
injector_number
self.leakage_test = leakage_test
self.static_flow_rate =
static_flow_rate…..
```

Fig. 3. *"class Fuelinjector"*

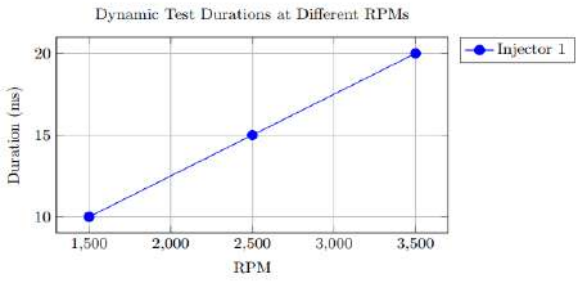


Fig. 4. Dynamic test graph

Data Classification Analysis through Machine Learning

To perform data analysis through Machine Learning, we first needed to create a model that

could recognize the different states of the injectors based on the test data. Here, we provide an example approach:

1. Data Preparation: This involved creating a dataset that includes information about the operational status of the injectors under various parameter changes. (see Table 7).

Table 7. Dataset

Mileage Readings, RPM, Flow, and Condition

Mileage	Speed (rpm)	Flow (g/s)	Condition
120,000	650	280	Normal
120,000	2,400	380	Normal
120,000	650	280	Normal
180,000	650	280	Normal
180,000	2,400	380	Normal
180,000	650	280	Normal
280,000	650	180	Attention
280,000	2,400	380	Normal
280,000	650	280	Normal

2. Model Creation: Here, we can use methods like *"Decision Trees"* or *"k-Nearest Neighbors"* to create a model.

3. Model Training: We divide the dataset into a training set and a testing set, then train the model on the training set.

4. Model Evaluation: We use the testing portion of the data to assess how well the model performs on unseen data.

5. Prediction of New Data: After successful training and evaluation, the model can be used to predict the operational status of injectors with new data.

Data Analysis Using the Time Series Method

Since the data we collected covers different time points and measurements of the injector operational status, we decided to utilize time series analysis. To use this method, we created time series data for each mileage point in kilometers. Here is how we did it:

First, we aggregated the data for each time point into a single observation containing the measured values for each test. We created a list of observations, where each observation contains the measured values for the respective time point. For example:

[{'3 ms, 650rpm': 280, '12 ms, 2400rpm': 380, '6 ms, 650rpm': 280}, ...]

Second, we organized the data in a structure that allows us to analyze time series data. To achieve this, we used “Python” and the "pandas" library. To combine it with the forecasting method, we had to visualize time series using "matplotlib" to create graphs showing changes in parameters from the tests concerning different kilometers. Using the "ARIMA" forecasting method, we built models to predict future changes in test parameters.

Autoregressive Integrated Moving Average

ARIMA is a time-series model used for forecasting future steps based on previous values. This model combines autoregression (AR) and moving average (MA) components to learn from the structure of time series data.

This code builds an "ARIMA" model based on the provided data and then makes forecasts for future values.

```
pip install pandas statsmodels
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from statsmodels.tsa.arima_model import ARIMA

from statsmodels.graphics.tsaplots import plot_acf,
plot_pacf……..
```

Fig. 5. ARIMA time-series model

Linear Regression Analysis

Creating a code for linear regression analysis of the research data using the ***"scikit-learn"*** library.

```
import numpy as np
import pandas as pd
from sklearn.linear_model import LinearRegression

# Your dataset
data = {
   "Mileage": [60000, 120000, 180000, 240000,
300000],
   "Injector 1 Measured": [280, 280, 280, 290, 270],
   "Injector 2 Measured": [380, 380, 380, 380, 375],
   "Injector 3 Measured": [280, 280, 280, 280, 280],
   "Injector 4 Measured": [280, 280, 280, 280, 280],
}……
```

Fig. 6. Code for linear regression analysis

This code uses linear regression to predict the values of data changes based on kilometers. These values can be replaced according to different types of measurements and requirements.

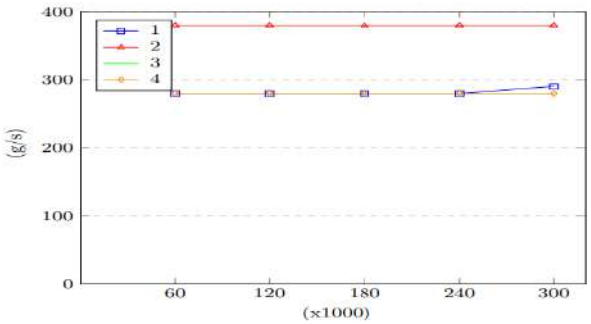


Fig. 7. Values of data change based on kilometres

CONCLUSIONS

Studying the factors that influence the characteristics of fuel injectors in gasoline-powered vehicles is of crucial importance for maintaining the optimal operation of the fuel system and the engine efficiency. Observing changes in the characteristics of the observed object allows us to detect alterations that could occur in their operation at an early stage of damage development and to take actions before they can impact the reliability of the system.

Applying diagnostic solutions based on the development of comparative and analytical models, through the implementation of algorithms used to assess the similarities between model datasets and measurement data, will reveal the relationships between the working time, the influence of various factors, and the changes in the characteristics of the observed object.

REFERENCES

1. Allocca L, Siano D, Montanaro A, Panza MA. *Imaging and Vibro-Acoustic Diagnostic Techniques Comparison for a GDI Fuel Injector*. SAE International, Warrendale PA 2019, https://doi.org/10.4271/2019-24-0058.
2. Bogusz W, Grabarczyk J, *Krok Fraanciszek. Podstawy Fizyki*. Oficyna Wydawnicza Politechniki Warszawskiej 2016. ISBN: 978-83-7814-511-0.
3. Bozhkov S, Milenov I, Slivarov O, Staneva G, Bozhkov P. Researching the waveforms of automobile electromagnetic actuators. *Facta Universitatis, Series: Automatic Control and Robotics*, **1**, (2016), pp. 1-7.
4. Figlus T, Konieczny Ł, Burdzik R, Czech P. The effect of damage to the fuel injector on changes of the vibroactivity of the diesel engine during its starting. *JVE International LTD. Vibroengineering Procedia*, **6**, (2015) p. 180-184.
5. Gawlica T, Samenfink W, Schünemann E, Koch T. *Model-based optimization of multi-hole injector spray targeting for gasoline direct injection*. Tagung Einspritzung und Kraftstoffe, Springer Fachmedien, 2019, pp. 271-289, https://doi.org/10.1007/978-3-658-23181-1_14.
6. Gritsenko A, Shepelev V, Zadorozhnaya E, Shubenkova K. Test diagnostics of engine systems in passenger cars, *FME Transactions*, **48**, (2020), pp. 46-52.
7. Hung NB, Lim OT. A simulation and experimental study on the operating characteristics of a solenoid gas injector. *Advances in Mechanical Engineering*, **11**, Issue 1, (2019), https://doi.org/10.1177/1687814018817421.
8. Isermann R. Model-Based Fault Detection and Diagnosis - Status and Applications. *IFAC Proceedings Volumes*, (2004), p. 37.
9. Isermann R. Mechatronic systems: fundamentals. Springer, London 2005. ISBN: 978-1-84628-259-1.
10. Isermann R. *Advanced model-based diagnosis of internal combustion engines*. Internationaler Motorenkongress Springer Fachmedien, 2016, pp. 413-432, https://doi.org /10. 1007 /978-3-658-12918-7_27.
11. Ismail MAA, Wiedemann S, Bosch C, Stuckmann C. Design and Evaluation of Fault-Tolerant Electro-Mechanical Actuators for Flight Controls of Unmanned Aerial Vehicles, *Actuators*, **10**, (2021), p. 175,
12. García, A.; Monsalve-Serrano, J.; Villalta, D.; Guzmán-Mendoza, M. Methanol and OMEx as fuel candidates to fulfil the potential EURO VII emissions regulation under dual-mode dual-fuel combustion. *Fuel*, **287**, (2020), 119548.
13. Bielaczyc, P.; Woodburn, J. Trends in Automotive Emission Legislation: Impact on LD Engine Development, Fuels, Lubricants and Test Methods: A Global View, with a Focus on WLTP and RDE Regulations. *Emiss. Control Sci. Technol.*, **5**, (2019), pp. 86-98.
14. Toumasatos, Z.; Kontses, A.; Doulgeris, S.; Samaras, Z.; Ntziachristos, L. Particle emissions measurements on CNG vehicles focusing on Sub-23nm. *Aerosol Sci. Technol.*, **55**, (2021), pp. 182-193.
15. Raslavi˘cius, L.; Keršys, A.; Mockus, S.; Keršiene, N.; Starevi˘cius, M. Liquefied

petroleum gas (LPG) as a medium-term option in the transition to sustainable fuels and transport. *Renew. Sustain. Energy Rev.*, **32**, (2014), pp. 513-525.

16. Saiteja, P.; Ashok, B. A critical insight review on homogeneous charge compression ignition engine characteristics powered by biofuels. *Fuel*, **285**, (2021), 119202.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

STUDY OF A TESTED SOLAR SYSTEM INVERTER

Vasil Ivanov
E-mail: vasil_bi@mail.bg

ABSTRACT

The solar inverter is widely used in DC electrical systems. Its function is to convert DC to alternating voltage in order to power networking loads. The conversion efficiency is high when operating in pulse mode and using the PWM function on loads in different modes.

Key words: *PWM function, solar inverter, alternating voltage*

INTRODUCTION

The testing of the solar system was carried out on a real working autonomous installation for small power comprising the following components [1, 3]:

1. Solar panels SP (photovoltaic modules)

Solar panels perform the function of a solar generator for DC voltage and current. The generated output power is used to power DC consumers or through a solar charge controller the capacity and nominal voltage of the rechargeable batteries (AB) are maintained.

Fig. 1. View of the installed solar panels of the low power inverter system.

The solar panels shown in Fig. 1 are of the same type in terms of output parameters, two in number and connected in parallel to generate a larger current. They are fixed on a south-facing roof at an angle of 45°.

2. Solar charge controller

It performs distribution and regulation functions between sources and consumers through a built-in algorithm (PWM) for controlling the output power.

The charge controller is connected to a solar installation via the terminal strip shown in Fig. 2.

- When choosing a solar charge controller, the condition for nominal current I_{max} at the output is observed:

$$I_{max} \geq 1.1.\ I_{s.c.} \quad (1)$$

where, $I_{s.c.}$ is the peak short-circuit current at the SP output.

Table 1. Solar panel parameters

Parameter, dimension	LX-100M 125-36
Peak power $\mathbf{P_{mpp}}$ [Wp]	100
The variation in power	+5%
Rated current $\mathbf{I_{mpp}}$ [A]	5.39
Rated voltage $\mathbf{V_{mpp}}$ [V]	18.70
Short circuit current $\mathbf{I_{sc}}$ [A]	5.87
Open circuit voltage $\mathbf{V_{oc}}$ [V]	21.60
Temp. power coefficient P	-0.49%
Temp. current coefficient I	0.05%
Temp. voltage coefficient V	-0.35%
Dimensions on modular construction	1194x542мм
Matrix by cells | model	4x9 | mono
Bypass diodes	2x 12 A

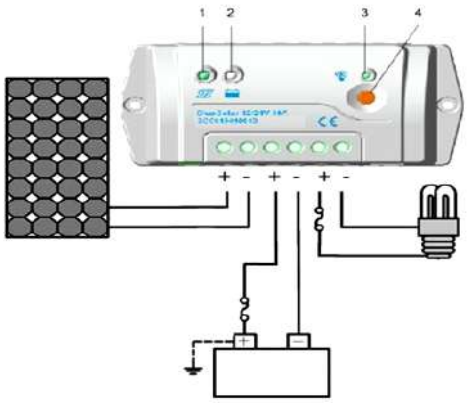


Fig. 2. Charge controller BlueSolar PWM - Pro Charge Controler 12/24V – 10A. 1. SP indicator. 2. LED for rechargeable batteries (AB). 3. Load level indication. 4. Output switching button

Table 2. Parameters for the Solar Charge Controller-BlueSolar PWM

Detects automatically U_{AB}	12/24V
Maximum operating current at the output	10A
Automatic shutdown of the output in case of overload	Yes
Maximum permissible voltage from SP	28V / 55V
Management of the control when changing the parameters of the sources	automatic low voltage shutdown
Protects against short circuit, AB polarity reversal and thermal.	Yes
Work temperature	-20 to +50°C
Maximum humidity (non-condensing)	98%
Maximum charging voltage AB	14.4V / 28.8V
Charging mode AB	13.8V/27.6V
Nominal charge value AB	14.6V/29.2V
Minimum charging	11.1V / 22.2V

3. Traction accumulator batteries (AB)

The charge controller is first connected to the AB and then to the solar panels (SP).

When the solar panels are not working, the accumulator batteries power the inverter system at night, and are charged during the day when the weather is sunny.

Fig. 3. Photo of the solar system elements connected in a schema.

Technical data for AB:

Nominal capacity 24Ah;

Nominal voltage 12V;

Nominal capacity when two batteries of the same type are connected in parallel 48Ah.

RESEARCH METHODS

Principle of operation and positions of the components in the box in Fig. 5

The solar inverter voltage with modified sine wave is connected through the input terminals to the output of the solar controller with a constant voltage of 12V [2]. The mains voltage on the output is 230V with a nominal power of 300VA for powering mains consumers.

Fig. 4. Picture of the box and input port on the left and output port the right of the voltage inverter.

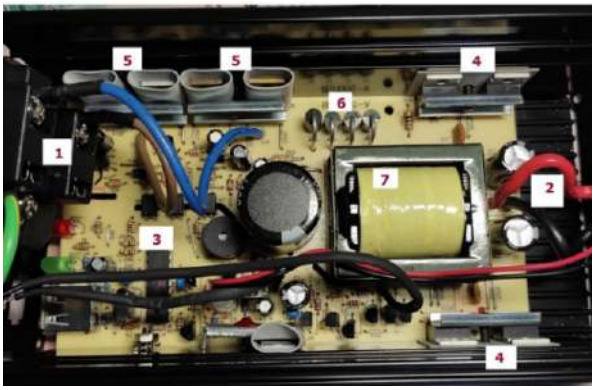


Fig. 5. Photo of the open box of the solar inverter from the elements side.

• **Position 1:** the output alternating voltage 230V;
• **Position 2**: input constant low voltage 12V;
• **Position 3**: integrated circuit - controller. Programmed with an algorithm setting the necessary control signals for the operation of the inverter system;
• **Position 4:** Four power pulse transistors on the low voltage side make up the two-arm bridge circuit architecture of the first inverter;
• **Position 5:** Four power pulse transistors on the high voltage side form the two-arm bridge circuit architecture of the inverter to generate high voltage at low frequency;
• **Position 6:** a bridge valve circuit of four power diodes is designed to high DC voltage;
• **Position 7:** the power step-up transformer is intended to transform with high frequency (10 - 40kHz) the voltage from the direct current source into one with an amplitude necessary for powering network consumers.

Determining the grid voltage waveform measured at the output of the inverter through an isolation step-down transformer

Fig. 6. Measured modified output voltage waveform across an isolation transformer

Efficiency on the voltage inverter

The efficiency factor Ŋ of the voltage inverter is determined by the ratio of the output power P_{out} to the input P_{in}.:

$$\eta = \frac{Pout.}{Pin.} . 100[\%] \quad (2)$$

AC current ~I and AC voltage ~U meters read their effective values.

Their amplitude values are calculated for sinusoidal signals by the expressions:

$$U_m = \sqrt{2}.U;\ I_m = \sqrt{2}.I \quad (3)$$

In non-sinusoidal form of the voltage, as is in the case of the modified sine wave, current and voltage meters show the average values:

$$U_{average} = 2/\pi . U_m \quad (4)$$

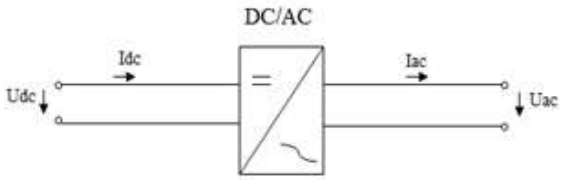


Fig. 7. Block diagram of the input and output values used to calculate the efficiency

The direct current power is determined by the expression:

$$P_{in.} = U_{DC} . I_{DC} \quad (5)$$

The alternating current power is defined by the expression:

$$P_{out.} = U_{AC} . I_{AC} . \cos(\varphi) \quad (6)$$

With an active load, we assume that only the first harmonic is in the output *f*= 50Hz, because cos(ϕ) = 1.

Then, for the output power we get:

$$P_{out.} = U_{AC} . I_{AC} \quad (7)$$

EXPERIMENT

Testing the solar inverter of the system with different types of consumers.

Testing with an inductive - active load mains transformer and incandescent lamps, in the output of the inverter

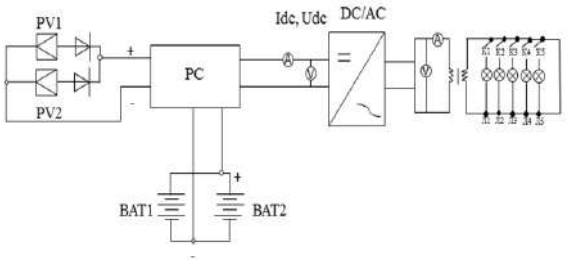


Fig. 8. Diagram of the experimental setup – connecting an inductive - active load mains transformer and incandescent lamps, in the output of the inverter

The load efficiency of the inverter until its nominal value is reached is determined in relative units by the expression:

$$\square s = S/S_m . 100\ \% \quad (8)$$

where: the current value of full power is S, VA; the nominal value of full power is S_m = 300 VA.

Table 3. The measured load data on the secondary side of the network transformer

incandescent lamps	U_{AC};V	I_{AC}.;A	S_{AC};VA	□s %
L_1	234	0.29	67.86	22.62
L_2	236	0.38	89.68	29.89
L_3	237	0.47	111.39	37.13
L_4	238	0.57	135.66	45.22
L_5	235	0.97	227.95	75.98

The load efficiency of the inverter is determined by the measurements in Table 3 until the nominal size is reached.

At a load of more than 45% a fan is automatically switched on in the box of the inverter to cool the power elements.

Testing with an active load - incandescent lamps and rheostat in the output of the inverter.

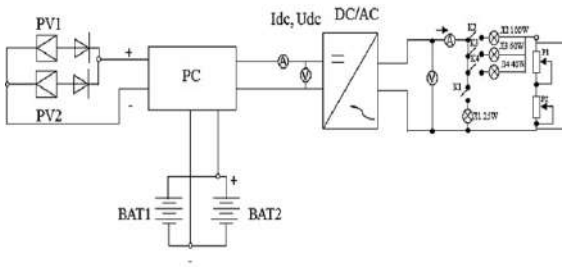


Fig. 9. Diagram of the experimental setup – connecting active loads - incandescent lamps for 220V at the output of the inverter.

The tests are carried out according to the diagram in Fig. 9 and the symbols of the measured and calculated values are:

- Constant voltage from the solar modules – U_{PV};
- Direct current from the solar modules – I_{PV};
- Constant voltage from the output of the charge controller – U_{DC};
- Constant current at the charge controller of the output I_{DC};
- AC voltage at the output of the voltage inverter – U_{AC};
- Alternating current at the output of the voltage inverter – I_{AC};
- Active power measured at the inverter input – Pdc, W;
- Active power measured at the inverter input in relative units – Pdc,% 300;
- Active power measured at the output of the inverter – Pac , W;
- Active power measured at the output of the inverter in relative units – Pac,% 300.

Table 4. Load of the solar system with an active load

Lamps and rheostat	U_{DC} V	I_{DC} A	U_{AC} V	I_{AC} A	U_{PV} V	I_{PV} A
R_1	14.4	1.86	223	0.078	20.2	1.9
R_2	14.3	4.6	230	0.19	17.5	4.7
R_3	14.3	5	227	0.21	17.2	5.1
R_4	14.3	5.5	230	0.23	16.7	5.6
R_5	14.2	6	230	0.27	15.2	6.3
R_6	14.2	6.5	228	0.29	15.1	6.6
R_7	13.7	7	228	0.31	13.9	6.4
R_8	13.9	7.5	228	0.33	14.1	7.1
R_9	13.8	8	228	0.36	14	6.8
R_{10}	13.7	9	235	0.41	14	7.1
R_{11}	13.6	10	233	0.44	13.8	6.9
R_{12}	13.4	11	236	0.50	13.8	5.7
R_{13}	12.8	19	235	0.85	13.1	6.5

Table 5. Data from the calculations when working with an active load

R, Ω	Pdc, W	Pac, W	к.п.д., %	Pac,% 300	Pdc,% 300
R1	26.78	17.39	64.94	5.80	8.93
R2	65.78	43.70	66.43	14.57	21.93
R3	71.50	47.67	66.67	15.89	23.83
R4	78.65	52.90	67.26	17.63	26.22
R5	85.20	62.10	72.89	20.70	28.40
R6	92.30	66.12	71.64	22.04	30.77
R7	95.90	70.68	73.70	23.56	31.97
R8	104.3	75.24	72.17	25.08	34.75
R9	110.4	82.08	74.35	27.36	36.80
R10	123.3	96.35	78.14	32.12	41.10
R11	136	102.5	75.38	34.17	45.33
R12	147.4	118,0	80.05	39.33	49.13
R13	243.2	199.8	82.13	66.58	81.07

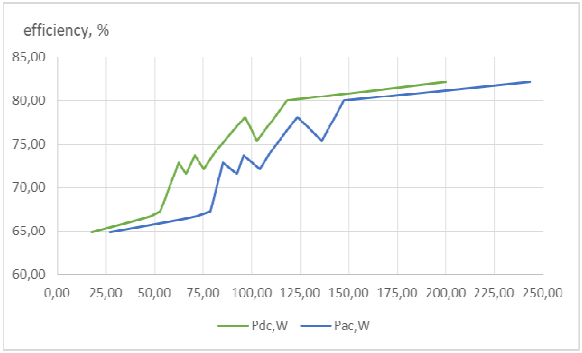


Fig. 10. Graphic representation of dependence of inverter efficiency on the change in the power of the load in relative units

CONCLUSIONS

- Design, research and experiments were carried out on a constructed and functioning solar system;
- An increase and stabilization of U_{AC} was observed in the analysis at rated load due to the operation of the inverter with the highest efficiency;
- The relationship between output and input power determines the efficiency of the system operation and is greatest at rated load [4, 5, 6]. The diagrams in Fig. 10 show an increased efficiency when the inverter is in nominal operation mode.

REFERENCES

1. Ivanov V., Research of autonomous low power supply system, *Annual of Assen Zlatarov University*, Burgas, Bulgaria, **50**, Book 1, (2021), ISSN 2603-3968.

2. Vodenicharov D., PhD thesis “Investigating the capacity of an autonomous photovoltaic system, powering IP video camera in continuous operation mode”, Burgas, 2019.
3. Ivanov V., Modelling of single-phase inverter system in Simulink software”, Annual of Assen Zlatarov University, **49**, Book 1, (2020), Burgas 8010, Bulgaria, ISSN 2603-3968.
4. Ivanov V., Ivanov Hr. Investigating the capacity of an autonomous photovoltaic system, powering IP video camera in continuous operation mode, ISSN 1311-106X, *Notices of the Union of Scientists - Ruse*, series 1, Technical Sciences, **15**, (2018), pp. 53-61.
5. M. Proykov, N. Simeonova, Ivanov V., Inverter model optimization in Simulink software environment, *18th Conference on Electrical Machines, Drives and Power Systems (ELMA),* Varna, Bulgaria, (2023), pp. 39-42, doi:10.1109/ELMA58392.2023.10202524.
6. Ivanov V., Proykov M., Simulation and analysis of a photovoltaic system using Matlab / Simulink, *Annual University Scientific Conference 2020, NMU “Vasil Levski”,* Veliko Turnovo, Bulgaria, (2020), pp. 147-159, ISSN 1314-1937.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

STUDY OF SOLAR VOLTAGE INVERTER MODEL FSP 3kVA

Vasil Ivanov
E-mail: vasil_bi@mail.bg

ABSTRACT

The solar inverter is widely used in DC electrical systems. Its function is to convert DC to alternating voltage in order to power networking loads. The conversion efficiency is high when operating in pulse mode and using the PWM function on loads in different modes.

Key words *PWM function, solar inverter, alternating voltage*

INTRODUCTION

Hybrid systems from renewable energy sources (RES) are electrical architectures providing the most possible uninterruptible power supply. In the hybrid version of the energy system, the maximum number of sources are used: a solar generator, rechargeable batteries, a gasoline or diesel generator, a wind generator, etc. (Fig. 1).

The hybrid scheme realizes a continuous operation mode for the longest period of time.

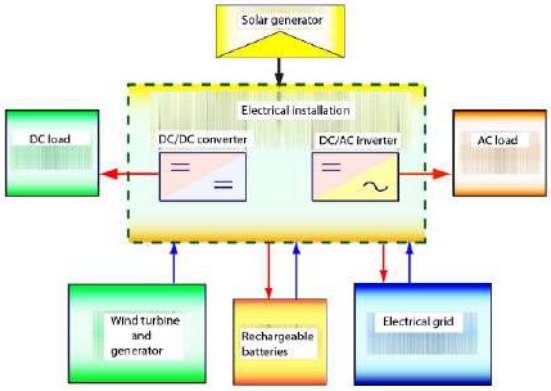


Fig. 1. A hybrid version of an energy system

The basic architecture of photovoltaic systems comprises **solar panels (SP)** connected to a controller **tracking the maximum power point (MPPT)** and controlling the charging modes of the **rechargeable batteries (RB)**.

The structure of photovoltaic systems feeding network loads includes a solar voltage inverter converting **constant voltage (DC)** to **alternating voltage (AC)** [1].

● Models of "dependent" solar inverters

Photovoltaic systems working in parallel with the public network are called dependent. The size of network consumers powered by a similar plant model depends on its installation power and for low-power systems it reaches a maximum of 5kW. A backup source of rechargeable batteries (RB) can be added to the structure, but the solar inverter of the system must work in sync with the power grid and turn off automatically when the voltage drops.

● Autonomous Photovoltaic Systems (APS)

APS are equipped with solar panels, rechargeable batteries with a charge controller and a solar inverter. The voltage inverter is commercially available in two versions: a cheap model with a modified sine wave or, the more expensive variants, with a pure sine wave. Autonomous work means that the solar system is independent of the public grid [2, 3].

● Solar voltage inverter

Photovoltaic systems designed to power grid loads must be structured in a scheme with a solar voltage inverter. It is a modern converter of constant energy into variable energy with a high efficiency, as a result of the pulse mode of operation (with the least losses) in the power semiconductor matrix. The transistor matrix control algorithm is implemented by **digital signal processor (DSP)** by the pulse width modulation (PWM) method.

● External factors influencing the effective work of the SP

Meteorological data from changes in external non-electrical factors, for a certain period of time, are related to the geographical location of the installed SPs. The data are recorded in real time using specialized software and monitoring used in the design of a solar field is created, built by a large number of SPs.

In the design and construction of a photovoltaic plant for large power over 100kW the characteristics of the geographical location of the solar panels are investigated in advance: the level of

solar radiation, the angle of inclination of the SP, the ambient temperature, the wind speed and humidity. The correct location of the SP during the construction of a solar park guarantees the most efficient year-round energy yield from the sun.

• The solar panels in photovoltaic systems are organized in string and parallel connections with cables and connectors, with their number taking into account the projected yield required for installation power.

• Each solar module produced is set with peak and nominal characteristics:

- output power $\mathbf{P_{SP\_STC}}$,
- idle voltage $\mathbf{U_{SPo.c.}}$,
- short circuit current $\mathbf{I_{SPs.c.}}$,

The indicators of nominal values are obtained under standard laboratory test conditions (STC) with the following external environmental parameters:

- integral level of solar radiation intensity $G = 1000W/m^2$,
- ambient temperature T = +25ºC,
- wind speed Vw =1m/s,
- the air mass coefficient AM=1.5.

RESEARCH METHODS

Study of solar inverter model FSP3kVA in a laboratory photovoltaic system

1. Solar panels (SP) are used in the system architecture [3].

For a single solar panel, the nominal electrical parameters are:

P_{SP_STC} = 275Wp; U_{SPmax} = 31.30V; I_{SPmax} = 8,85A; η_{SP} =16.8%.

With 4 units of SP in a mixed connection scheme, the total parameters are:

ΣP_{SP_STC} = 1108Wp; ΣU_{SPmax} = 62.6V; ΣI_{SPmax} = 17.7A (Fig. 2).

Fig. 2. Photos of four SPs mounted permanently on the roof of the laboratory in the University facing south with an angle of inclination of up to 45°

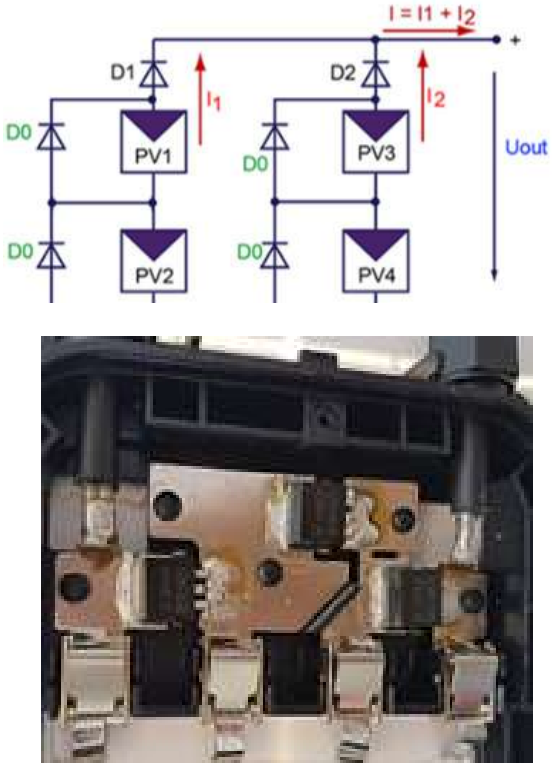


Fig. 3. SP connection diagram (above); Photos of the shunt diodes D0 in the junction box from the back of the SP (below)

2. Rechargeable batteries (RB) are used as a second independent power supply of the inverter. They have the following common nominal parameters: capacity C_{RB}=230 Ah; total voltage ΣU_{RB}=24V; η_{RB}=85%; total energy $\Sigma W_{RB} = C_{RB}. \Sigma U_{RB}. \eta_{RB}$ = 4692Wh.

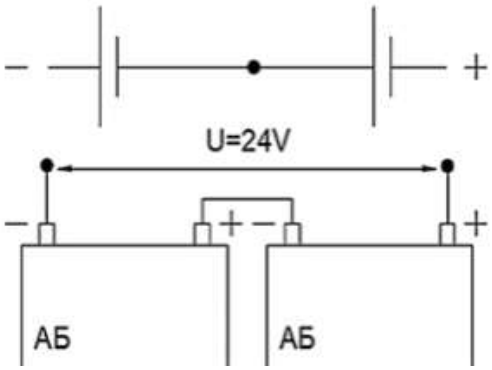


Fig. 4. Diagram of serial connection of two RBs with a common output voltage of 24 V

Important: A characteristic feature of RBs used in autonomous solar systems is their construction. This kind of batteries is made using a special technology allowing for deep dis-

charge/charge cycles and a large range of variation of their capacity percentage.

3. Solar voltage **converter (DC/DC converter)**.

The voltage **DC/DC converter** is shown in the block diagram in Fig. 5. It is powered by RB or SP, as the priority is determined by the intensity of solar radiation. The purpose of the DC/DC converter included between the SP and the inverter is stabilization of the input voltage through a controller, with the ability to set the output voltage depending on the rated voltage of RB.

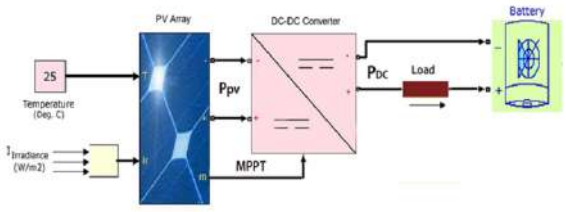


Fig. 5. Block diagram of the connected DC/DC converter (built into the inverter), array of solar panels SP (PV Array) and rechargeable batteries (RB);

The DC/DC converter controller uses a maximum power point tracking (MPPT) algorithm with current and voltage feedback and discharging for RB.

Single-phase solar DC/AC voltage inverter for 3kVA

Output nominal parameters:

U_{out} =230V pure sine wave, I_{out} =12A, f =50Hz;

1. Architecture of the laboratory photovoltaic system

The solar system consists of three independent energy sources:

- rechargeable batteries (RB), solar panels (SP) and public electricity network.

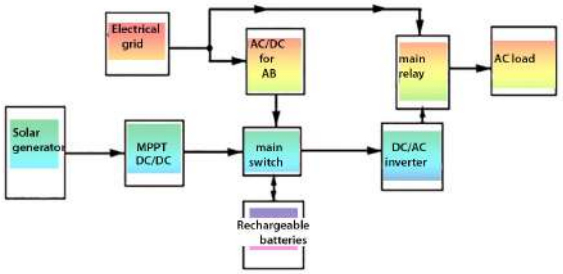


Fig. 6. Block diagram of the laboratory solar inverter in a photovoltaic system

The block diagram in Fig. 6 is made up of external components and internal ones which are the architecture of the solar inverter model FSP 3kVA. The priorities for the energy exchange directions between the input/output circuits are programmed by the solar voltage inverter.

▪ The solar inverter is controlled by a digital signal processor (DSP) of the latest generation, as an intelligent part of the architecture.

▪ The main function of an inverter is to convert DC voltage into AC, by applying pulse width modulation (PWM) with high efficiency. At full load it reaches 98%.

▪ An important characteristic is stabilization of the DC voltage after SP through a DC/DC step-down converter model and a program for the optimal charge/discharge mode of the battery according to its type. An algorithm for tracking the MPPT maximum power point of the SP is embedded in the DC/DC controller [4, 5].

2. Main board of the solar voltage inverter model FSP 3kVA

The photo in Fig. 7 is conditionally divided into several modules.

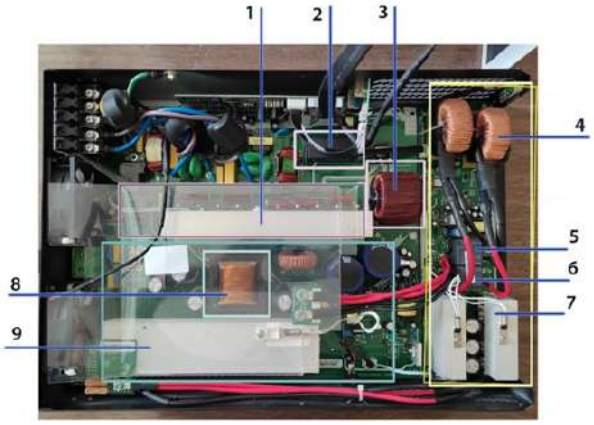


Fig. 7. Board-side elements of the voltage inverter model FSP 3kVA

● Component 1 in Fig. 7 is a heatsink with mounted power semiconductor elements that break the constant voltage of 300V with a period of 20mS or a frequency of 50Hz.

● Positions 2 and 3 form an output resonant LC filter, smoothing the shape of the voltage sine wave with parameters ~230V/50Hz;

● Positions 4, 5, 6, and 7 in Fig. 7 perform the function of a step-down voltage model (DC/DC converter) from SP and are controlled by a controller for tracking the point of maximum power MPPT. It controls and stabilizes the magnitude of the generated voltage and current through feedback connections implemented as standard voltage dividers and current transformers (position 4).

● Positions 5 and 6 are main relays for switching operation modes and priorities from the sources to the consumers.

● The power module supplied by the RB through the DC/DC converter indicated in positions 8 and 9 stabilizes the voltage from the SP at 24V. A pulse converter using a powerful high-frequency transformer with a ferrite magnet (position 8) converts the voltage from DC to AC (DC/AC) at 300V at high frequency. The resulting pulsed current is rectified by a power bridge rectifier, filtered with high-voltage electrolytic capacitors and fed to the input of the above-mentioned block indicated in position 1.

● At position 9, a powerful network rectifier according to a bridge circuit of 24V is indicated, charging the RB during the time when the inverter works in public network mode. The maximum charging current is setup in the software menu depending on the type and nominal capacity of the batteries used.

● As can be seen from the picture in Fig. 7, the cooling of the power elements is carried out with small radiators, due to the installed two fans in the inverter box. The temperature rise of the power transistors is measured by the sensors mounted on the radiators and the fans are automatically turned on when the set value is exceeded.

Synthesis of Solar Inverter Operation Screens (DC/AC)

The display mounted on the front of the solar inverter shown in Fig. 8 visualizes the operation of functional blocks and the electrical circuits. The magnitudes of the measured input and output characteristics are reported in real time. Below the display LED indicators and function buttons are located for controlling and setting up the system.

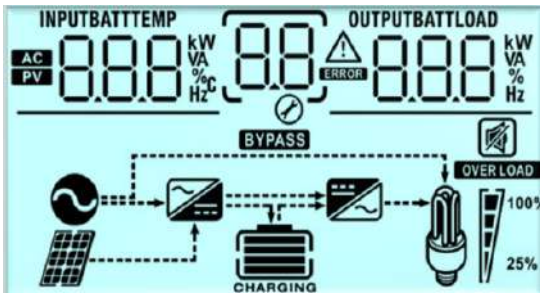


Fig. 8. Smart control preview display of modern models of solar voltage inverters.

▪ In the upper part of the display in Fig. 8, the current parameters of the input part (left) and the output part (right) are visualized in real time.

▪ In the lower part of the display, the connection diagram of sources and consumers is shown. The dashed lines indicate possible combinations depending on the set operation algorithm of the solar inverter.

• Using the display, it is possible to adjust the solar inverter by means of buttons on the front panel, depending on the components used. The other possibility of programming is through a computer where the specialized management software application is installed. From there it is possible to record the data and perform monitoring of the main parameters, which is done in the experimental part.

EXPERIMENT

1. The diagram in Fig. 9 is a record of the change in the magnitude of the input $U_{network}$ with an effective value of 230V in intervals of 1 hour for a period of 24 hours. A change in the voltage from the public network 230V was reported, which fluctuated within the norm of about 5%.

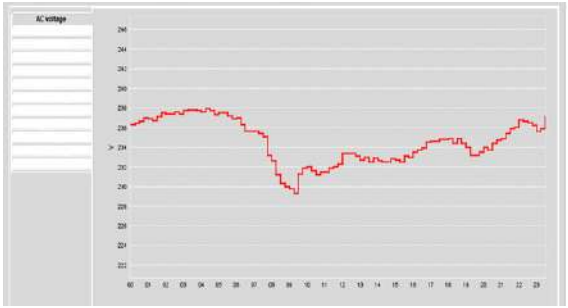


Fig. 9. Records in graphic form of the variation of the input voltage from the external network 230V

The diagram of the change in the magnitude of the output voltage shown in Fig. 10 in the period of 8 h. until 5 p.m. was received when the system worked in inverter mode with solar energy to power the consumers.

In the analysis of the diagram in Fig. 10, a stabilization of the output voltage in a time interval of 8 hours was observed until 5 p.m., when the solar inverter started working.

The result of the experiment shows the stabilizing capabilities of the voltage inverter when the output network voltage deviates from the set nominal value.

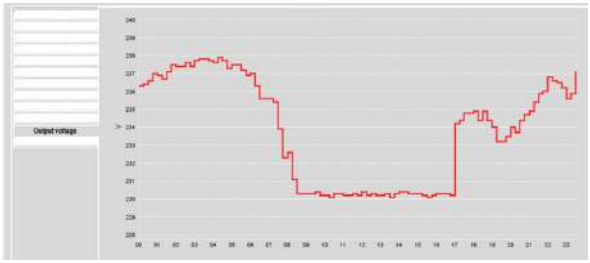


Fig. 10. Record in graphic form of the change in the magnitude of the output voltage supplying the consumers for a period of 24 hours;

2. Diagrams tracking the frequency of the input voltage grid and the frequency of the output voltage from the operation of the solar inverter for a period of 24 hours.

The graphically presented results in Fig. 11a and Fig. 11b show several deviations within tenths of hertz. When operating the system in inverter mode during the period of 8 hours until 5 p.m., the network frequency stabilizes, which is shown in the diagram in Fig.11b.

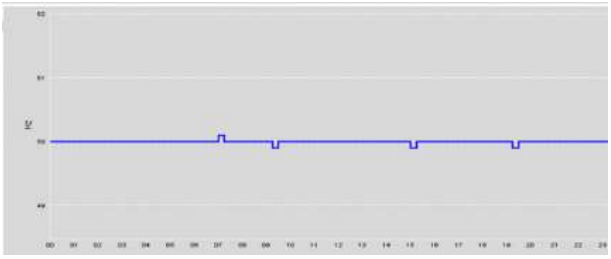


Fig. 11a. Record of the monitoring of changes in the frequency of the input mains voltage

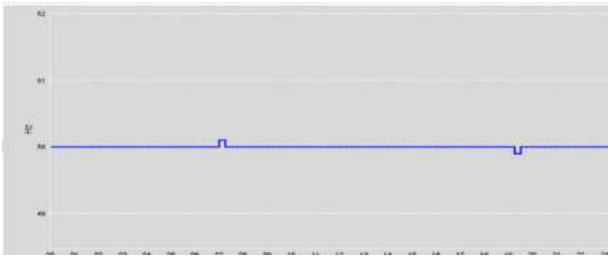


Fig. 11b. Record of the monitoring of changes in the frequency of the output mains voltage

The monitoring of the operation of the inverter for a period of 24 hours is shown in Fig. 10 and Fig.11b. When operating in inverter mode, two stable output parameters characteristic of quality voltage inverters (nominal output voltage and output grid frequency) are taken into account.

3. Efficiency of the solar inverter in different load modes

A solar voltage inverter is most efficient at rated load for an extended period of time. Efficiency varies at different load stages, being the lowest when operating without a consumer.

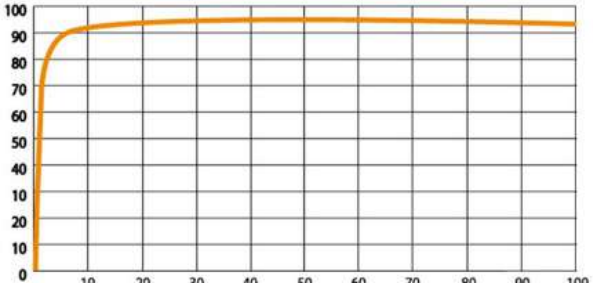


Fig. 12. Percentage expression of the efficiency of operation of the solar inverter at a graduated load in output.

The diagram in Fig.12 shows the variation of voltage inverter performance as a ratio of power and efficiency, in relative units.

The application of solar inverters is relatively large in households and the industry due to quality indicators related to energy efficiency and "green" energy.

The modern model of the solar voltage inverter is a compact and highly efficient converter and stabilizer of electrical energy with an efficiency factor close to 100%.

CONCLUSIONS

Conclusions from the analyses:

- Time studies and experiments were carried out on a constructed functioning laboratory solar system by recording data with monitoring software.
- The results of the monitoring are the diagrams Fig. 10 and Fig. 11, which show stabilization of the output voltage and frequency when the photovoltaic system was operating in inverter mode.
- Prerequisites for increasing the efficiency of the solar inverter:

The analysis of the graph in Fig. 12 leads to the conclusion that, when operating at idle up to 10% load, the performance of the inverter is degraded. This creates losses in the conversion of energy from one form to another [6].

● The moment of starting the solar inverter and its idle operation create conditions for loss of active power and worse harmonic composition of the output parameters – current and voltage. When installing the solar inverter in the system, the following conditions are required:

• Starting the solar inverter should be a one-time operation for an extended period of time.

• The idle mode should be short-lived, with the load quickly reaching nominal values.

• The system will operate most efficiently at rated load for an extended period of time.

REFERENCES

1. Stoyanov Iv., Ivanov V., Iliev T., Ivanov Hr., Yield and Performance Study of a 1MWp Grid Connected Photovoltaic System in Bulgaria, *Journal of Engineering Science and Technology Review X*, ISSN:1791-2377, doi:10.25103/jestr.132.43;
2. Ivanov V., Kasarov R., Investigation of an autonomous low power photovoltaic system, *Annual University "Vasil Levski" NMU*, Veliko Turnovo Scientific Conference 2022, ISSN 2367-7481.
3. Belovski Iv., Ivanov V., Solar powered thermoelectric cooling system, Annual of Assen Zlatarov University, ISSN 2603-3968, **47**, Book 1, (2018), pp. 101-104.
4. Ivanov, V., Stoyanov Iv., Mihaylov L., Optimization of the maximum power point of photovoltaic systems using a DC/DC converter, *International scientific conference UNITEH* 2015, volume I, TU - Gabrovo, University Publishing House "Vasil Aprilov" - Gabrovo, p. I – 203 – I – 207, ISSN 1313 – 230X.
5. Iliev, I., Panchev H., Proykov M., Analysis and rationalization of the circuit technical characteristics and features of connection to the network of a photovoltaic system with a capacity of 1MWp, Co*llected papers of Energy Forum NTSEB*, Varna, Bulgaria, (2021), pp. 206-211, ISSN 2367-6728
6. I. Iliev, Panchev H., Proykov M., Study of the energy characteristics of a grid connected photovoltaic system, *Collected papers of Energy Forum NTSEB*, Varna, Bulgaria, (2021), pp. 212-217, ISSN 2367-6728.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

SEQUENTIAL REACTIVE ENERGY COMPENSATION

Mladen Proykov
e-mail: m_proykov@yahoo.com

ABSTRACT

A laboratory model for sequential reactive power compensation was constructed. The benefit of reactive power compensation was examined.

Key words: *reactive power compensation, energy eficiency, power quality*

INTRODUCTION

The quality of electrical energy and the efficiency of power supply systems (PSS) are greatly affected by the levels of reactive loads circulating in them. The large amount of inductive loads (transformers, electrical motors, induction furnaces, etc.) in the network, in total have a significant reactive power that circulates between generators and consumers and degrades cosφ.

One of the reasons for maintaining a high cosφ is the imposition of penalties by electricity distribution companies when the consumer's cosφ is below 0.9. In addition, the transfer of reactive power in PSS is also associated with a number of other negative consequences, such as [9]:

– Increased losses of active power on power transmission facilities;

– Incomplete use of synchronous generators and power transformers, as it loads them additionally;

– The decrease in cosφ leads to an increase in the current in the networks;

– Increased voltage losses at low cosφ.

The listed unfavorable situations of low cosφ require the implementation of measures in the PSS of industrial enterprises (IE) to improve it. These measures are carried out in two directions: improvement of cosφ with or without compensating devices (CD) [7].

The improvement of cosφ without CD is carried out in the following ways:

– Correct choice of electrical equipment at the design stage;

– Quality repair of electric motors;

–

– Lowering the supply voltage;

– Arrangement of the technological process in order to improve the energy regime of the facilities;

– Use of synchronous (SM) instead of asynchronous (AM) motors when it is possible;

– Replacement of lightly loaded AM's and power transformers with ones with lower power;

– Limiting the idle time of the electric motors and power transformers.

In most cases, it is not possible to achieve the desired increase in cosφ with the "natural" methods described above. Then it turns out to be technically and economically expedient to install reactive energy compensators to improve cosφ, namely [2]:

- Static compensating devices – power capacitors, reactors and thyristor-controlled capacitors and reactors;

- Dynamic compensating devices – SM, synchronized AM, compensating converters, synchronous (SC) and asynchronous (AC) compensators, etc.

- Modern solutions for compensation of reactive loads based on flexible alternating current systems (Fig. 1).

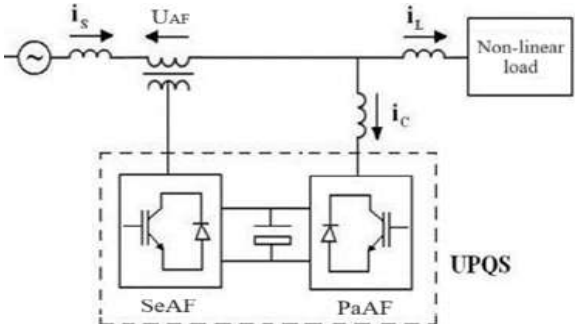


Fig. 1. Active filter for RPC

A particularly great effect is achieved by implementing an automatic CRT, leading to [1]:

– Optimization of the control scheme and more precise control of compensating devices;

– Reduction of the time for turning on and off the compensating devices;

– More accurate maintenance of the desired cosφ.

THEORETICAL

Sequential compensation is particularly effective where the deep entry scheme is used. It is also particularly appropriate in the event of a sudden variable load on the network, for example when supplying arc furnaces, welding units, etc. Compensation of reactive loads reduces voltage loss and ensures the correct sizing of electrical networks, already in the process of their design. One of the main issues to be addressed in the design of the PSS of the IE is the issue related to the RPC [3, 4].

The following quantities are used for quantitative assessment of the dependence between active and reactive power [5]:

- Instantaneous value of cosφ:

$$cos\varphi(t) = \frac{P(t)}{S(t)} = \frac{P(t)}{\sqrt{P^2(t) + Q^2(t)}} \qquad (1)$$

- Average value of cosφ for time interval T:

$$cos\varphi_{av.} = \frac{1}{\sqrt{1 + \left(\frac{W_r}{W}\right)^2}}\ ;\ \ tg\phi_{av} = \frac{W_r}{W} \qquad (2)$$

- Natural cosφ – this is the value of cosφ for a group of consumers without considering the performance of the compensation devices (CD):

$$cos\varphi_n = cos\left(arctg\frac{Q}{P}\right) = \frac{P}{\sqrt{P^2 + Q^2}} \qquad (3)$$

- Actual cosφ – taking into account the reactive power of the consumers and of the compensation systems (CS):

$$cos\varphi_a = cos\left(arctg\frac{Q - Q_c}{P}\right) \qquad (4)$$

- Rate of reactive power compensation [1]:

$$C_K = \frac{Q_c}{Q} \qquad (5)$$

- Power supply system (PSS) saturation with compensating capacities:

$$H = \frac{Q_K}{P_M} \qquad (6)$$

In a sequential RPC, the necessary CB's are connected in series to the network and the full current of the line flows through them. The power of the CB's is determined by the consideration that the current through it is equal to the full current I that flows through the supply line. The following methodology is used for quantitative assessment [6]:

- Determination of the required capacitive power:

$$Q_c = \frac{P}{\cos\varphi}.\left[sin\,\varphi - \sqrt{\left(\frac{U_1}{U_2}\right)^2 - (\cos\varphi)^2}\right] \qquad (7)$$

$$Q_c = \frac{I^2}{\omega.C.10^{-3}}\ ;\ \ I = \frac{U}{X_c}.10^{-3} \qquad (8)$$

- Determination of the voltage loss in the line, before and after the RPC (ΔU_1 и ΔU_2):

$$\Delta U_1 = \frac{P.R + X.Q}{U}.10^{-3} \qquad (9)$$

$$\Delta U_2 = \frac{P.R + (X - X_c).Q}{U}.10^{-3} \qquad (10)$$

- Determination of voltage loss reduction δ(ΔU):

$$\delta(\Delta U) = \Delta U_1 - \Delta U_2 = \frac{X_c.Q}{U}.10^{-3} \qquad (11)$$

PRACTICAL RESEARCH

A laboratory model (Fig. 2) was constructed for the realization of a sequential RPC. It visually simulates the effect and benefits of implementing sequential compensation. The RPC controller (Fig. 3) performs automatic control of CB in single-phase and three-phase networks. It has installed filters for harmonic components of voltage and current, which is why

it is characterized by high precision and accuracy of reactive power management.

Fig. 2. Laboratory model

The installed reactive power compensation controller has the following parameters:

- Sensitivity: 100mA;
- Nominal frequency: 50Hz ± 5%;
- Nominal current: (0 ÷ 5)A;
- Automatic or manual analysis function;
- Adjustment of desires cosφ: from 0.8 to 0.99, with a step of 0.01;
- Nominal voltage: 220/380VAC ±10%;
- LED / LCD display: shows the current parameters of the electric circuit.

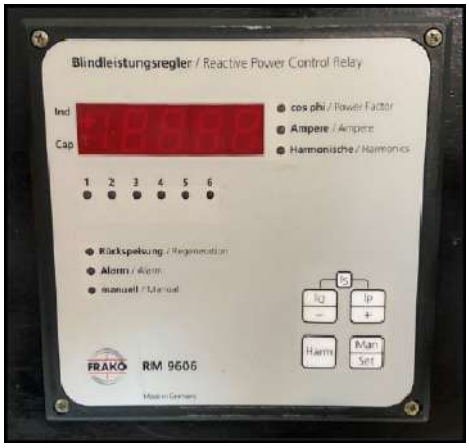


Fig. 3. Reactive power compensation controller

In order to implement different modes of operation, it is possible to change the active and inductive load.

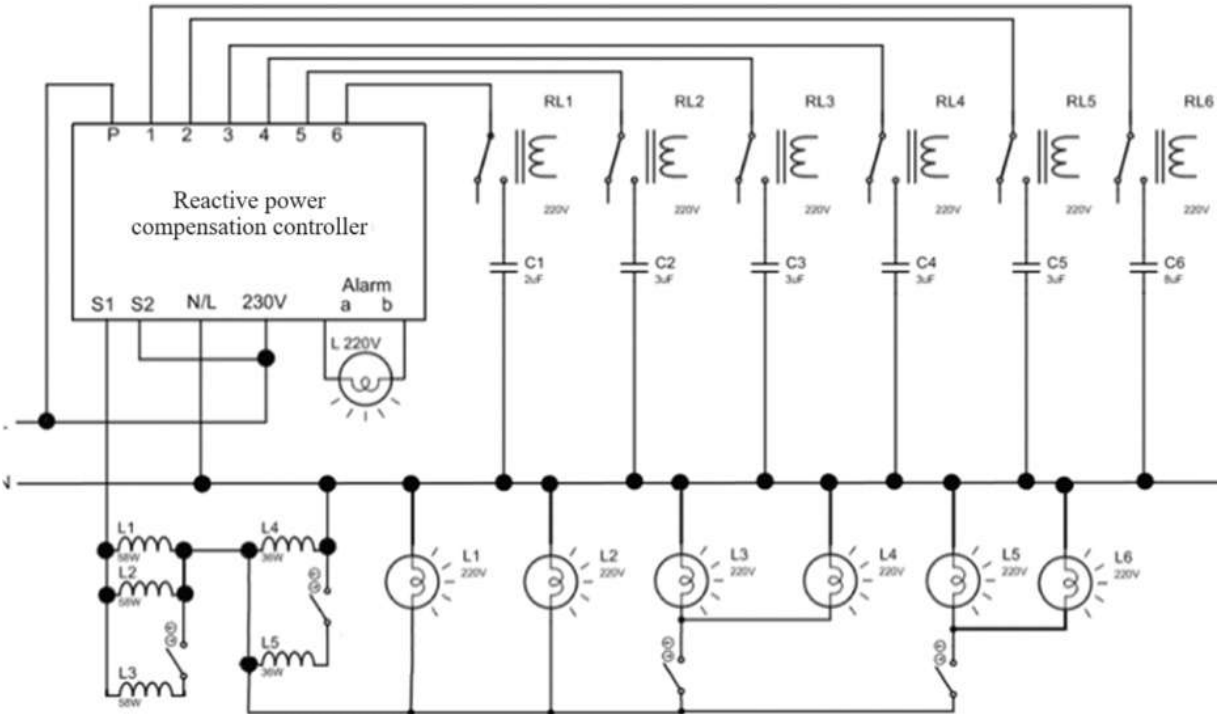


Fig. 4. Circuit diagram of the laboratory model

Description of the laboratory model:

- Frako (RM 9606) – controller for reactive power compensation;
- HL1 ÷ HL6 - light bulbs: P_n = 100W; U_n = 220VAC (active load);

- C_1 – capacitor with nominal data: C_n = 0.2μF; U_n = 450VAC;

- C_2; C_3; C_4 and C_5 – capacitors with nominal data: C_n = 3μF; U_n = 450VAC;

- C_6 – capacitor with nominal data: C_n = 8μF; U_n = 450VAC;

- L_1; L_2 and L_3 – throttles (inductive load) with nominal data: U_n = 220VAC; L = 230mH; f = 50Hz; I_n = 0.79A;

- L_4 and L_5 – throttles (inductive load) with nominal data: U_n = 220VAC; L = 100mH, f = 50Hz; I_n = 0.32A.

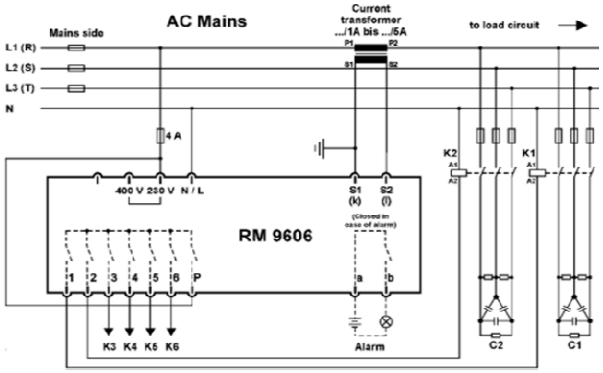


Fig. 5. Wiring diagram of RCP controller

Table 1. Parameters of the electrical circuit before reactive power compensation

I, A	0,9
I_A, A	0,43
I_R, A	0,78
U_1, V	232
P, W	186
U_2, V	153
ΔU, V	79 (34%)
ΔU_{add}, %	2.5 / 5
cos φ	0.49
cos φ (d)	0.91

The measured values of the current harmonic components before compensation are:

- Third harmonic: 1.6%.I_1;
- Fifth harmonic: 1.5%.I_1;
- Seventh harmonic: 1.7%.I_1;
- Ninth harmonic: 1.4%.I_1;
- Eleventh harmonic: 0.2%.I_1;
- Thirteenth harmonic: 0.2%.I_1.

According to formulas (7, 8), the required capacity C_K of the CB realizing the required Q_K = 220VAr is C_K = 13μF.

When RPC capacitors C_2, C_5 and C_6, are included, realizing C'_k = 13μF. Therefore, the capacitive power input by the controller is Q_K = 220VAr.

The saturation of the circuit with compensating power H, determined by formula (6) is 118.27%. The degree of RPC determined by formula (5) is 128 %.

Table 2. Circuit parameters after reactive power compensation

I, A	0.74
I_A, A	0.67
I_R, A	0.30
U_1, V	232
P, W	156
U_2, V	210
ΔU, V	10 (4%)
ΔU_{add}, %	2.5 / 5
cosφ	0.91
cosφ (d)	0.91

The measured values of the current harmonic components after compensation are:

- Third harmonic: 1.3%.I_1;
- Fifth harmonic: 1.2%.I_1;
- Seventh harmonic: 1.4%.I_1;
- Ninth harmonic: 1.1%.I_1;
- Eleventh harmonic: 0.2%.I_1;
- Thirteenth harmonic: 0.2%.I_1.

A slight decrease in the values of the third, fifth and seventh harmonics is observed, due to a decrease in the value of the total current in the circuit, as a result of lowering the reactive component of the current in the electrical circuit. The values of the eleventh and thirteenth harmonics are not changed due to their too low values.

RESULTS AND DISCUSSION

The performance of a laboratory device for RPC was investigated. After applying sequential RPC, cos φ increased from 0.48 to 0.91. The application of a transverse KRT led to the unloading of the electric circuit from the transfer of reactive energy Q. With an increase in cos φ, the full current I in the circuit decreased 2.6 times, which makes it possible to choose switching - protective equipment with lighter parameters, and smaller section wires. The reduction of the total current in the circuit led to the reduction of the consumed active energy, due to the reduction of the active losses in the wires and equipment. The RPC led to a voltage increase at the installa-

tion point of the CB and compensation of the voltage drop. Therefore, sequential RPC can be used in electric networks in order to increase their stability and also to improve the voltage regime (reduction of deviation and fluctuation of voltage), when turning on powerful consumers. The coefficient of total harmonic distortion of the current THDI also decreased. This leads to an increase in the indicators of the quality of electrical energy and an improvement of the electromagnetic compatibility in the electrical circuit.

REFERENCES

1. Apukhtin D. Y. etc., Implementation of AMS PT during substation reconstructions, PE, No. 7, 2005.
2. Baev, D., *Handbook on energy efficiency management in enterprises*, Sofia 2015.
3. Gotman, V. I., Evaluation criteria for compensation of reactive power, *Electricity*, 2009.
4. Ivanov V., Research of a parallel oscillating scheme in Simulink, *Annual of Assen Zlatarov University*, Burgas 8010, Bulgaria, **41**, Book 1, (2022), ISSN 2603-3968;
5. Ivanov V., Simulation, modelling and analysis of a series oscillating circuit, IOP Conf. Series: Materials Science and Engineering; *International Scientific Conference on Communications, Information, Electronic and Energy Systems – CIEES 2021*, AIP Conf. Proc. 2570, 030010-1–030010-8, ISBN: 978-0-7354-4375-4, doi:.10.1063/5.0100042;
6. Ivanov V., A simulation method for improving the efficiency of power lines from electric networks, *Proceedings of the Union of Scientists - Ruse*, Technical Sciences, ISSN 1311-106X, **16**, Book 1, (2022), pp. 50-56.
7. Karafeizov Ts., Transfer of reactive power in power lines, *Energetika*, 2003.
8. Kirov R. M. et al., Reactive power compensation an efficient way to save EE, *Energy Forum, Proceedings*, 2006;
9. Kirov R. M. et al., Optimizing compensation of reactive power, performed using synchronous motors and capacitor banks in PSS's of powerful industrial facilities, *ELMA*, 2011.
10. Proykov M., N. Simeonova, Study of the possibilities for optimization of reactive power according to the criterion "electric power quality" in the power supply system of a port complex, *8th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE 2022), Conference Proceedings*, Ruse, Bulgaria, 2022, IEEE Catalog Number CFP22V95-USB, ISBN 978-1-6654-0708-3, doi: 10.1109/EEAE53789.2022.9831288;
11. Proykov M., Laboratory model for compensation of reactive power, *Annual of Assen Zlatarov University*, Burgas, Bulgaria, Technical and natural sciences, ISSN 2603-3968, **48**, Book 1, (2019), pp. 104-109.
12. Proykov M., The effect of reactive power compensation on the operation of power supply system of „ELKABEL" LTD, *Annual University Scientific Conference 2020, NMU "Vasil Levski"*, ISSN 1314-1937, Veliko Turnovo, Bulgaria, (2020), pp. 141-146.
13. Proykov M., Ivanov V., Simulation and analysis of a photovoltaic system using MATLAB / SIMULINK, *Annual University Scientific Conference 2020, ISSN 1314-1937, "Vasil Levski" NMU*, Veliko Turnovo, (2020).

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

EMOTIONAL AND MENTAL ENGAGEMENT OF PRE-SCHOOL CHILDREN IN THE PERCEPTION OF MUSIC

Smilena Smilkova
E-mail: smilenads@abv.bg

ABSTRACT

Preparing a future music audience is one of the important tasks of preschool music education. The perception of music stimulates and develops the audience's emotionality, abstract thinking, and imagery. Part of the preparation and education of future listeners is described in the proposed study based on the Perceiving Music musical activity. The purpose of the study is related to the expansion of children's general musical culture and aesthetics through the development and manifestation of their emotional sensitivity and imagination, based on the perception of the artistic image in music while listening to classical piano pieces. The assigned tasks include different ways of provoking children's interest: verbalization of the artistic musical image; the game as an incentive to realize the creative beginning in children. The described forms of work are adapted to three levels of music perception defined by Mihaly Csikszentmihalyi.

Key words: *music perception, preschool age*

INTRODUCTION

Knowledge and wisdom accumulated in human history and development are the basis on which the experience, insight, culture, and sensitivity of the individual, the group, and the society are built. On this foundation, children begin to build their knowledge and practice, through which they develop their imagination, transferring and transcribing sensations from and about the real world into their personal mental and emotional world. As a consequence, the expansion and consolidation of knowledge based on past experience, passed through the prism of experience and imagination, accumulated, enriched and united natural sensibility and insight with the wisdom of time - past and present - is achieved.

According to Leon Levy, knowledge has two prerequisites. The first is the subject of knowledge, especially man with his mental activity, intellect, scientific thought, society, and humanity. The second is the object of knowledge, which can be anything from the atom to the universe (Levy 2006, 10-11). It is the multifaceted, multidirectional, diverse, and peculiar in its form, essence and possibilities object of knowledge that can unlock the creative beginning in the personality. It is a matter of personal attitudes, curiosity, interest or desire to perceive a single or several objects that provoke a person's both mental and emotional world. Depending on the level of development of the person's senses, the imagination can be visual - with a predominance of the image visible in the mind; auditory - related to timbre, pitch; motor - based on the movement and caused not only by the kinetics of the body, but also by the rhythm, meter, tempo of dynamism. In children, imagination takes place through perception. Children bring their feelings and perception to the accepted ideas in games. Expressing and acting out their fantasy, children materialize it through the pictorial plasticity of body, mind, and spirit.

CHILDREN'S IMAGINATION AND CREATIVITY

A child's imagination knows no bounds. It is definitely individual, and is decorated and coloured by the psyche of the individual child, by their life experience, by the knowledge accumulated over time, by upbringing and the characteristics of their physiological and emotional nature. The purpose of children's creativity is not to create works of art. Acquainting children with the various arts and their specifics, characteristics, and means of expression is a step on their way to getting to know the world through the aesthetics and values embedded in them. Properly provoked interest is a guarantee of stimulating children's curiosity, observation, imagination and creative thinking. With children, the joy of play-

ing is an act that brings them not only satisfaction, delight, and happiness, but also knowledge about the world around them, about the relationships between them, about the sweetness of victory, or the disappointment of failure.

Edward de Bono, known as the creator of the term and concept of lateral thinking, defines two main directions of thinking: forward and parallel. The key question of parallel thinking is what else is there (what other possibilities, perspectives, perceptions), and of forward thinking it is what comes next (direction of movement, thoughts, actions). Bono notes that parallel thinking is sometimes called divergent thinking and forward thinking is called convergent. According to him, thinking in education is always reactive – logic (reason) is used to arrive at the answer, but wisdom is based on perception – the ability to be comprehensive (Bono 2001, 139, 142). In this regard, it is important for education based on convergent thinking to combine logic and perception so that facts can be coloured by the breadth and diversity of ideas, sensations, and understandings of the world around us. This leads to an increase in the productivity of education, to the optimization of children's thinking, to the expansion of logic and imagery in intersubject connections, to the search and achievement of original ideas and their solution.

Rumen Stamatov is of the opinion that the relationship between creativity and learning is too contradictory. In the context of learning, creativity is present more as a means than as an end. When creativity is not valued, school achievement is lower. Also, creative students are rated higher if the teachers are creative (Stamatov 2015, 61-62). To a large extent, our educational system is related to the accumulation of knowledge through facts, which, when arranged meaningfully, lead logically to a common direction, goal, or result for the participants in the educational process. Divergent (lateral) thinking is the opposite of convergent thinking. It is based on the different, non-standard, on freedom and curiosity, on the inventive, creative solution to the same problem. This thinking is characteristic of children – they are not burdened by the status quo, norms or channels, free in the field of their imagination, experiencing joy from unexpected, new and non-standard thoughts and ideas.

"The most productive methods of modelling the artistic and creative process are the methods of meaningful analysis of works of art and those of stimulation and motivation, control and self-control" (Chaika 2011, 201).

THE ARTISTIC IMAGE IN MUSIC

The perception of music is related both to auditory sensations and the imagery that these sensations give rise to. According to Andreeva, "musical images, musical processes allow variation in their recreation and at the same time are placed in one field of permissible deviations" (Andreeva 2010, 22). The author specifies that the boundaries of this field are determined by the objective notational text, and the variety of perceptual imagery is based on associations, "with the individual attitude and culture of musical perception being of great importance" (Andreeva 2010, 22). In this sense, Hristozov summarizes that the musical image "reflects the common through the uniquely individual" (Hristozov 1995, 99).

"The artistic image in music is that 'awakened' sensibility which, speaking through its specific and abstract language, succeeds in instilling in man the feeling of a visible 'materialization' of his invisible nature. Based on movement (meter, rhythm, melody), developing over time, music through the image created by it is a kind of impulse, an irrational impulse and a feeling of unlimited freedom of human fantasy and its flight" (Smilkova 2003, 84).

AUDIENCE

"In perceiving and appreciating music, the experience of beauty, the pleasant effect, the feeling of coherence, the elevation of the human spirit - the aesthetic delight is in the first place" (Kholopov 1982, 60).

The good music listener is patient. Patience helps them to allow the art of sound to conquer, to evoke images and reflections, colours, and emotions, to purify and elevate the listener to the invisible levels of his natural essence. The good listener is purposeful – to the right selection of music, to the needs that this selection will satisfy, to the achievement of aesthetic and sensual pleasure. The hedonistic function of music as art is a higher sphere of influence on the sensory, intuitive, emotional human nature. In order to educate and build the foundations of a future responsible, understanding, appreciative and aspiring audience of the musical art, it is necessary to develop the listening needs of children from an early age. The perception of music stimulates and develops the emotionality of the listener, their abstract thinking, their imagery. In the education of future listeners, this activity develops

musical hearing, memory, thinking, experience, fantasy, and imagination. Valuable advice in this direction is given by the Russian composer and teacher D. Kabalevsky: "If you want your young listeners to be active, be active yourself; if you want them to show interest in music – always feel this interest in yourself; if you want them to love music, love for it must live in your own heart; if you want to teach them to think about music – think with them" (Kabalevsky,1980, 55).

The audience's imagination is based on personal life experience, worldview, and the breadth of the surrounding environment from which the listening audience of musical art mostly draws information to feed its imagination. The Russian musicologist Nazaikinsky wrote: "The whole world, in its colours, sounds, sensations, visible, audible, life destinies, smiles and grimaces, passions and moods, sad and cheerful thoughts – this is the sea of life impressions of the artist, which suddenly takes on specific musical sound forms, and after passing through this strait, again flows into the sea of full-fledged, multifaceted, associative representations of the listener" (Nazaikinsky 1972, 178).

RESEARCH

The described observations and research, which lasted for 2 years, were carried out in a kindergarten by the author of the article, and the participants were 35 children aged between 4 and 6. The research is related to the Perception of Music musical activity. Of course, working with children requires flexibility, variety and constantly stimulated interest, which implies a combination of listening, interpretation and creativity in musical activity.

The musical repertoire used is for piano, in relation to the professional skills of the author. It includes fragments from the endless wealth of piano pieces by Diabelli, Clementi, Haydn, Mozart, Beethoven, Schubert, Chopin, Tchaikovsky, Debussy, Gillock, Cornick, Aaron and Bulgarian composers: Marin Goleminov – Five miniatures for piano, Alexander Raichev – Children's album for piano, Krasimir Miletkov – Music box, Parashkev Hadzhiev – Babina's tale. The selected plays have figurative titles – close to the children's world with their content, expressiveness, imagery, emotionality and message.

The purpose of the study is related to the expansion of the general musical culture and aesthetics of children through the development and manifestation of their emotional sensitivity and imagination. Achieving this goal is a step on the way to raising and building a future listening audience.

The tasks set are in the context of the target intentions and include various forms of provoking children's interest: verbalization of the artistic musical image; the game, as an incentive to realize the creative beginning in children.

FORMS OF WORK

Mihaly Csikszentmihalyi defines three levels of music perception: "Listening to music at first is usually a sensory experience. In this phase, we pay attention to the qualities of sound that cause pleasurable physical reactions that are genetically encoded in our nervous system... The next level of difficulty in listening to music is the analogue mode of listening. At this stage, a person develops the ability to call up in his mind feelings and images corresponding to the organization of the music... The most complex form of listening to music is the analytical one. In it, the attention is redirected from the sensory and narrative elements of the music to the structural ones... For this purpose, the ability to critically evaluate the performance is required; to compare the work with earlier or later works by the same composer or with the works of other composers who worked at the same time... As listeners' analytical skills develop, the chances of deriving enjoyment from music increase enormously" (Csikszentmihalyi 2021, 148-149).

Based on the cited three levels of music perception and adapted to the proposed research, the author applied the following forms of work:

The first stage involved an initial hearing of the work. Two variants were experimented: the name of the play was announced/not announced. In both cases, the children's task was to share whether they liked the piece of music or not, and why they liked it or did not like it. In the context of the answers, clarifications were made regarding the expressed preferences: what the children's feelings were while listening to the musical piece; what were the images provoked by the music; which colour was appropriate to illustrate the mood in the performed miniature; if they were artists, what would they draw in the background of the proposed piece of music. In the variant with the announced title of the performed play, the children determined their answers according to the specifics of the image, connecting their emotionality and fantasy with their life experience, with their knowledge of the surround-

ing nature and reality. The lack of a figurative title provoked the child's imagination and transported it (in most cases) to the ideal world visible only to the child, based on dreams, desires, and needs. Of course, this option was also related to children's practice and observations of the surrounding environment.

The second stage was related to the verbalization of the image embedded in the music. The children's task was to compose a short story or a fairy tale after listening to the musical piece again. This exercise delighted the little writers. The ocean of abundance of children's ideas, inspiration, creative invention, enthusiasm and responsible attitude towards themselves and the members of the group – enthusiastic listeners, participating actively and adequately in the narrator's universe – was endless.

Another form of work was a dramatization of the musical image or images embedded in the listening work. Most kids liked performing on stage. It was an opportunity for manifestation of artistic presence (even unconsciously); personal fulfilment; realized thoughts and ideas; and a spontaneous and sincere desire for play in its various forms. Children organized themselves, assigned roles, specified a plot and implemented their plan for the creative and stage importance of the truth they had composed. The dance, facial expressions, and selected movements were in sync with both the musical image and the elements of musical expressiveness – melody, tempo, meter, dynamics, and touches.

Acquainting children with reproductions of the paintings of famous artists who worked at the time when the piece of music was created was a way to expand their cultural and historical knowledge, enrich their visual representations, accumulate impressions, thoughts and concepts.

The third stage regarded the analyticity of the future listeners: critical thinking, comparison, which led to a depth of understanding, meaning and contact with music, to the formation of aesthetics and taste in the future audience for melodic sound art. This period is long and continues at different ages, but it is good to build its foundation from early childhood. In this sense, the forms of work used were aimed at developing children's initial manifestation of critical evaluation through comparison: differentiation of feelings and images in two musical works contrasting in mood; comparing the music of different composers who worked in the same period of European art; distinctiveness in the sound of uniform themes, created by Bulgarian and foreign authors; juxtaposition of the performance of a piano piece transcribed and interpreted through other musical instruments or voice. The development of analytical thinking in children when perceiving music is a necessity, helping both to create a future listening audience of classical music, and favouring (as a perspective) the possibility of uniting the individual structural elements into a whole – a useful process in personality development. The use of the abovementioned forms of work in kindergarten to perceive the artistic image in music by listening to classical piano pieces has a favourable effect on maintaining children's interest in the pictoriality of the musical language; creating listening habits; the personal initiative and commitment of young listeners; children's creative thinking and imagination.

CONCLUSION

The perceptions that the invisible musical language paints do not directly inform. Rather, they engage especially the imagination and fantasy of the individual emotionally and mentally. Listening to classical piano works in kindergarten and verbally expressing their emotional-figurative content develop children's creative thinking and form their listening habits. The role of the teacher is of great importance in creating and maintaining children's interest in perceived classical works. The teacher provokes children's curiosity, intelligence and creativity through his active, engaging and professional presence.

Preparing a future audience – with an established taste, attitude and understanding of the power of sounds and impact of classical music art – is one of the important tasks of preschool music education.

REFERENCES

Andreeva, Ts. 2010: *Methodology of music-performance training*. Plovdiv, VESELA.

Bono, E. 2001: *Teach your child how to think*. Sofia, Kibea.

Chaika, I. 2011: What is a modern music lesson like? Pedagogy of music education problems and development prospects. *III International scientific and practical part-time conference, Nizhnevartovsk*, Izd. Nizhnevartovsk State University for the Humanities, pp. 200-205.

Csikszentmihalyi, M. 2021: *Flow*. Plovdiv, Hermes.

Hristozov, H. 1995: *Musical psychology*. Plovdiv, Macros-2000.

Kabalewski, D. 1980: *How to talk to children about music*. Sofia, Music.

Kholopov, Y. 1982: Changing and unchanging in the evolution of musical thinking. *Problems of tradition and innovation in modern music*. Moscow, Soviet composer, p. 52-104.

Levy, L. 2006: *Cognitive Psychology*. Sofia, Paradigm.

Nazaikinsky, E. 1972: *On the psychology of musical perception*. Moscow, Music.

Smilkova, S. 2003: *Music – the voice of the soul*. Sofia, Shalom.

Stamatov, R. 2019: *Creativity*. Plovdiv, Paisii Hilendarski University Publishing House.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

MODERN TRENDS AND CHALLENGES IN TOURIST ANIMATION

Alexander Angelov
E-mail: office@bvs-entertainment.com

ABSTRACT

Animation began its modern development in the past fifty years and is widely used in tourism. Besides being a valued job in tourism, it helps to call attention to the work of other tourism staff: hoteliers, tour guides, bartenders, sommeliers, those working in the restaurant industry, in casinos, variety shows, spa and wellness centres, etc.

The purpose of this paper is to examine the trends in the development of modern tourist animation and to reveal the challenges it faces. For this purpose, the following tasks have been solved: 1) The term "animation" is defined; 2) The types of tourist animation are examined; 3) The relationship between animation and hospitality is emphasized. In conclusion, possible solutions are given to address the contemporary challenges of tourist animation.

Key words: *tourist animation, trends, challenges, opportunities, solutions*

INTRODUCTION

Tourism of the new millennium. Problems and perspectives for tourism in Bulgaria

Tourism as an economic and social phenomenon is increasingly present in the daily life of hundreds of millions of people around the world. Through tourism, one seeks not only rest, but also cultural experiences, social contacts and acquaintances. The development of tourism, both on a global and national scale, is related to the discovery of new and unknown places and the diversification of the tourist product and the entire range of services.

The tourism industry as an activity, as M. Ribov (Ribov 2003, 18) writes in his work "Tourism in the era of quality", is aimed at “satisfying diverse and constantly growing needs of people for various types of recreation and leisure travel with rational use of all available tourist resources”. The goal is for the client to be not only entertained, but also educated and enlightened. It can be said that accommodation is the face of any tourist destination. Hospitality increases the value of tourist resources by including them in the tourist offer and satisfying the primary and additional needs of tourists. According to T. Dabeva, the hotel industry is "a basic socio-economic tourism activity that produces and sells a complex, territorially limited product to satisfy the basic and additional needs of tourist clientele within a specific physical and social environment" (Dabeva 2017, 19).

Tourism is a set of services. A service is an act or action of the producer in which the user obtains a benefit, but not ownership of tangible physical elements (Kotler 1996, 43).

It is of particular importance to point out that tourism contributes to the development of other related branches of the economy, such as trade, transport, agriculture, communications, etc Tourism occupies the first place in the world among other sectors of the economy in providing jobs, and it can be noted that 10.6% of the total workforce in the world is employed in the field of tourism. According to UNWTO statistics, for 83% of the countries in the world, tourism is one of the five most important sources of income, and for 38% of them, it is the main source of income. Observations show that the state of the trade and payment balance of a given country, the political and international situation, the employment and the income of the population have an impact on the development of tourism.

In recent years, the development of tourism has acquired new dimensions. Many new sites are being built, and existing ones are being reconstructed and modernized. While at the beginning these changes could only be spoken of positively, at the present moment the rampant and indiscriminate construction, especially in sensitive areas, has begun to arouse concern.

On the one hand, it cannot be denied that the inflow of fresh investments and the construction of modern establishments has attracted the attention of tourist operators and customers to the

Bulgarian product. Competition in the tourist market has intensified, as a result of which our country no longer lags behind global criteria and standards in the industry.

On the other hand, the lack of adequate government policy in recent years, the excessive construction and destruction of part of the natural resources, defaced a large part of our tourist resorts by turning them into cities. The outdated and under-capacity infrastructure proved to be a serious problem, which led to a number of problems in the service of tourist sites. In this line of thinking, the rates at which the tourist regions in the country are developing and building are unreasonable and excessive. The ensuing negative effects have been evident in the last few years, when individual tourist sites suffer losses from poor occupancy and from the inevitable decrease in the prices of tourist services, as a result of increased competition. On the other hand, the poor and scarce advertising of Bulgaria in foreign media, as well as the strong influence of the countries competing with ours, also contribute to these processes. In the past two years, Turkey and Greece have greatly reduced the prices of the tourist packages they offer, which attracted a significant part of the tourism clientele, including Bulgarian tourists.

Another serious problem turned out to be the lack of qualified and well-motivated personnel. On the one hand, this is related to the crisis in our entire education system, and on the other hand, the "brain drain" abroad should not be underestimated. The role of individual business organizations in the stimulation, motivation and adequate remuneration of employees in the tourism branch should not be neglected. The problem of personnel and their role is a key factor for improving the quality and development of tourism products, not only because it is the personnel who bring the income for the employer, but also they are the ones on whom it depends whether the tourism business will continue to develop in the future or not.

And last but not least, the still rapidly developing global COVID-19 situation should be noted. A good example is the drastic outflow of 70% of German tourists from our resorts in the summer season of 2020 (https://www.dw.com/bg/).

Modern trends in the development of tourist animation

Tourist animation is a specific activity that combines the development and implementation of special programs for organizing free time. Animation programs include not only sports games and competitions, dances, carnivals, games, hobbies and activities, but are also designed to satisfy higher needs (Dimitrova 2016, 318-323).

One of the fundamental scientific questions in animation concerns the classification of types of tourist animation. In the literary sources, the problem of the classification of animation is considered by individual authors without, however, arriving at uniform criteria, which leads to serious differences. The types of animation in tourism indicated by some of them do not correspond to the modern trends in the development of tourist animation. For example, some of the specified criteria and the classification made by D. Semerdzhiev are generally relevant to this day, but others are can be regarded as an anachronism of tourism practices. The classification of the types of animation is according to tourist activities and free time of tourists (general and specific), age (children, youth, for the third age), and place (hotel, club). According to the "time" criterion, D. Semerdzhiev (1991) defines animation as day and night activities, and according to the demand and interests of tourists as sports, creative animation through communication, animation through experience, cultural animation and animation for relaxation. According to financial criteria, the author indicates free and paid animation. Nowadays, however, we can no longer talk about free animation, but about the fact that a large part of the animation programs is pre-included in the tourist packages on offer, especially in the all-inclusive type.

A. Kokinov, L. Atanasova and B. Balinova (1993) indicate the following classification of animation in tourism: hotel, cultural-cognitive, work-creative, game-adventure, and sports-entertainment. Similar criteria and classification are made by Art. Stamov and Y. Aleksieva, adding the criteria of "nationality", "activity" (passive or active) and "form of expression" (individual or group). According to them, the following types of animation are taking shape in tourism: animation in motion, creative animation, communication animation, experiential animation, cultural animation and relaxation animation. The classification is made on the basis of six criteria, through which a variety is formed in the types of animation in tourism.

The first of these is “age”. This criterion is based on the anatomical-physiological and psycho-emotional characteristics of individual age groups and the need to offer suitable animation

programs for them. According to this criterion, the animation is children's, youth, animation for working age tourists (up to 65) and for those of the so-called "third age".

The second criterion, "place", includes the types of animation offered in the establishments of residence (the hotel and its varieties); in means of transport – the so-called cruise ships, buses, vintage trains and, more recently, airplanes; in dining establishments, attractions, casinos, water parks and theme parks. The "place" criterion is related to the geographical location of the site for animation: mountains, seas, forests, villages, etc.

The third criterion is "form of expression". Until recently, the main thing was the group appearance of the tourists when organizing animation programs. Today, for specific segments of the tourist clientele, individual animation programs are offered on a yacht, while diving, in unique spa centers, with helicopters and others.

The fourth criterion is "time". Two strands of animation types are outlined through it.

The first covers the types of animation, as part of the day - daytime, evening and night (related to animation in attractions, gaming halls, discos, etc.);

The second is related to the consumption of the animation product in a certain season of the year or year-round, as well as to the peculiarities of their supply at the beginning or end of the tourist season.

The fifth criterion is related to the motives for seeking and consuming certain types of animation. According to this criterion, basic types of animations are formed, which permanently dominate over others: cultural, sports, creative. The essential characteristic of their animation product covers various areas of human civilization, relevant even for today's modern society: culture, art, sports, recreation, entertainment.

The sixth criterion is "connection with types of tourism". In modern tourism, the main types of animation should be distinguished and each of them should have its own directions of development.

An animation product may include one or more types of animation. In this case, it is considered a combined or complex type of animation. The tourism organization prepares and offers types of animation for which there is a demand in the tourism market and the necessary resources to supply.

Part of the whole set of animation tourist services is the hotel animation, without which the large hotel complexes based on All Inclusive packages will lose their appearance. Sports and fitness activities for the purpose of entertainment or active sports, themed and creative days for the hotel's youngest guests, group activities for teenagers, evening show programs – these are only a few of the range of activities offered to tourists during their stay in such hotels. This helps to increase the rating of the hotel in the global sites for collective opinions and shares, e.g. hollidaycheck.de or TripAdvisor, it popularizes them and makes them more competitive in the market. Animation is that department in the hotel which is in constant, direct contact with every single tourist. Very often, the animators are the ones from whom the hotel management learns about current problems of operational nature, i.e. animation also contributes to the improvement of operational management. Again, thanks to animation, all other additional services and commercial establishments on the territory of the resort can be promoted. Animation is there to make every tourist's stay filled with positive emotions.

The development of animation is influenced by the development trends of the international tourist market, which in a certain sense are contradictory: on the one hand, globalization of markets and in some segments a great homogenization of tastes, but at the same time the emergence of phenomena such as "global individualism" and, accordingly, new approaches in market segmentation.

International tourist flows (and revenues) are concentrated in a small number of inbound and outbound countries. In America, these are the US and Canada; in Europe – the EU countries, Switzerland and Turkey; in North Africa – Egypt; Japan and some other Asian countries – Singapore, China, and Thailand are becoming increasingly involved.

Animation as a share of tourism is dependent on the availability of resources and factors capable of offering international tourist services: natural resources, cultural heritage, human resources – employment and qualification, technological progress and innovation, prices of services as a motivating factor.

Animation develops in close connection and interaction with other services that are provided during travel and at the place of residence (accommodation, meals, entertainment).

A leading trend in animation is the increased demands on the "animator" profession. The animator is a central figure who strives to create an

unforgettable atmosphere for tourists during their vacation and a good animation product, as well as to raise the image of the tourist clientele.

Animation increases the quality of tourist services. Through it, an attempt is made to mitigate some negative aspects of basic tourist services.

Aligning the concept of the animation product of the tourist organization with the presence of certain types of attractions, natural phenomena, and anthropogenic resources is a trend that seriously stands out in animation today.

There is a worldwide trend towards shorter holidays, but increasing in number and combined with greater demands for quality and variety.

Animation is becoming a key phenomenon in the leisure industry. Free time is used by individuals in accordance with their individual ideas of its appropriate use. Globally, there is a shortage of the "free time" factor, and this has a negative impact on tourism and entertainment clientele.

Recent years have seen an extraordinary diversification of the animation product into traditional types of animation.

Through animation, tourist organizations create unique tourist products offering exciting experiences, motor activities, contact with nature, etc. This shapes the tendency for most animation programs to be complex.

Animation in tourism is subordinated to tourists' preferences, fashion trends and their idea of a full vacation, which is in tune with their attitude to relaxation, more activities, new knowledge, etc. Depending on these preferences, they also choose the tourist destination where to realize their expectations and preferences.

Animation in restaurants contributes to the creation of new consumer habits, to the presentation of new services. Thus, in a festive atmosphere and with the active participation of tourists, new drinks, exotic types of cuisine, etc. can be presented.

One of the avant-garde trends in tourism and sports – wellness – is also applied in animation.

In order to complete the analysis of the trends in the development of animation in tourism, several pillars can be summarized that are the basis of the creation, promotion, imposition and development of the tourist services market. These are: the one created on June 5, 1950. from Belgian Gerard Blitz club "Med"; the German tour operator TUI; large German tour operators Nekerman and ITS, which spontaneously entered Bulgaria in the 1960s; the hotel franchise company Iberostar Hotels and Resorts and the global hotel chain RIU.

Animation enriches the content of the tourist product, gives it more qualities. This increases its usefulness, makes it more valuable for its consumers, the tourists. In addition to becoming more attractive to traditional customers, such a product is successfully launched in other market niches, as animation makes it attractive and relevant. As a product with more features, with opportunities to satisfy a greater number of needs, the tourism product that contains animation has a higher price and brings more revenue. The individual animation events should mostly be free; their role is to increase the total value of the service package.

Some types of animation contribute to the instillation of new consumer habits, the presentation of goods and services, and the advertising of new menus. Thus, in a festive atmosphere with a lot of fun and mood, with the active participation of customers in the program in a restaurant, they can advertise drinks, exotic types of cuisine, and new dishes.

Animation creates opportunities for extending the tourist season, for a better the hotel occupancy. A rich and entertaining program fills and makes sense of the larger amount of free time. Its saturation with cultural events, with opportunities for interesting activities and performances, with the practice of appropriate sports can make a place a travel destination, regardless of the tourist season.

Another trend is that hotel animation is becoming a powerful experiential marketing tool for hotels, so it is very important what kind of animation in terms of variety and quality hotel properties apply. Quality hotel animation contributes to customer retention, which is one of the indicators of the effect of relationship marketing. A proof of this is the relatively large number of tourists who choose the place of accommodation with regards to a specific animation product. More and more hotels pay great attention to animation, as a service in their advertising portfolios (on websites and social networks), thus attracting certain groups of tourists at certain times of the year.

Challenges and possible solutions

Production is internationalized, globalized and integrated. The processes of globalization and regional integration have been developing dynamically in recent years. The movement of people, goods and capital is constantly accelerating. The successful development of national economies is determined by competitiveness, productivity, rapid implementation of new tech-

nologies, continuous improvement of knowledge, capacity and professional skills. For these reasons, the demands on workers and especially on management personnel are increasing. Human resource management must rise to this challenge, and it increasingly requires global thinking and local action (Markov 2008, 220-223).

"When asked 'What is the most serious challenge facing your business today?', the three most common answers are staff shortages (36 per cent), rising prices of goods and services (28 per cet) and the inability to plan long-term business (24 percent). Compared to last year's summer season, hoteliers who consider staff shortages to be a major challenge have grown by 10 percent – from a quarter to a third of all surveyed participants" (https://www.24chasa.bg/biznes/article/13891766).

The development of the potential opportunities of those employed in the hotel business are the main goal in future personnel management. Those hotels that are able to purposefully use the individual capabilities of their employees will be successful. On the other hand, however, the question arises of how to respond to expectations, to activate the potential of people to obey the interests of the organization. More and more people are paying attention to working conditions and quality of life. The economy is also changing. A transition from a social to a socio-ecological economy is taking place. A lot more is required of organizations: they must be socially responsible, environmentally friendly and efficient at the same time. The development of strategies of hotel companies that meet these requirements cannot be done without taking into account the potential of the human resources that are available. Enterprise strategies and human resource management strategies should be coordinated and developed interrelatedly (Vachkova 1998, 87-89).

Technological development drives the changes in production and requirements for employed human resources. The update of products and services is accelerated. Hotel organizations that cannot adapt to the accelerating pace of change will lose their potential for development. In this regard, the requirements regarding the qualification of the personnel have increased. A central place is given to the development of human resources and organizations.

Labour markets are increasingly affected by demographic developments. Accelerated population aging increases the average age of the working population and the ratio of the elderly. The number of people exiting economic activity exceeds the number of new generations entering. The number of population migrations between countries and continents is increasing. At the same time, as technology grows, so will the demand for more skilled labour.

In recent years, the management of workers and the understanding of the role of the human factor have undergone a reassessment and a significant change. The person as the bearer of the organization's opportunities for success is at the center, not only in theoretical debates, but also in the practice of managing more and more organizations.

Unleashing the potential of the workers and placing it at the service of the success of the organization becomes a main goal in the management of human resources. Concepts such as vision, intuition and creative power, leadership, and qualification are gaining more and more importance.

A big challenge for animation in tourism is that the animation product is quite expensive and for that reason it is mainly offered in all-inclusive hotels. There are many other small family hotels which are in no way inferior to the quality of the large hotel complexes. These small hotels cannot afford a full animation program. An alternative solution is to use only children's entertainment to make the stay of young families with children more comfortable and pleasant. Thus, parents will be able to spend time without their children, being sure that there is someone to take care of them and entertain them.

The animation product has a life cycle from the moment we conceive it, then we look for ways to implement it. It cannot be repeated next season. The moment when it is no longer in great demand, something new has to be developed in parallel with it. In order to have an economic benefit, we must discover the tourist's need for a certain type of service or activity and be the first to offer it in the market.

Animation should be considered as a purposeful activity of the tourist company. It is not an amateur performance by a certain individual, but a well-planned, organized and managed activity. It is characterized by all general regularities valid for the production, supply and sales of services in tourism.

In order to organize a successful animation activity, there are certain requirements for well-trained human resources, specifically prepared individuals, and it must be the work of the whole team.

The need for animation exists and it is caused by the current deficits of the living environment, which have not found concrete expression in the daily consciousness of potential tourists. Tourists would not be able to realize their intentions on their own without the necessary organizational and material prerequisites. Effective animation contributes a lot to heightening emotions and stimulates the mental stabilization of the personality.

CONCLUSION

Animation is no longer a service inherent only to tourism. It can be successfully implemented both in sports (through various games and methods of communication to achieve high results), and in corporate business, through the organization of various team building events. Its purpose is not only to entertain guests, to use their free time, but also to divert the attention of the guests from various organizational problems that exist in every hotel. In addition, through hotel entertainment, people with different personalities and from different nations create friendships.

Attracting and hiring the right people for the "right job" is the biggest challenge facing modern tourism, especially tourist animation. This can be guaranteed with a well-established policy and procedures for recruitment and selection of job candidates in the respective company. The entertainer, collaborator or employee should be seen as a bearer of mental, physical and creative potential. The correct and effectively built system for remuneration of employees is a prerequisite for a high degree of productivity and strong competitive advantages, expressed in better service, motivation and personal successes, initiative and creativity, adaptability and loyalty.

REFERENCES

1. Dubeva T. et al. Hospitality. UI. *Science and Economics*, Varna 2017, p.19
2. Dimitrova, Zl., Animation having specific activity and the need for qualified human resource training, *Manage*m*ent and Education*, **1**, (2010), pp. 318-323.
3. Kotler, F., Marketing Management. *Analysis, planning, implementation and control*, Volume II, Graphema, Sofia, 1996, p. 43.
4. Kokinov, A., L. Anastasova, B. Balinova. *Model for animated tourist model of a Black Sea resort*, Burgas, 1993.
5. Markov, I, N. Apostolov, *Tourist resources*, V. Tarnovo, Astara, 2008, pp. 220-223.
6. Ribov M., *Tourism in the era of quality*, Trakia - M, Sofia, 2003, p. 18.
7. Semerdzhiev, D. Analytical review. *Tourist animation - problems and solutions*, 1991.
8. Vachkova, E., *Human resource management. European Comparative Studies*, Univ. ed. "Economy", Sofia, 1998, pp. 87-89
9. UNWTO (United Nations World Tourist Organization), https://www.unwto.org/
10. https://www.dw.com/bg/balkanturism-po-vreme-na-pandemia-kak-se-spravae-bulgaria-v-crizata/a-54548840.
11. https://www.24chasa.bg/biznes/artcle/13891766, accessed on 10.12.2023.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

INNOVATIVE SOLUTIONS IN THE GREENING OF RESTAURANT PRODUCTS

Mincho Polimenov
E-mail: mpolimenov@gmail.com

ABSTRACT

The article aims to study the modern development of the restaurant business and the possibility of innovation of a number of factors aiming at greening the restaurant product. The emphasis is on clean production, where the stages of the technological cycles and preservation of the natural qualities of food products and their chemical and gastronomic composition are important.

Key words: *innovation, environmentalization, axiological-valued*

INTRODUCTION

Greening of the technological production process is related to actions related to "reduction of hazards and minimization of risk" [1]. In production operations, it is important to preserve nutrients during technological processing, and to prevent the risk of microbiological processes. On the basis of modern technical and technological challenges and good innovative practices, clean production and compliance with standards [5] are sought, everything must respond to the greening of production processes and the question of producing ecological, healthy and quality food. Innovative modern technologies [6] should allow multiple repeatability and duration of production cycles while maintaining the standard. The guidelines are for putting natural ingredients into culinary production and increasing the healthiness of dishes while consuming less energy in production and reducing harmful substances from production processes. Not changing the quality of the restaurant product, its healthiness and environmental friendliness should be the basis of the restaurant activity and be a factor in increasing the competitiveness of the restaurant product. Accompanying innovations and adopted innovations should not only take into account the advantages of the introduced technology and service, but should also take into account the costs and benefits of the technology /preservation of the nutritional value of the raw materials during processing and the organoleptic indicators of the culinary products/. Customer reactions to the procedural changes and the axiological advantages of the culinary product. A technology that reduces consumer satisfaction is not useful, no matter how high-quality and cost-effective it is and how much it has reduced production costs. It should not be used and does not lead to prospects.

SUMMARY

An ecological restaurant product entails rational nutrition and innovation of culinary production, improving the quality of culinary production in compliance with technological norms and recipes in order to adhere to holistic healthy nutrition, and to the maxim that food is medicine [7].

Ecological "green" restaurant products strive to offer a more competitive product with a higher quality and a higher price. The recommendations of the American Institute for Strategic Planning are that investment, market share, and net profit, expressed as a percentage of sales, directly depend on quality [4]. The quality of the Wellness ecological "green" restaurant product is a function of the quality of the organoleptic culinary production and of the service technology. It is related to the opportunities and prospects of innovation in the food preparation unit and front of house of the holistic Wellness restaurants. We have a high-quality Bulgarian eco-restaurant product with the synchronization of all production elements capable of working as a whole [2]. It is important for restaurateurs to understand which factor in the innovative eco-production process leads to an increase or decrease in the quality of the healthy restaurant product and whether the innovation investments made lead to an improvement or deterioration in the quality of the Wellness restaurant product and how long it will take to return the expenses made.

Factors that improve the quality of the ecological restaurant product in the individual phases of production are related to innovation coefficients and lead to improved quality, determine the overall approach to culinary production and greater care for the environment and the saving of resources. The factors for innovation of the restaurant activity Ii/RA/ are a function of the innovation coefficients /Ii/ of the factors for innovation of the culinary-production block Ii/CPB/ and of the innovation coefficients of the factors for innovation of the sales hall of the restaurant Ii/CA/ or:

$$Ii/RD/ = Ii/CPB/+ Ii/CA/$$

The material and technological state of technological and production processes in catering establishments is determined by various factors. The specific factors form an indicator of innovation /Pi/ in the specific production block and it is a function of the specifics of the technological operations and of the indicator of innovation of the specific production module. The factors for Ii/RD/ lead to the implementation of innovations in the restaurant product and improvement of the innovation coefficients for quality [8] of the restaurant product Iq/RP/ or the innovation coefficients /Iq/ of the culinary production and the service technology as well as the atmosphere of the offered product dominate here, or:

$$Iq/RP/ = Iq/CP/ + Iq/ST/ + Iq/A/$$

Culinary innovations must be developed in such a way that they should lead to the purification of the body; during technological processing the integrity of the plant and animal cells must be preserved, aspiring to eliminate harmful toxins and chemicals in a unique way and stop the generation of fat deposits. The properties of ionized water with clinoptilolite are invaluable for the human body, the innovation achieves an increase in metabolism, stimulation of the cardiovascular and digestive systems. The aspiration is towards heat treatment with ionized water and consumption of light foods in the spring and summer in compliance with the technological mode of treatment such as:

- When steaming vegetables, meat or fish, it is necessary to slightly salt the water with sea salt to extract the dyes and add flavour to the salt-soluble proteins, to boil and then plate the product.
- Thermal treatment of the plate of fish or meat – the product is previously slightly salted, after both surfaces are sealed for a short time with the purpose of preserving and not leaking digestive juices.
- Healthy vegetables in broth at high temperature – in a large hot functional "wok" pot, instead of oil broth is used, which is heated and then the vegetables are added, processing is quick and vegetables are preserved fresh in depth.
- Healthy steaming of vegetables in broth at a medium temperature – place broth in a functional pot, steam onions for about 3 minutes, add garlic and fresh ginger for one minute, then add the deer.
- Sealing, breading the product in a heated functional dish – processing continues quickly for 2-3 minutes on both sides.

Implementation of innovative technological equipment and technological processes in culinary production leads to the improvement of the quality and preservation of the nutritional and aromatic substances of the products in the culinary products and supply of the digestive system with valuable nutrients in an active form. This innovative culinary model offered in the recipes processes the semi-finished products with machines and technologies in technological and thermal treatment, both in depth and superficially at a strictly defined temperature for a defined time and pressure. Each recipe must ensure the freshness of the nutrients and their caloric content. Dishes during culinary processing must have a specific colour, aroma, juiciness and pleasant taste; when directly affected by the olfactory and gustatory reception, they should arouse the appetite and be accessible. The specific flavours of Bulgarian national dishes lead to the activation of enzymes, the release of digestive juices and consumer satisfaction. Combining the flavours of semi-finished products during pickling and technological processing with herbs and antioxidants such as resveratrol (found in the skins of red grapes, in some herbs, blueberries and seeds) leads to the production of modern healthy culinary menus with good organoleptic qualities (taste, aroma and others.). Dishes prepared technologically in a culinary way (boiling, stewing, baking) must be ecological and healthy for consumers. Dishes with a proven antioxidant effect are being developed, where the action of various free radicals is stopped, which can damage the cells. In the technological processing essential oils are increasingly used through products such as artichoke and parsnip, which stimulate the breakdown of heavy fats in food and help against stress. It is necessary to control the quality of culinary production in a warm kitchen, to

implement and apply such innovative technological operations that will ease the nodal technological operations and reduce costs. The investigated "5/E" restaurants lack a strategy and a production program to focus on reducing costs and increasing quality. Therefore, the coefficient for quality and competitiveness is the lowest /Iq-1.76/ (Fig. 1).

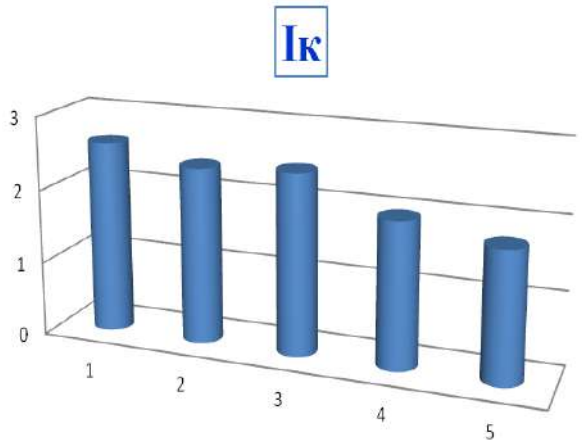


Fig. 1. Coefficient of competitiveness /Iq/ based on the quality and price of the restaurant product. Source: Adapted from "Innovations in restaurant management", based on surveys of the restaurants studied

In the technological processes, we also observe deviations from the culinary rules, dosing, mixing of food products, which leads to anomalies in the culinary production, low weight of the portions and side dishes, low degree of readiness of the dishes and an increase in waste [3]. Reducing waste will also improve the quality of semi-finished products, but this depends on innovative machinery and processing technologies, as well as on the competencies and skills of the workforce, which are often not at the required level. The knowledge should be focused on the complexity of mixing and dosing, combining the products and to what extent. The level of competence will improve the quality of semi-finished products, which is essential for a healthy and rational diet. Implementation in the production of innovative technological equipment in the technological processes leads to the improvement of the quality and preservation of the nutritional and aromatic substances of the products in the culinary products, during such processing of the digestive system, valuable nutrients are supplied in an active form.

CONCLUSION

The analysis carried out leads to the conclusion that the quality of the ecological restaurant product with a positive coefficient for innovation mainly depends on the innovative production factors, on the service technology, design and animation. The implemented innovations lead to the quality and competitiveness of ecological Wellness restaurant products and to an increase in price, which means that with a relative indicator greater than or equal to one, the restaurant business is competitive in the market and to its competing Wellness restaurant products.

ACKNOWLEDGMENTS

The authors are thankful for the support provided by the project of Asen Zlatarov University under Ref. No. NIH-486/2023 “Modeling management decisions with new analysis tools in fuzzy environments”.

REFERENCES

1. Marinov, S., *Nasoki za vnedryavane na kontseptsiyata „Zeleni khoteli” v obshtina Varna*, Izd. „Dangrafik”, Varna, 2009, p. 16.
2. Marinov, S., *Savremenni vidove turizŭm*, Izd. Nauka i ikonomika., IU-Varna, 2011, p. 167.
3. Polimenov, M., [„*Inovazii v restorantyorstvoto*”, Monografiya, izd. Avangard Prima, Sofiya], Polimenov, M *Innovations in restaurant management*, Monography, ed. Avangard Prima, Sofia, ISBN-976-619-160-416-6, Bulgaria, Sofia, 2014, pp. 3-96.
4. Ribov. M. *Turizam bez granitsi Konkurentno predimstvo v turizma*, Izd: Nova zvez-da, 2005, p. 104.
5. Stoikova, I. Zakonovi predpostavki za razvitie na ustoichiv turizam v Bulgariya, *Godishnik na SU ”Sv. Okhridski”*, GGF, 2008., pp. 100-102.
6. Tranev, S., Menidzhmant s izkustven intelekt (AI), *Balgarsko elektronno nauchno spisanie „Stopansko upravlenie“*, Br. 1, 2023, p. 22-50, https://spisanie-su.eu/189-2/
7. Hipokrat, *Neka hranata bade vashe lekarstvo i lekarstvoto bade vasha hrana*, c. 400 BC
8. Jones, Peter and Paul Merricks. *The management of Foodservice Operations*. London, 2007.

ANNUAL OF ASSEN ZLATAROV UNIVERSITY, BURGAS
BULGARIA, 2023, v. LII

EDUCATION OF PATIENTS WITH TYPE 2 DIABETES AND GLYCEMICS CONTROL

Nikolay Kostadinov
E-mail: n.kostadinov_m.d@abv.bg

ABSTRACT

Having in mind the extraordinary variety of medicinal products in recent years, the reason for the poor control turns out not to be the lack of modern treatment. Additional factors are important, the identification and management of which is the key to achieving good glycemic control. A large proportion of patients with type 2 diabetes do not achieve optimal glycemic control. This can be corrected and optimization of glycemic control can be achieved through appropriate patient education. To control the disease properly, a complex approach is needed, including appropriate therapy, change in style and lifestyle, and patient education. The effectiveness of the training is determined by the fact that it can be done at any age and there is an affordable and easy way of application with an accumulative effect, without side effects.

Key words: *type 2 diabetes, education, glycemic control*

INTRODUCTION

A large proportion of patients are not well controlled, and the main reasons for suboptimal glycemic control are:

• the lack of awareness regarding the rules of nutrition, healthy lifestyle and physical activity and the correct intake of medication;

• neglect of the condition on the part of the patient, the lack of possibility for systematic control of the disease.

The reasons affecting training can be grouped as follows: economic factors, geographic factors, factors of patient culture and education, and those related to the inability to access training programs, as well as the lack of unity and consistency of these programs.

REVIEW

Insufficient knowledge about the goals of diabetes care may be one of the reasons for the low level of control of risk factors. According to various studies, 23-25% of patients know what their HbA1C target values are and are aware of how to interpret HbA1C levels in relation to their own control [1]. Diet, physical activity, and medication are partners in the battle to achieve and maintain low-risk levels of blood sugar, lipids, and blood pressure [2]. In addition, courses providing information about DM2 are needed so that older people can change their attitudes to the disease [3]. Patients should be active participants in their treatment and, if necessary, be encouraged in decision-making [4].

Physical activity and therapeutic nutrition are part of the complex treatment of the patient. What is more, in diabetes mellitus, strict adherence to a certain food and exercise regimen are even more important than drug therapy [5]. During follow-up, it was found out that men show less willingness to be trained and attend training course, but at the same time demonstrate better results in an assessment test. At the same time, men are less inclined to apply the knowledge, so the training does not achieve the desired positive effect [6].

MATERIAL AND METHODS

40 patients with diagnosed type 2 diabetes mellitus were examined and surveyed. In order to clarify the medical status of the patient and the history of the disease and accompanying complications and treatment, the patient's medical file was used. The research period was March 2023. – August 2023. Statistical analysis includes descriptive statistics, Student's t-test and Spearman's correlation analysis. A value of $p < 0.05$ is accepted for statistical dependence.

RESULTS AND DISCUSSION

Sociodemographic characteristics and therapeutic approach in the analized patients with diabetic polyneuropathy are presented in Table 1.

Table 1

Demographic characteristics	Values
Sex (%)	
male	50
female	50
Age at onset, years (mean years ± SD)	
male	55.1±6.51
female	50.7±5.7
Duration of diabetes (mean years ± SD)	7.9±5.2

In the studied group of patients, the duration of diabetes mellitus was 7.9±5.2 years. With suboptimal glycemic control of diabetes, 80% (n = 32)-HBA1C-over 7.0% (Figure 1).

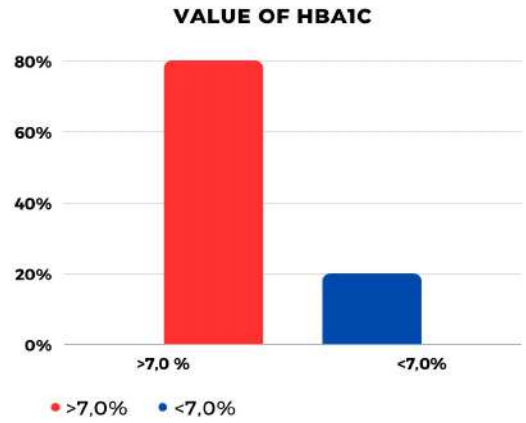


Fig. 1

Patient education is at the heart of diabetes management and good disease control. Without proper training, any therapy is doomed to fail. There are different approaches for implementing the training process, such as group or individual training through brochures and posters, presentations. 17.5% (n = 7) of the respondents felt the need for training for practical exercises, 35% (n = 14) reported a deficit in knowledge of reactions in certain situations, 10% (n = 4) reported a deficit in basic concepts, 77.5% (n = 31) assessed insufficient knowledge about the prevention of complications and 97.5% (n = 39) of patients had a deficit in knowledge about the diet. The data are shown in Figure 2.

At the same time, despite the demonstrated great desire to learn (and maybe in accordance with this), a deficit in knowledge and mistakes in their actual application are found in a large part of patients.

Fig. 2

For a comparison: the opinion of patients about what they want to learn relatively coincides with the opinion of doctors, regarding their omissions. 27.5% (n = 11) of the surveyed group appeared to have a deficit in knowledge about practical exercises, 40%(n = 16) are unprepared for reactions to certain conditions, 22.5 (n = 9) are not aware of basic concepts, 90% (n = 36) are deficient in the prevention of complications, 82.5% (n = 33) are not aware of what their dietary regimen should be. The data are presented in Figure 3.

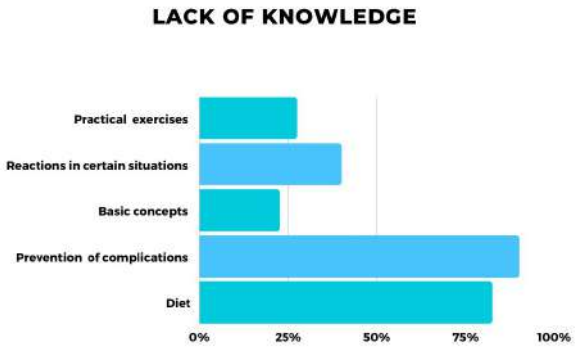


Fig. 3

CONCLUSIONS

The purpose of the training is for the patient and his family to receive basic information about the disease, treatment rules, food and exercise regimen, building practical skills for reactions in emergency situations such as hypoglycemia, familiarization with the chronic complications of the disease. On the part of the patient, there is often a lack of motivation, a lack of trust in the service staff, a lack of commitment in the treatment and

training process, a tendency to deny their role in this process or not to assist in the implementation of the given appointments and prescriptions. The main goal of the training is to motivate the patient to be an active participant in the treatment, performing strict self-control. As possible reasons for the suboptimal control with an assessed good level of knowledge are the application of knowledge that is incorrectly remembered or interpreted by patients, lack of real application of acquired knowledge, errors in practical skills, neglecting the importance of nutrition rules, physical activity and reception of treatment, loss of the effect of training over time, and systematic conscious violations of the dietary regimen.

REFERENCES

1. Harwell TS, Dettori N, McDowall JM, Quesenberry K, Priest L, Butcher MK, Flook BN, Helgerson SD, Gohdes D. Do persons with diabetes know their (A1C) number? *Diabetes Educ*., 28 (1), (2002) pp. 99-105.
2. Tankova T, Borisova AM, Orbetzova M. *Recommendations for Good Clinical Practice in Diabetes Mellitus*, Bulgarian Society of Endocrinology, 2019.3
3. Lima, A. P., T. R. B. Benedetti, L. Z. Oliveira, S. S., Bavaresco, C. R. Rech, Physical activity is associated with knowledge and attitudes to diabetes type 2 in elderly, *J. Phys. Educ*., **30**, (2019), e3017.
4. Daskalova I., Ts. Totomirova. Evaluation of the role of re-education of patients with diabetes mellitus in achieving optimal disease control. *Science Endocrinology*, **5**, (2011), pp. 196-198.
5. Stanchev P., Orbetsova M., Incretins in diabetes mellitus. *Journal of Endocrinology*, **4**, (2016), p. 147.
6. Daskalova, I., Ts. Totomirova, *MEDINFO*, **4**, (2016), pp. 62-64.

ASSEN ZLATAROV UNIVERSITY
ANNUAL, Vol. LII, 2023

TECHNICAL AND NATURAL SCIENCES
ISSN 2603-3968

SOCIAL SCIENCES
ISSN 2603-3976

Design and layout
Libra Scorp Publisher
www.meridian27.com

Printed in M&BM Ltd.
www.mbm-bg.com

Edition of
Assen Zlatarov University
www.uniburgas.bg

BURGAS, 2023

ISSN 2603-3968

ISSN 2603-3976