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ASSOCIATION OF FEEDING WAY IN PEOPLE WITH APOE GENOTYPE ON COGNITIVE FUNCTIONS

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Abstract

Consumption of food in dementia has significant role, not only in aspect of delivery necessary nutrients, but also in psychological aspect. There are some reasons for which patient behaves in that way, like: cognitive dysfunction, psychiatric and neurological symptoms, and decline. Approximately 50% of individuals with symptoms of dementia will have problems within 8 years of disease onset. In the advanced stage of it, they will be greater. Eating-related difficulties may be describe by four significant components, such as: overeating, swallowing problems, decrease in appetite, and obsession with food. Hand feeding and tube feeding might be adopted in such situation. There are many factors contributing to eating disturbances accompanied dementia, they can be divided into: physiological, psychological and sociocultural. The orexigenic system is a group of AgRP/NPY neurons that express appetite stimulating substances, for example NPY (neuropeptide Y) and AgRP (agouti-related peptide, product of the AgRP gene), which initiate meal intake and reduce energy expenditure in starvation. It has a relevant role in regulation of appetite, also in elderly with dementia.

Keywords:

eating disturbances, Alzheimer's senility, elderly

Introduction

Consumption of food in dementia has significant role, not only in aspect of delivery necessary nutrients, but also in psychological aspect. People with dementia require support during eating, as during bathing or toilet.

There are some reasons for which patient behaves in that way, like: cognitive dysfunction, psychiatric and neurological symptoms, and decline. Thanks to that there are changes in appetite and behavior during eating or difficulties, for example „swallowing disturbance”, „change of appetite”, „change of eating habits”, „consumption of inedible objects” [1].

Approximately 50% of individuals with symptoms of dementia will have problems within 8 years of disease onset. In the advanced stage of it, they will be greater [2].

Types of disorders connected with eating in dementia

There are some signs of dementia which accompany consumption. They are showed in Tab. 1.

Tab. 1. Main signs of eating disturbances

Appetite change	Loss of appetite
	Increase in appetite
	Seeking out food between meals
	Overeating at meal time
	Requesting more food
	Reporting hunger
	Reporting being overfull
	Other change about appetite
	Needs to limit food
Food preference	Preferring sweet foods more than before
	Drinking more soft or sweet drinks
	Drinking more tea/coffee or water
	“Taste” in food changed in some way
	Adding more seasoning to their food
	Developing other food fads
	Hoarding foods
	Drinking more alcohol
Eating habits	Wanting to cook or eat the same food every day
	Tending to eat foods in the same order
	Wanting to eat at the same time every day
	Decline in table manners
	Eating with hands
	Other change about food preference
	Taking a long time to eat
Other eating behaviors	Tending to overfill mouth
	Chewing or sucking without trying to eat
	Eating non-edible foodstuffs
	Tending to snatch or grasp any food items
	Becoming a heavier smoker or taking up smokin
	Episodes of vomiting naturally
	Episodes of vomiting by using their fingers

Source: own elaboration based on K. Kai et al. (2015)

Other study conducted on institutionalized people with dementia reveals that eating-related difficulties may be describe by four significant components, such as: overeating, swallowing problems, decrease in appetite, and obsession with food [3].

Possible solutions of eating problems

Hand feeding and tube feeding might be adopted in such situation. Tubes for feeding patients with dementia do not examined enough to implement them into guidelines. In turn, requires caregivers and acceptanceof food taste from patient. Other problems which may occur: clamping the mouth shut, delayed swallowing and refusing to eat [2, 4].

Effects of inadequate food intake

As a result of inappropriate appetite difficulties and so on, some severe disorders can appear, like dehydration, weight loss, malnutrition, and ultimately death. Such conditions are extremely dangerous for elderly person. Factors which have influence on it, are: physiological and psychological factors in an individual and sociocultural level of environment.

Physiological factors can be:

- motor impairments;
- visual impairments;
- dental situation;
- oral hygiene;
- dysphagia.

The most frequent psychological factor is depression and declines linked with dementia potentiate that (impairment of cognition and attention).

Sociocultural factors are:

- a loose-seated dining environment;
- the company of relatives [2].

Regulation of appetite

In the hypothalamus there is the appetostat – the major regulator of the appetite. Some structures in the brain, like: the ventromedial hypothalamic nucleus (center of satiety), the lateral hypothalamus (center of hunger) and the arcuate nucleus, take part in regulation of appetite by several nuclei and interactions among mentioned. Modifications connected with peptides regulating appetite and feeding result in reduction of appetite with age [5].

Neurohormonal path – the orexigenic system

This is a group of AgRP/NPY neurons that express appetite stimulating substances, for example NPY (neuropeptide Y) and AgRP (agouti-related peptide, product of the AgRP gene), which initiate meal intake and reduce energy expenditure in starvation [6].

NPY is a 36-aminoacid neuropeptide, which is produced in others in the hypothalamus. Food rich in carbohydrates has the most orexigenic effects. There are no sure results from studies on NPY and its changes with age. Most of researches were conducted on animals, mainly on rats and mice. What is interesting, higher concentration of NPY in CSF is in female, not in male and it is linked with aging.

Agouti-related protein (AgRP) belongs to neuropeptides and is produced by the AgRP/NPY neurons. AgRP is co-expressed with NPY. It participates in increase of appetite and decrease of metabolism and expenditure of energy. There are no data with the participation of humans. Studies carried out with participation of animals showed that changes in AgRP gene expression progress with aging.

Orexin-A and orexin-B are linked with cravings for food. Due to age-related loss of orexin neurons and the decrease in the orexin-A receptor protein level, they role is minor in animals. Orexins are activated by ghrelin and hypoglycemia and inhibited by leptin [5].

Summary

There are many factors contributing to eating disturbances accompanied dementia, they can be divided into: physiological, psychological and sociocultural. Appetite, neurohormonal pathways and behaviors are connected to eating changes with age. Further studies on humans, taking into account the orexigenic system are needed.

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ASSOCIATION OF FEEDING WAY IN PEOPLE WITH APOE GENOTYPE ON COGNITIVE FUNCTIONS

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Abstract

Consumption of omega-3 fatty acids (FAs), included in fish and fish oil may improves cardiovascular health. Apolipoprotein E (APOE) genotype can impact concentration of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), causing their deficits. Studies conected with E4 are inconsistent, but some of them indicated that reduction in intake of saturated FAs could reduce in LDL-C. Next suggested that interactions between APOE and EPA were significant with HDL-C and particle concentrations of large and total HDL. Carriers of E4 isoform are more exposed to occurence of cognitive decline. Research conducted on mices aimed at comparing concentration of omega-3 FAs established that E4 had a bigger depletion of omega-3 FAs and that early supplementation of DHA may counteract Alzheimer's disease (AD). Storage of amyloid in brain, E4 isoform might reduce DHA supply to cerebrospinal fluid (CSF) in AD. Researches on E4 in human are higly needed with designation of nutritional treatment.

Keywords:

APOE genotype, cognitive functions, diet

Introduction

Apolipoprotein E (ApoE) in human is in three isoforms (ApoE2, ApoE3, and ApoE4). These isoforms vary by a single amino acid replacement. ApoE4 determines the major risk factor for Alzheimer's disease (AD) in genetic filed, ApoE3 is indifferent and ApoE2 has a protective aspect. Pathogenesis of AD with the participation of ApoE isoforms remains unexplained in full. ApoE is probably excuded by glia and induces amyloid- β (A β) production through stimulation of ApoE4, then ApoE3 and finally ApoE2, in sequence. ApoE is joined with ApoE receptors and dual leucine-zipper kinase (DLK) is activizing, as a result. Then MAP-kinase activizes MKK7 and ERK1/2 MAP-kinases. cFos phosphorylation is caused by activated ERK1/2 and the transcription factor AP-1 is impeled. Such mechanism supports transcription of A β precursor protein (APP), what causes rise of concentration of A β [1,2].

Protein mentioned earlier is responsible for lipid transport and major ligand for low density lipoprotein (LDL) receptors, also having a role in metabolism of cholesterol and pathiogenesis

of cardiovascular diseases, not only of neurodegenerative disorders. Every kind of ApoE has specified functions. ApoE2 is involved in causing higher risk for heart disease and in poorly binding to LDL receptors, in that way boosts atherogenic lipoprotein levels. ApoE4 is similar to ApoE2 in terms of entailing the risk for heart disease, but also downregulates LDL receptors by binding preferably to low density lipoproteins, rich in triglycerides [2].

Way of feeding rich in saturated FAs may be connected with accelerated circulating of LDL and with risk of cardiovascular disease [3]. As data from the University of Kansas's Alzheimer's Prevention through Exercise (APEX) Study shows, impaired glucose metabolism and peripheral hyperglycemia are linked with a greater risk of AD. Examined with Type 2 Diabetes Mellitus (T2DM) or with increased concentration of blood glucose, are more endangered of AD occurring and its faster progression from Mild Cognitive Impairment (MCI). Furthermore, peripheral hyperglycemia and insulin resistance contribute to slow glucose flow in the brain, what can react with cerebral amyloid deposition. Even adults who are cognitively normal could have regional cerebral amyloid burden, in case of abnormal fasting glucose [4].

Polymorphism of ApoE gene

ApoE is encoded by the ApoE gene. Polymorphism is connected with methylation. It can be changed at the ApoE locus, where are set polymorphisms of three functional single nucleotide (SNPs). One of the SNP - rs405509 - is in the region of promoter. This kind of SNP is suspected to induce growth of DNA methylation, what is bounded up with decreasing effect on gene transcription. This mechanism constitutes the main functional effect of DNA methylation. rs429358 and rs7412 are following SNP. They are located in the exon 4 and determine isoforms: E2, E3, E4. Last mentioned SNP probably modify DNA methylation, in way of location in the CpG island contained in the exon 4 and they both are CpG-related SNPs (the cytosine allele forms a CpG dinucleotide).

In 2014 were conducted first research linked with methylation of ApoE and its further consequences. Researchers examined near thousand participants and drawn some conclusions due to functions of ApoE, associated with age.

Findings from this research, were:

- Patterns of ApoE methylation are alike in blood lymphocytes and other cell types.
- Apo E gene expression can be linked with methylation process.
- Age is significant component in ApoE methylation.
- ApoE methylation could influence on lipids in the blood.
- Specified ApoE isoforms - genetic variants – are connected with methylation.
- Between age and genetic isoforms overlap some interactions [5].

Triad of factors contributing to AD

There is such a triad in developing of AD. Age, ApoE4 and chromosomal sex are risk factors for AD. Mechanisms associated with them are complex. Differences between sex certainly exist, taking into account AD and this is modified by ApoE genotype. ApoE4 isoform is very frequent in people with AD - over 60% of them have it (at least one). Women are most at risk of AD, also over

60% of individuals with AD, what is examined in significant degree. What is more, ApoE4 decides in more extent of AD in female than in male. One allele of ApoE4 suffices to that in heterozygous women. What is curious in the other hand, homozygous men, carrying ApoE4 are at higher risk for MCI and AD. Unique risk in female could be linked with conversion from perimenopause to menopause. In turn, in men in early aging process AD might occurs [6, 7].

Another study indicates also to Body Mass Index (BMI) as a factor contributing to metabolism of lipids, as determinant in response on omega-3 FA supplementation, what may play a role in progression of AD [8].

ApoE – reason for cognitive decline?

ApoE4 augments the risk for neurodegenerative diseases, diminishes age of morbidity and modifies their progression. Domain interaction – it is probably cause of altered structure of ApoE4, in what overlaps interaction betwixt its carboxyl- and amino-terminal domains. Neurons can be stressed or injured and then ApoE is formed in order to change the location of cholesterol (repair or remodeling of neurons). In this case, they have modified structure, ApoE, which come from them, succumb to neuron-specific proteolysis. As a result of it, neurotoxic fragments is made and they induce for example tau phosphorylation [2].

Both ApoE4 and A β cause consequences in cognitive domains. In research from 2016, in which over thousand participants get involved, among people with MCI, ApoE4 and ravages connected with them were predominantly observed on function of frontal executive (examined with one or two copies of ApoE4). They had worse productivity. Results of A β influenced on cognition, memory, and visuospatial ability. ApoE4 and A β had combined effects in global cognition and verbal recognition memory. In turn, A β had impact on clinical severity and functional status [9, 10].

Altered metabolism of brain EPA and DHA in AD

A β deposition is responsible for sequential proteolytic processing of the APP. The APP and its secretases are transmembrane proteins, secretases are imminent to APP and both are in the lipid bilayer. ApoE is primary lipoprotein in the brain, which role is transport of lipids and metabolism of lipid in the brain. As some studies revealed, in CSF, concentration of lipid showed changes, as the same as in post mortem AD brains.

EPA is frequent combined with DHA in studies. In non-amyloidogenic mechanism of APP is involved EPA, polyunsaturated FAs, they cause accelerated secretion of α -APP secretion. PUFAs augment α -secretase activity in neuroblastoma cells and membranes. PUFAs are lessened in human post mortem AD brains. Omega-3 FAs supplementation could increase A β phagocytosis. Dihydroxy- or trihydroxy-metabolites of Omega-3 FAs (resolvins), especially resolvin D1, is also connected with A β phagocytosis, but also with inhibition of fibrillar A β apoptosis. Moreover, neuroprotectin D1 reduces A β production and expression of gene having pro-inflammatory functions. As a result of it, PPAR- γ signaling causes decreased A β production on non-amyloidogenic pathway.

In AD concentration of DHA is minimalized, due to lower supply in liver and diet. Not only such factors play role, but also superior needs, resulting from processes during neurodegeneration.

Epidemiological researches indicate that seafood intake can moderate cognitive decline in ApoE4 carriers, slowing this mechanism. Neuronal function, signaling, and neuroprotection – these are sections in which DHA participates [11].

Dietary treatment ameliorating blood flow in brain

First of all, one of risk factor of AD is high-glycemic diet. Postprandial glycemia and insulin secretion are important and are modulated by kind of carbohydrates and their amount. Such food includes many processed carbohydrates and sugar, what highly affects the concentration of peripheral glucose and insulin metabolism. This way of feeding promotes not only T2DM, but also aggregation of A β . As Taylor et al. suggests, that type of diet has relevant meaning before occurring of first symptoms of AD in cognitively normal older. Dietary prevention is one of the key component in counteracting of appearing AD [4].

In study conducted on mice, there was used diet called „Fortasyn diet”. Such nutrition may have protective mechanisms on vascular and neurons functioning and included: uridine, docosahexaenoic acid, eicosapentaenoic acid, choline, phospholipids, folic acid, vitamins B12, B6, C, E and selenium. During it there was increased production of phospholipids, what can maintain synaptic genesis and their repair. Mice in this research had 18 months of age and is needed to conduct experiment on older specimens, for example at the age of 24 months of age or older [12].

Summary

ApoE4 genotype, mainly in woman, in combination with older age and unsuitable way of feeding and eating habits, may induce AD and concomitant cognitive decline. Diet conducive to A β pathology is hyper-glycemic and rich in saturated FAs and in general in fats.

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COMPARISON OF SURFACE ROUGHNESS OF Ni-Cr ALLOY AFTER ABRASIVE BLASTING USING Al_2O_3 AND SiC

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Abstract

In the literature data, there are no tests that concern the proper preparation of the Ni-Cr alloy with blast-abrasive treatment for the connection with ceramics, which directly affects the roughness. The aim of this study was to analyze the impact of abrasive blasting using Al_2O_3 and SiC abrasives on the surface roughness of the nickel-chromium alloy. In this research three particle sizes (50, 110, 250 μm) and pressures (0.2, 0.4, 0.6 MPa) was used. Roughness was measured on Hommel-Etamic T8000 device. The highest values of parameters before Al_2O_3 treatment were obtained for 110 μm particles, under pressure 0.4-0.6 MPa and for 250 μm particles under 0.6 MPa. For SiC abrasive the highest parameters were noticed for particles of 250 μm and 0.4 and 0.6 MPa pressures. For the smallest size of abrasives, similar values of roughness are observed under each pressure. Finally, the highest roughness parameters obtained for both abrasives may be best for nickel-chromium alloy and ceramics bond.

Keywords:

Ni-Cr alloy, roughness, abrasive blasting, prosthetics, metal-ceramic bond

Introduction

Dental restorations in form of ceramic crowns in clinical use mainly are formed on metal substructures [1, 2]. Due to the good strength properties and the ability to reduce the thickness of the metal, cobalt-chrome and nickel-chromium alloys are used [3, 4]. In addition, they are characterized by biocompatibility and good corrosion resistance [5]. Metal-ceramic bond is divided into mechanical, chemical and physical. Abrasive blasting ensures the creation of a suitable surface roughness that will ensure mechanical embedded of the ceramic. The diffusion of elements from metal to the opaque creates a chemical bond and appropriate selection of the coefficient of thermal expansion (CTE) of ceramics and metal results in the formation of physical bonds [6].

Incorrect surface preparation or inadequate CTE selection causes the ceramics to break off from the metal foundation. Aboras et. al. in their research checked the problems faced by patients using ceramic restoration. The biggest defect of restoration is the occurrence of air bubbles in ceramic and it concerns 31% of all complaints. A slightly smaller problem, which concerned 25% of applications, was the adhesive chipping off of ceramics from the surface of the metal substructure [1]. Due to the difficult repair of the damaged dental crown, the strength of the

connection is widely researched, looking for a solution that will provide the most durable restoration. In the case of the coefficient of thermal expansion, it is believed that the best solution is to use materials where the CTE of the ceramic is smaller by $0.5 \times 10^{-6} \text{ K}^{-1}$ than the metal CTE [7]. For cobalt-chromium alloy, the abrasive blasting parameters, which provide the best bond strength are determined by the use abrasive size $110 \mu\text{m}$, pressure 0.4 MPa at an angle of the 45° nozzle to metal surface [8]. In the case of a nickel-chromium alloy, which has smaller hardness than the Co-Cr alloy, in literature data is no information about the abrasive blasting parameters that ensure the best connection with ceramics.

The abrasive blasting directly affects surface roughness, which is why many studies focus on the analysis of this issue. Aluminum oxide is used as an abrasive, but some researchers are looking for new solutions that will increase the surface roughness. And so Külünk et. al. they checked the influence of other abrasives on the metal-ceramic bond. Finally, it was recognized that the use of abrasives such as boron nitride positively affects the strength of the boundary between the substructure and ceramic material [9]. Summarizing, the aim of this work was to analyze the surface roughness of a nickel-chromium alloy after previous abrasive blasting, taking into account the influence of Al_2O_3 and SiC abrasives on its parameters.

Materials and methods

The Heraenium® NA nickel-chromium alloy (Heraeus Kulzer GmbH, Hanau, Germany) was used for the test, whose chemical composition is shown in Tab. 1. The samples had the shape of cylinders having a diameter of 7.8 mm and a height of 15 mm . A sandblaster Alox 2001 (Effegi Brega, Sarmato, Italy) was used for abrasive blasting.

Tab. 1. The chemical composition of Heraenium® NA nickel-chromium alloy

Chemical composition							
Ni	Cr	Mo	Fe	Mn	Ta	Si	Nb
59,3	24,0	10,0	1,5	1,5	1,5	1,2	1,0

In order to determine the appropriate time of treatment, the impact of the blasting time on the surface roughness was checked. Al_2O_3 abrasives with a grain size of $250 \mu\text{m}$ at a pressure of 0.2 MPa were used for this test. The distance of the nozzle from the surface was 15 mm , and the angle of 45° . Taken 12 samples, each of which further were treated with a time of 5 seconds longer. Then, in order to remove the loose abrasive grains from the surface, the samples were cleaned in an ultrasonic bath for 8 minutes using deionized water. A surface roughness test was carried out using a Hommel-Etamic T8000 profilometer (Jenoptic, Schwenningen, Germany) with a measuring probe with a tip radius of 0.005 mm . The measurement speed was 0.5 mm/s with a 3.2 mm profile mapping section. Ultimately, 15 seconds was determined for the appropriate abrasive blasting time. Above this time, no statistically significant differences in the roughness parameters were observed.

In further tests, the samples were divided into two groups, of which the abrasive Al_2O_3 was used for the abrasive blasting and in the second the SiC. Each group was divided into subgroups, where the size of abrasive grain and pressure was variable:

- Size of abrasive grain:
 - 50 μm
 - 110 μm
 - 250 μm
- The pressure of treatment:
 - 0.2 MPa
 - 0.4 MPa
 - 0.6 MPa

Each sample was processed at a distance of 15 mm from the surface, set at an angle of 45° . The surfaces were then cleaned from loose abrasive grains in an ultrasonic bath for 8 minutes using deionized water. The surface roughness test was carried out with a profilometer, as in the case of the impact of blast-cleaning time. The results were obtained from the parameters Ra, Rz, Rv, Rp, Rt, Rq and Rk.

Results

The results from the surface roughness test after abrasive blasting are presented in Tab. 2 and Tab. 3. The comparison of the Ra and Rz parameters for Al_2O_3 and SiC treated samples is presented in Fig. 1 and Fig. 2.

The highest values of all tested profile parameters for Al_2O_3 blasted samples were achieved for grain size 110 μm , under pressure 0.4 MPa. Slightly lower values are observed for the same abrasive size and for 250 μm at a pressure of 0.6 MPa. The smallest roughness values are observed for the treatment with the lowest pressure (0.2 MPa) and the finest grain (50 μm).

Tab. 2. Roughness test results for abrasive blasting with Al_2O_3 samples

Al_2O_3								
Size of grain [μm]	Pressure of treatment [MPa]	Ra [μm]	Rz [μm]	Rv [μm]	Rp [μm]	Rt [μm]	Rq [μm]	Rk [μm]
50	0,2	0,73	5,22	2,57	2,64	6,59	0,93	2,30
	0,4	0,89	6,23	2,85	3,38	7,27	1,12	2,76
	0,6	0,68	4,57	2,35	2,21	5,27	0,87	2,10
110	0,2	0,99	6,58	3,09	3,50	7,92	1,23	3,23
	0,4	1,83	10,86	5,45	5,40	13,71	2,26	6,17
	0,6	1,62	10,31	5,22	5,10	12,39	2,02	5,26
250	0,2	0,93	6,32	3,04	3,29	7,30	1,17	2,96
	0,4	1,40	8,94	4,19	4,75	10,39	1,74	4,55
	0,6	1,54	10,02	5,01	5,00	12,15	1,92	4,95

Source: own elaboration

In the case of roughness parameters obtained for samples after abrasive blasting with SiC, the highest values are observed for the surface sandblasted with the largest grain (250 μm) under pressure 0.4 and 0.6 MPa. With the reduction of abrasive size, the values of all parameters are reduced, and so the smallest is noted for 50 μm grains. Noticeable is also the influence of the pressure of abrasive blasting on roughness, where in every grain size, the use of the smallest value of pressure causes the reduction of the profile parameters. However, the use of a larger grain size increases the roughness.

Tab. 3. Roughness test results for abrasive blasting with SiC samples

SiC								
Size of grain [μm]	Pressure of treatment [MPa]	Ra [μm]	Rz [μm]	Rv [μm]	Rp [μm]	Rt [μm]	Rq [μm]	Rk [μm]
50	0,2	0,72	4,79	2,42	2,37	5,82	0,90	2,22
	0,4	0,92	6,27	2,82	3,45	7,46	1,15	3,02
	0,6	1,00	6,97	3,28	3,69	8,02	1,26	3,22
110	0,2	0,88	6,39	2,89	3,51	7,50	1,11	2,82
	0,4	1,59	10,96	5,40	5,64	13,20	2,02	5,00
	0,6	1,50	10,59	4,93	5,65	12,51	1,90	4,85
250	0,2	1,95	13,14	6,34	6,81	16,15	2,47	6,18
	0,4	2,86	19,24	9,30	9,94	24,29	3,68	8,37
	0,6	2,89	18,40	9,11	9,29	22,97	3,65	8,80

Source: own elaboration

Comparison of Ra values between the samples after Al_2O_3 and SiC treatment, it can be observed that in the case of 50 μm grain size blasting at 0.2 and 0.4 MPa pressure, Ra values are almost the same for both abrasives. The use of 0.6 MPa pressure during Al_2O_3 treatment decreased the Ra value, inversely as in the case of SiC where a slight increase in the analyzed parameter is observed. The grain in size 110 μm for abrasive blasting with aluminum oxide ensure the highest values of roughness parameters for pressure 0.4 and 0.6 MPa. Also, high enough values are observed for 250 μm blasting surfaces, under the same pressures. When using the lowest pressure in both sizes of Al_2O_3 abrasives, similar values of the Ra parameter are noticed. Preparation of the surface with silicon carbide causes that the highest roughness parameters are obtained for the treatment with the largest grain used (250 μm). For 110 μm abrasives, the Ra values for each pressure are lower compared to aluminum oxide.

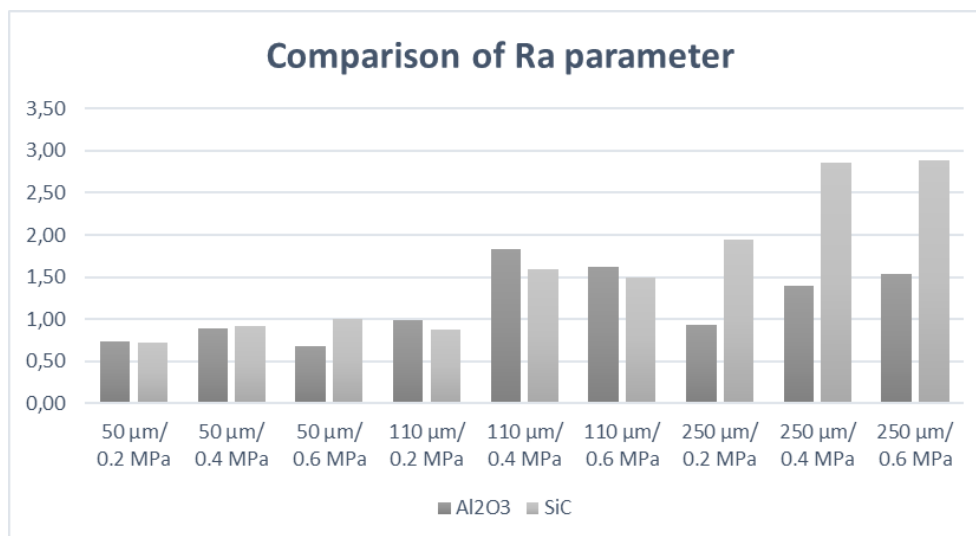


Fig. 1. Graph showing the differences in the Ra parameter value for the blasting samples with Al₂O₃ and SiC abrasive
Source: own elaboration

According to Pietnicki et. al. statistically significant parameter of surface roughness turns out to be Rz, which concerns the roughness height. [10] Comparing these values for samples after Al₂O₃ and SiC treatment, it can be observed that for grains with a size of 110 μm no differences are observed (Fig. 2), in contrast to the Ra parameter. In other cases, the ratio of compared abrasives remains unchanged.

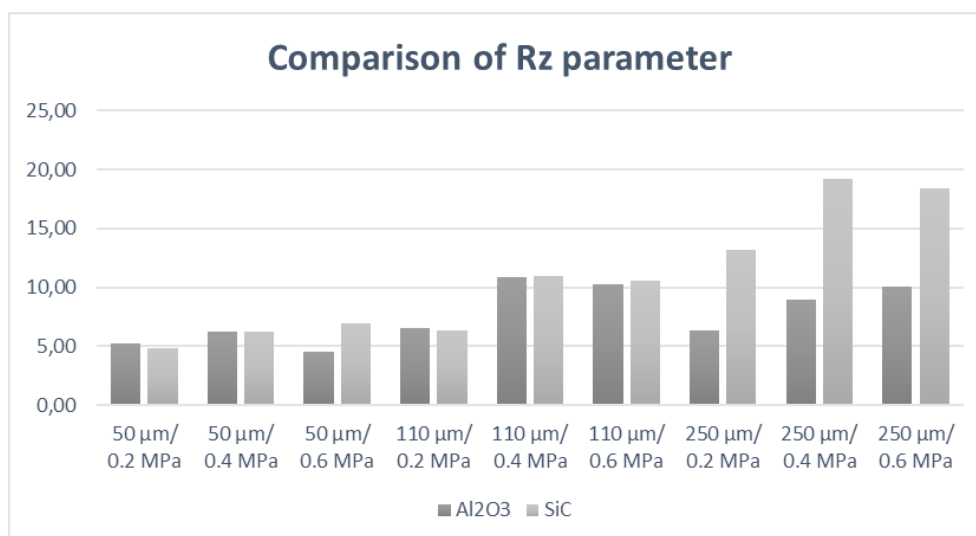


Fig. 2. Graph showing the differences in the Rz parameter value for the blasting samples with Al₂O₃ and SiC abrasive
Source: own elaboration

Discussion and conclusions

In the dental technician, nickel-chromium and cobalt-chromium alloys are mainly used to form the metal substructure for the restoration [11]. These alloys are characterized by good mechanical properties, and the biggest differences between them occur in hardness values. In the case of Ni-Cr, the hardness is between 210 and 380 HV, the hardness of the Co-Cr alloy and between 330 and 465

HV [7]. During abrasive blasting, which is the basis for creating a mechanical connection between metal and ceramic, the hardness of the work surface translates into the amount of abrasive stuck into it. There are studies in the literature data that concern the analysis of the percentage of abrasive on the surface of the metal after sandblasting with aluminum oxide. In the case of a cobalt-chromium alloy, the largest amounts of embedded abrasive are observed for treatment at an angle of 90° to the surface of the sample and they are less than 30% [12]. The best parameters for sandblasting the Co-Cr alloy for ceramic restorations are the use of 0.4 MPa pressure, Al_2O_3 grain size $110\text{ }\mu\text{m}$ and an angle between 45° and 60° . [8, 13, 14] In these parameters, the amount of abraded abrasive is determined at 16.8-15.5%. For the nickel-chromium alloy, the percentage of embedded grain in the given parameters increases to 26.4-28.0% [15]. These values can greatly affect the strength of the metal-ceramic bond.

The roughness of the surface of the metal substructure affects its connection with the ceramic, which during the firing flows in unevenness causing the formation of a mechanical hitching [13]. The abrasive blasting of the nickel-chromium alloy with aluminum oxide causes that the best roughness results are obtained, similarly as in the case of the cobalt-chromium alloy, for the grain size $110\text{ }\mu\text{m}$ at 0.4 MPa. The high strength of the metal-ceramic joint can also be achieved by samples, where the surface has been sandblasted with a grain size of $110\text{ }\mu\text{m}$ and $250\text{ }\mu\text{m}$ at a pressure of 0.6 MPa. The lowest roughness parameter is obtained for the lowest pressure (0.2 MPa) and the smallest grain size ($50\text{ }\mu\text{m}$). For SiC abrasive blasting, the highest roughness is observed for grain size $250\text{ }\mu\text{m}$ and these results are much higher compared to the best parameters obtained for the first abrasive. Ultimately, this can significantly increase the strength of the metal-ceramic bond. The Rz parameter, which according to the researchers is statistically significant when creating the ceramic restoration, turns out to be almost the same for both abrasive grains with a particle size of $110\text{ }\mu\text{m}$ for each pressure. In the bond strength test, after ceramic firing, similar values should be obtained.

Pietnicki et. al. in their research they checked the surface roughness of the cobalt-chromium alloy after abrasive blasting using Al_2O_3 abrasive [10]. The abrasive blasting pressure was 0.4 MPa and the grain size: 50, 110 and $250\text{ }\mu\text{m}$ were determined. The Ra parameter for $50\text{ }\mu\text{m}$ grains was $0.64\text{ }\mu\text{m}$, for $110\text{ }\mu\text{m}$ - $1.2\text{ }\mu\text{m}$ and for $250\text{ }\mu\text{m}$ - $1.52\text{ }\mu\text{m}$. For the Ni-Cr alloy, the Ra values were respectively: $0.89\text{ }\mu\text{m}$, $1.83\text{ }\mu\text{m}$ and $1.4\text{ }\mu\text{m}$. The greater roughness that was achieved for the Co-Cr alloy when blasting $250\text{ }\mu\text{m}$ grain caused a reduction in the connection strength from 41.92 MPa for $110\text{ }\mu\text{m}$ grains to 28.88 MPa. Higher values obtained for the Ni-Cr alloy may result in the best strength values obtained with abrasive blasting using $250\text{ }\mu\text{m}$ particles. In research Akova et. al., Al_2O_3 with a grain size of $150\text{ }\mu\text{m}$ was used to process the surface of the metal using a pressure of 0.6 MPa [16]. Higher values of shear strength of the metal-ceramic bond were achieved for the Ni-Cr alloy and amounted to 81.6 MPa. For samples made of Co-Cr alloy, the bond strength was 72.9 MPa. Such results may support the hypothesis that the larger grain has a positive effect on the combination of Ni-Cr-ceramics. Many cases in the literature refer to strength tests of metal-ceramic bond, where the surface of the Ni-Cr alloy is treated with a grain size of $50\text{ }\mu\text{m}$ [17÷22]. They mainly concern the comparison of abrasive blasting with laser surface etching and abrasive blasting is performed using different pressures ranging from 0.2 MPa to 0.6 MPa. The results of the conducted strength tests range between 11 and 30 MPa, so ultimately the smallest abrasive grains

can be considered as having a negative impact on the joint by creating insufficient roughness on the metal surface.

Mainly in the research, the surface of metal alloys is treated with aluminum oxide. Külünk et. al. in their study, they compared the effect of surface blasting with different abrasives on a metal-ceramic bond. In this test Al_2O_3 particles with sizes 50 and 110 μm , synthetic diamond particles (30-50 μm) and abrasive materials in the form of boron nitride (60-80 μm) are used [22]. Abrasive blasting took place under very low pressure, which was 315 Pa. The shear strength of the bond was tested, where it turned out that even at such a low pressure, the boundary strength was increased by using Al_2O_3 particles with a size of 110 μm also for the Ni-Cr alloy compared to 50 μm particles. An increase in bond strength in the samples, where the treatment was carried out with a different abrasive than Al_2O_3 was also observed.

Finally, the dependence between the abrasive blasting parameters and the strength of the metal-ceramic bond is observed. Surface roughness significantly affects prosthetic restorations. The surface roughness tests carried out show that in the case of Al_2O_3 abrasives, the parameters that ensure the highest surface roughness appear to be grains with a size of 110 μm at a pressure of 0.4-0.6 MPa and abrasive at 250 μm at a pressure of 0.6 MPa. The use of SiC particles increases the roughness significantly using grain size 250 μm . For smaller grains, roughness parameters are almost the same as for alumina oxide.

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ANALYSIS OF METHODS PREVENTING STALING

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Abstract

Slicing bread leads to a series of adverse organoleptic changes. The skin becomes soft and dull, while the crumb is dried and brittle which is associated with the redistribution of water during storage. The fresh scent of bread and the characteristic taste are also gone. The speed of the staling process depends on many factors depending on the technological process and storage conditions.

The methods to prevent staling include:

- addition of excipients (eg enzyme preparations, proteins, lipid compounds),
- freezing,
- thermal method,
- storage in a modified atmosphere.

The complete stopping of staling is virtually unachievable, however, the search for methods capable of prolonging the storage life of the bread is undertaken all the time [1].

Keywords:

bread, supplements, bakery

Introduction

Chopping leads to a series of adverse changes in the organoleptic characteristics of the bread. Crust of bread becomes dull and soft, and the crumb is crumbly and dried, which is related to the redistribution of water during storage. The smell of fresh bread and the characteristic taste disappears. The speed of staling is determined by many factors that result from the technological process as well as the storage conditions. Changes related to the technological process result from the quality of flour used, baking parameters and additions to the dough. Regardless of the conditions used, storing is taking place during storage. This process can only be inhibited in some way by using the right packaging, optimal temperature and composition of the atmosphere gas and various additives. Chopping bread is not the same as drying bread, however, these two processes can run at the same time [1].

Mechanism of staling process

The mechanism of staling is complex and not fully understood. It is associated, inter alia, with changes occurring in the starch-protein complexes. Until recently, it was thought that the main element included in the wheat bread is gluten, while starch is responsible for the formation of bread crumbs in rye bread. Starch was treated as an inert filler, necessary in a certain amount to dilute the protein and obtain appropriate properties. However, gluten was able to replace the gelling substance, while no substance replaced the starch, which indicates that it is the irreplaceable when preparing the bread [2].

Gluten during the production of the dough acts as a skeleton with a spatial structure that binds hydrated starch grains. The staling process itself is related to structural changes that take place in individual starch fractions. A series of reactions consists in the interaction between its macromolecules, which then leads to their crystallization, aggregation, and loss of ordered structure. During baking, the starch absorbs some of the secreted water from protein, while during staling it releases a certain amount of absorbed water. Then, the solubility of the starch is reduced, as well as the solidification of its structure (hardening). The most important in this process is attributed to the changes that amylose undergoes. During baking, it changes into a liquid form, and during staling it is transformed into a gel again [1].

When the hot bread cools down and the crumb temperature decreases to 60°C, so-called retrogradation of starch appears. "Retrogradation consists in certain transformations of starch, which from a state that is partly unsteady during baking, passes back in an orderly form, creating a crystalline network. This phenomenon is accompanied by the release of water, which migrates towards gluten. Starch bonds are formed in the starch molecule. Therefore, the process of staling the bread is the opposite of baking. With appropriate size of amylose chains, hydrogen bridges may be formed between the oxygen-containing substituents of adjacent chains" [2]. The phenomenon of retrogradation occurs mainly in short-chain amylose, because particles containing 1000 glucose units show some inertia and it is difficult to approach another type of particles [2].

The transformations that occur in the amylopectin during storage of the bread result in a reduction in the starch swelling capacity during staling. Retrogradation of amylopectin is limited, due to its irregular structure. There is only association of external, simple, short chains. The association process that runs only within the side branches of amylopectin and allows its particles to contact, does not allow them to be set in a specific order, and thus the amylopectin is more difficult to remove the water of hydration.

The newer model of breading, developed by Hosene and Martin, assumes the emergence of interaction between the continuous (gluten) phase and the swollen starch granules that lead to the formation of hydrogen bonds. At the moment of staling the bread, the pound loses its kinetic energy and hydrogen bonds become stronger, more numerous, and increase the hardness of the crumb [1].

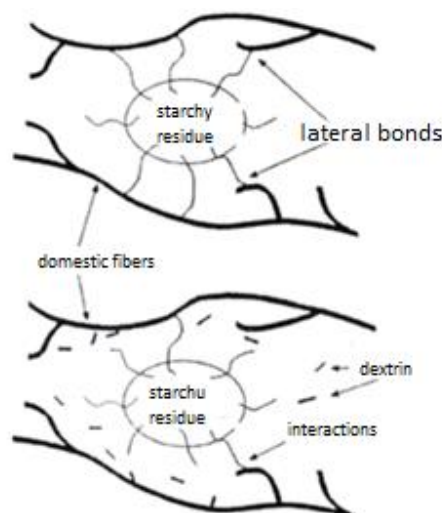


Fig 1. The process of hardening of the crumb and the role of dextrins in the prevention of staling [2].

The authors of this model (Fig.1) assume that the amount of cross-links between gluten and starch is dependent on the starch itself, specifically the degree of its swelling and lozenge. At the moment when the grains are less swollen and less amount of starch particles (mainly amylose) is dissolved, the smaller the contact area of gluten proteins and starch. As a result, weaker cross-links between the starchy and protein fraction are formed, which leads to a reduction in the hardening of the crumb. The dextrin content, which arises due to the activity of amylases that hydrolyze starch molecules during baking as well as the fermentation of dough, is important in the described model. Dextrins consisting of approx. 3-9 glucose units (average chain length) are able to delay staling. The bread with α -amylase hardens much slower than without the addition of enzymes.

The amylases used in industry act on starch during fermentation and baking, and also contribute to the formation of dextrins that hamper the formation of cross-links between protein fibers, slowing down the entire staling process.

It is possible to partially refresh the bread, determined even by the reversibility of staling, by providing energy in the form of heat. This leads to the breaking of hydrogen bonds, and then the gel goes into a free state, which allows the particles to roll back into a spiral. The starch-fat complexes also have a significant influence on starch retrogradation. During the gelatinization of starch, as well as the release of amylose, release of monoglycerides may lead to a situation where the starchy grains are surrounded by insoluble complexes (monoglycerides-amylose), which block or reduce the further action of amyloses. In this way, some starch granules can still maintain the natural form at higher temperature limits, and the amount of released amylose present between the starch grains is reduced. Limiting the swelling of starch granules increases the availability of water in the gluten phase and this can affect the level of hydration between gluten and starch. Due to the fact that amylose can crystallize already in the first hours after baking, reducing the amount of so-called "free amylose" may contribute to improving the elasticity of the parenchyma [2].

Methods of preventing staling

Numerous losses related to staling tend to search for optimal solutions that will be able to stop this process and prolong the freshness of the bread.

For this purpose, various additives are used, among which one can be distinguished:

- enzymatic preparations,
- emulsifiers and hydrocolloids,
- lipid compounds,
- proteins,
- non-starch carbohydrates [3].

Enzymatic preparations

For several decades, enzymatic preparations have been used in the bakery industry, the addition of which has the purpose of slowing staling. Amylases are very effective, because they contribute to the distribution of starch to dextrins and disaccharides, and also increase the volume of the loaf and improve the porosity of the crumb. The most optimal are enzymes that remain active above the gelatinization temperature and lose it due to thermal inactivation at the end of baking. Therefore, preparations with a low degree of thermostability, eg cereal and fungal amylases, do not contribute to the reduction of crumb hardness. Preparations with high thermal stability (bacterial amylases), despite their effect on the structure, cause its gummyness and lack of typical elasticity. Therefore, to obtain bread with favorable structural properties, the bacterial amylases should be controlled by selection of the dose and the temperature of inactivation. Unfortunately, this is a very difficult operation, because during the baking enzymes are not inactivated and they remain active in the finished product. The best enzymes to achieve this effect are the exoenzymes produced by *Aspergillus Niger* and *Bacillus megaterium*, which is characterized by average thermostability. One of the best enzymes for this purpose are α -amylases, which release from the starch low molecular weight dextrins that limit the retrogradation of amylopectin, thereby delaying the staling of the bread. In addition to starch degrading enzymes - fat, protein, hemicellulose and pentosan preparations are used. The use of proteases as a supplement is indicated in the case of flour with very strong gluten, in order to loosen its structure, as well as improve dough consistency, color and bread volume expansion. The addition of cellulases reduces the hardness of the crumb and reduces the speed of starch retrogradation, while the pentozanases break down pentosans, improving the structure of the crumb and increasing the bread volume, and also facilitate the even distribution of water.

The use of lipases causes the release of mono- and diglycerides from fats present in the flour. This leads to an increase in the softness of the bread. On the other hand, lipases combined with triglycerides added to the flour cause an increase in the bread volume and a reduction in the hardening or staling rate. In the bakery industry, the addition of dried maltodextrines or ready-made starch hydrolysates, which are more and more often used as a fat substitute, are used to improve the quality of bread [1].

Emulsifiers and hydrocolloids

The surfactants, eg emulsifiers and hydrocolloids, which shape its structure, have a positive influence on the durability and quality of bread. According to Ambroziak [1], these substances provide a strong connection to the protein during the mixing process and thus reinforce the dough structure, while during baking at high temperatures they combine to form complexes with starch. Thanks to this, the bread crumb freshness is increased and its elasticity increases. Mono- and diglycerides of fatty acids, their mixtures and esters with various types of acids, e.g. lactic, acetic, citric or tartaric acid, are used as emulsifiers of confectionery, confectionery and bakery fats.

The natural emulsifier can be considered lecithin, which is a phospholipid and accompanies vegetable and animal fats. In the industry, it is obtained by hydration of vegetable oils, mostly rapeseed and soybean oils. In studies carried out by Haber and others [5], wheat bread with the addition of soy or rapeseed lecithin showed less compressibility or hardness of the crumb. The loaf was characterized by a larger volume, and the stalactite slowdown was also observed, which was correlated with the content of the CO₂ stored in the dough. The most beneficial effect was found after using hydroxylated lecithin. According to studies by Sobczyk and Lewczuk [6], 1% addition of powdered or raw soybean lecithin to flour resulted in lengthening the freshness of the bread and improving the overall quality. Hydrocolloids are important when making dough and shaping the gluten matrix. They exhibit a high water absorption capacity, and their presence reduces the rate of hardening of the crumb, and also has a pronounced effect on the physical properties of gluten. In the case of the industry, seed meals, natural vegetable gums, hydrocolloids obtained by microbiological methods are used [3].

Lipid compounds

Another group of compounds used to prolong the freshness of bread are endogenous lipids and flour fats. During baking, they form complexes with starch, thus delaying the hardening of the crumb and stale bread. During dough growth, lipids can also be complexed by flour proteins. The formation of lipid-starch aggregates is strongly related to the presence of low molecular weight hydrophobic proteins with aggregation tendencies (ligolins). They are responsible for the fat distribution between the gluten protein. The fats that are incorporated into the protein matrix are important because they shape the properties of the crosslinked gluten and are necessary for the propagation and retention of carbon dioxide. In most of the flours, the amount of endogenous fats is not too high, therefore their addition will allow to prolong the freshness of the bread and guarantee the proper, fine porous structure of the crumb [1].

Proteins

A beneficial effect on the various characteristics of bread can be obtained by adding wheat gluten to flour, other proteins or high protein raw materials such as dairy products or soy flour. Skimmed milk powder, added at around 3%, also increases the nutritional value of the bread and the calcium content of the flour. In addition, it improves the color of the skin, the porosity of the crumb, as well as the taste of bread and extends its freshness. As a supplement to improve the qualities of

bread, whey is used, which allows you to improve porosity, elasticity, improve the aroma and taste qualities and give a more intense color to the skin. Such bread has a higher shelf life compared to bread without whey.

The most appropriate choice is to use a counterpart of acid whey with a high degree of concentration (60% dry matter), which has a positive effect on the overall quality of the bread. Whey contains calcium, which increases the degree of aggregation of proteins by forming ionic bonds between carbonyl groups of adjacent protein chains. This phenomenon has a significant impact on the hardness of bread and by reducing the amount of calcium in the proteins, it helps to obtain the right softness of the crumb. In addition, heat treatment of whey proteins reduces the rate of bread staling [3].

Non-starch carbohydrates

The non-fractions fraction of sugars, which is a large amount of dietary fiber, has a positive impact on the production technology and, consequently, on the quality of the bread.

In the rye grain, this sugar fraction consists mainly of arabinoxylans (pentosan substances), insoluble and water-soluble lignins, cellulose, beta-glucans, and a small amount of pectin. The largest amounts of pentosans are found in rye flour, where they constitute 3-8%, while in wheat flours there are about 2-3%. These substances show high water absorption and the ability to form aqueous solutions with increased viscosity. Due to this, they improve the properties of the dough and the bread obtained from it. Insoluble and soluble pentosans, despite some similarities in the chemical structure, have a different effect on the quality characteristics of bread. Soluble Pentosans increase the volume of bread, while insoluble pentosans have a positive effect on the textural properties of the crumb and the volume of bread. In addition, pentosans limit the formation of intermolecular amylose connections and also slow down the retrogradation process of starch gel and stale bread. As a result of these reactions, the loss of soluble amylose in the bread is reduced, and the starch susceptibility, to α -amylase activity, is increased. The added pentosans affect the production technology, physical characteristics of the dough and gluten. A similar effect of improving quality and freshness is achieved by adding 2% of the dried pectin extract obtained from apples to the flour [4].

Other factors that prolong durability

In addition to the abovementioned staling process, the right flour quality, the right baking process and the preservation of finished products can also affect. In order to extend the shelf-life of the bread, a portion of the flour is used and intense mixing is carried out. The final quality of bread and durability during storage are also influenced by appropriate processing parameters, fermentation conditions, optimum dough growth and, above all, optimal baking temperature.

Fixing rye, wheat and wholemeal bread packed in aluminum foil or kraft paper, using a radiation dose of 1.5 kGy, allows maintaining the proper microbiological quality (stopping the development of mold), even up to 30 days at room temperature or higher. Slicing bread to a greater extent depends, however, on the production method itself, and not microbiological fixation, which does not stop the transformation of starch. Another method of fixing is the use of elevated

temperature - the so-called thermal method. It involves heating the bread and obtaining a temperature of 95°C inside the crumb for a few minutes. In Poland it is also acceptable to use the so-called antifungal substances such as propionic acid and some of its salts (sodium, calcium). By adding them in the amount of 0.2%, the shelf life of the bread is extended to 10 days. They also have an adverse effect, delay the fermentation of the dough, and with the use of light flours slightly change the taste. All kinds of preservatives should be only an auxiliary means to extend the durability of bread [3].

Freezing food

For fixing methods in which low temperatures are used, we can include:

- cooling - temperature 10-0°C,
- freezing - temperature below -18°C.

Freezing food, including bread, is considered a method that allows to maximally extend durability while maintaining the nutritional value and sensory attributes of bread [4].

Freezing bread, followed by storage in a frozen state is considered to be very effective means of delaying staling, it also allows for prolonging shelf life and shelf life. In addition to the storage temperature, the freshness of the bread is also significantly influenced by the relative humidity and the composition of the atmosphere. The most favorable conditions for storing bread are temperatures below -15°C and above +35°C. However, the interval between the temperatures exchanged is not beneficial for maintaining the desired bread characteristics, because in this range, and especially from -2 to 0°C, the starch retrogradation process and staling are fast. After cooling, the bread is subjected to very fast freezing, usually to a temperature of -20°C in the thermal center, and then at the same temperature it is stored. At lower temperatures, there is the possibility of freezing water from the starch-water colloidal system, and after thawing, the starch goes into a crystalline form. Storage using freezing prolongs the shelf life of the bread, but unfortunately does not completely stop the physicochemical and sensory changes. The intensity of this type of transformation depends on the recipe, the baking technology, the type of bread, the speed of freezing and the conditions and time of freezing storage, as well as the method of thawing. Bread baked from frozen dough usually has a smaller volume, which results from a decrease in yeast activity, especially during long storage times and temperature fluctuations. These unfavorable processes, resulting from the use of low temperature, can be limited by the use of gluten as a dough additive [3].

To reduce the problems associated with baking frozen dough, the following methods can be used:

- addition of vegetable oil,
- honey addition,
- using the right type of yeast resistant to low temperatures,
- limiting the fermentation process,
- proper selection of freezing parameters.

In recent years, the so-called deferred baking method. It consists of the following stages:

1. Preparation of the dough according to the established recipe.
2. Baking bread (74-86% of the time necessary for full baking).
3. Freezing storage.
4. Defrost.
5. The baking of bread.

Bread baked (after stage 2) has a high stability of textural and sensory features even up to 11 weeks of freezing storage (step 3). After defrosting and complete baking, the quality characteristics are higher than the frozen counterpart that has been fully baked. It follows that the discussed method is an effective way to extend bread durability.

Summary

Staling is a very complex process consisting of complex physical and chemical changes of many components such as proteins, fats, starch, water and their mutual interactions. Therefore, the complete stoppage of this process is practically unachievable, however, actions are taken all the time, which allow to extend the storage life and it is possible that in the near future a method capable of completely stopping the staling process will be discovered. [3]

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IDENTIFICATION AND DETERMINATION OF PAHS CONTENT IN FOOD BY HIGH-RESOLUTION MASS SPECTROMETRY METHODS

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Abstract

This article reviews the suitability of the high resolution mass spectrometry methods (also in combination with gas/liquid chromatography) for the identification and determination of polycyclic aromatic hydrocarbons (PAHs) in different food samples. As many PAHs have toxic, mutagenic/carcinogenic properties and one of the major routes of humans exposure to these compounds is consumption there is a need for fast and simple techniques for determination of polycyclic aromatic hydrocarbons in food. The mass spectrometry and tandem mass spectrometry methods combined with gas/liquid chromatography are an excellent tool for the analysis of PAHs content in complex food matrices, because they provide highly accurate results and enable the simultaneous detection of many different compounds. Moreover, the typical HRMS experiment is relatively uncomplicated and takes just a few minutes, and the analysis of the resulting spectra using the available chemometric methods is a simple and fast process.

Keywords:

High-Resolution Mass Spectrometry, Food, PAHs

Introduction

The quality of food depends on a number of complex parameters, including the nutritive and calorific values of food products and their content of bioactive substances, but also their sensory properties, stability, and absence of microbiological or chemical contaminants and mechanical impurities. Another important aspect of food quality is its modification by using particular processes, packing methods, or storage conditions [1, 2]. Especially appealing to many consumers is the health-related value of various foods and their attractive sensory features, including their appropriate appearance (color, texture and structure), palatability and aroma [3].

In individual cases, consumers may have substantially different perceptions of the quality of certain foods, for instance, with respect to their sensory properties or price, but there is no doubt that only safe food products are products of good quality [4, 5]. Since recently, the food industry in the European Union has been required to use systems relating to manufacturing conditions and practices to ensure food safety, and the laws governing the quality of food have been harmonized.

In order to guarantee food safety, similar systems should be complied with in trade in food products between the European Union member states and other states [6].

The presence of chemical contaminants in food is one of the most substantial threats to its safety. The potential sources of chemical contamination include, but are not limited to contaminated raw materials or water, toxins which are normally found in the raw materials, chemical compounds being formed in unsuitable storage conditions, as well as extra additives which are deliberately added to products in technological processes [7]. Some of the chemical compounds which are present in food, mainly in plant-based food products, may cause undesirable reactions, such as allergy or gastro-intestinal disorder, in some consumers [8, 9]. The most hazardous and most frequently detected chemical contaminants in food products include: heavy metals, polycyclic aromatic hydrocarbons (PAHs), residues of different types of pesticides, dioxins, polychlorinated biphenyls, mycotoxins, acrylamide, or nitrosamines [10 ÷ 12]. Since so many chemical compounds are regarded as food contaminants and their structure, more often than not, is highly complex, their correct identification and determination of their content in food are challenging tasks. The exact identification and quantification (determination of type and content) of chemical contaminants in food products typically requires a combination of various methods, e.g., those based on separation (liquid and gas, and thin-film chromatography etc.) and with the techniques which are used for the substance identification, e.g., Mass Spectrometry (MS), Infrared and Ultraviolet spectroscopy (IR and UV spectroscopy), and Nuclear Magnetic Resonance (NMR)[13, 14].

High Resolution Mass Spectrometry methods (HRMS), based on measurement of the mass-to-charge ratio (m/z) of the analyte ions in the gas phase, may also be used independently for determination of individual chemical contaminants in food [15, 16]. In advanced mass spectrometers, such as Orbitrap or FT-ICR (Fourier Transform Ion Cyclotron), the analyzer is characterized by very high resolution, excellent sensitivity and accuracy of mass measurement (<5 ppm). The use of such spectrometers enables the unambiguous determination of molecular masses, detection and quantification of substances in complex mixtures and verification of product purity [17]. However, the obtaining of detailed information on the structure of the chemical contaminants – such as pesticides or PAHs - requires the use of Tandem Mass Spectrometry (MS/MS). The technique is based on the controlled decomposition of selected ions of a given chemical compound into smaller fragments, followed by an analysis of the resulting ions. The structural analysis of the polycyclic aromatic hydrocarbons can be carried out using one of the most popular technique, collision induced dissociation (CID), which involves inelastic collisions of ions with inert gases. Typically CID leads to breaking of the weakest bonds in the molecule [18]. The high resolution and tandem mass spectrometry methods have increasingly been used in the qualitative analysis of food contaminants, however, their potential still needs to be fully appreciated [19, 20].

The objective of this paper is to demonstrate that the mass spectrometry and tandem mass spectrometry methods can successfully be applied for the determination and identification of polycyclic aromatic hydrocarbons (PAHs) in different types of food products. Limitations connected with the application of the HRMS and MS/MS methods have also been mentioned.

Application of High-Resolution Mass Spectrometry (HRMS) methods for the identification and determination of Polycyclic Aromatic Hydrocarbons in food

Aromatic hydrocarbons – both those with a single aromatic ring (such as benzene, xylene, toluene) and polycyclic (PAHs, e.g. benz[a]anthracene, benzo[b]fluoranthene) – are very commonly found in nature. Their sources include both natural processes (such as microbial or algal biosynthesis), ecological disasters (such as volcanic activity, forest fires) and human activity (growth of heavy industry, use of conventional furnaces, stubble burning, etc.) [21]. A number of substances in the aromatic hydrocarbons category have been classified as particularly hazardous to human life and health and to the environment in general. Benzo[a]pyrene and benzene have been classified by the International Agency for Research on Cancer (IARC) as carcinogenic compounds. It has also been proved that a number of compounds which are classified as PAHs (e.g., dibenz[a,h]anthracene) are mutagenic and genotoxic to humans and animals. Aromatic hydrocarbons have a detrimental effect on the blood production system and the respiratory system, they tend to accumulate in tissues and their metabolites have been detected in brain tissues and other spots. Although not readily volatile, most of the aromatic hydrocarbons are able to adsorb on the surface of dust, this helps them spread with polluted air having a high content of dust. The compounds enter the human body by inhalation and through the skin, but primarily by ingestion, therefore, food monitoring for its content of the extremely harmful aromatic hydrocarbons is required [21, 22]. Structures of selected compounds belonging to the PAHs group occurring in different food matrices are shown in Fig. 1.

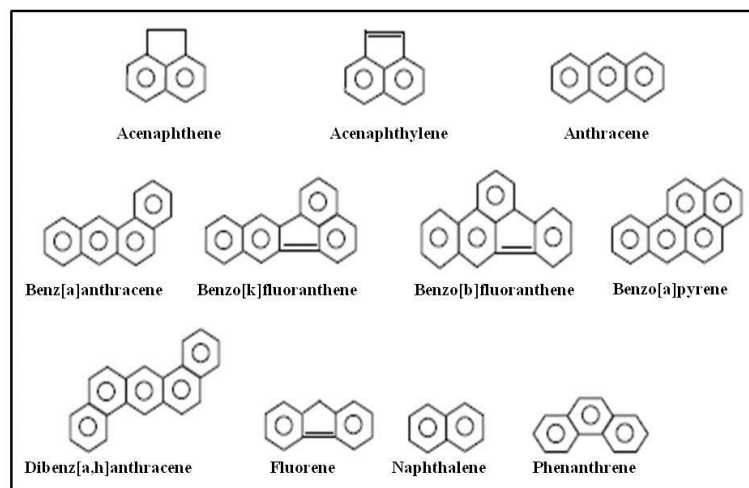


Fig 1. Structures of chosen polycyclic aromatic hydrocarbons.
 Source: own elaboration based on [21-22].

Identification and determination of the content of aromatic hydrocarbons in food samples and in environmental samples using mass spectrometry methods is not easy not only because the samples are rather complex but mainly because the compounds are non-polar, neutral and hydrophobic, and it is difficult to ionize them. The aromatic hydrocarbons can be ionized, for example, by the desorption atmospheric pressure photoionization technique (DAPPI), which leads to the formation of mainly $[M + H]^+$ or $M^{+•}$ ions in the positive ion mode, and $[M - H]^-$ or $M^{-•}$ ions in

the negative ion mode, depending on the analyte and the spray solvent used [23]. Kauppila and co-workers [24] carried out a series of experiments based on the combined method of DAPPI-MS. When analyzing environmental and food samples (orange peel), they determined the content of the selected chemical compounds classified as PAHs and pesticides, using various solvents. A number of compounds have thus been successfully identified, however, the PAHs levels in the food samples has been very too low to enable the tandem mass spectrometry (MS/MS) experiments to be carried out. However they reported, that the DAPPI-MS method is suitable for the rapid, qualitative screening analysis of environmental or food samples for the evaluation of PAHs compounds and pesticides without the sample pretreatment steps, which are time-consuming. Cha and co-workers performed ionization of non polar gas phase polycyclic aromatic hydrocarbons by the electrospray ionisation (ESI) and noticed the formation of protonated molecular ions $[M + H]^+$ without radical cations. They also reported that the combination of gas chromatography and electrospray ionization tandem mass spectrometry (GC/ESI-MS/MS) has been characterized by better sensitivity to the limits-of-detection of PAHs than liquid chromatography (LC)/ESI-MS/MS, which can be related to the characteristic ionization mechanism of the gas-phase analyte under ESI [25].

Determination of the PAHs content in food samples is often carried out using a combination of chromatography and mass spectrometry methods and, typically, requires the use of complex separation techniques in its initial steps. Rozentale and co-workers [26] analyzed more than 30 cereals and bread samples to determine their content of PAHs using two methods: gas chromatography coupled to tandem quadrupole mass spectrometry (a tandem mass spectrometer with an electron impact (EI) interface) and high-resolution sector mass spectrometry. Their results clearly indicate that, although the two methods do enable determination of the content of harmful PAHs which are present in very low amounts in food products, their use as a combination requires the appropriate sample preparation, thus extending considerably the duration of the analysis. A combination of dispersive solid-phase extraction and liquid-liquid extraction was applied by Chen and co-workers as a separation technique for determination of 16 polycyclic aromatic hydrocarbons in tea by gas chromatography-tandem mass spectrometry [27]. Duedahl-Olsen and co-workers used pressurized liquid extraction (PLE) followed by highly automated clean up steps for gel permeation chromatography (SX-3) and solid phase extraction for an analysis of the samples of 18 brands of tea leaves and 13 brands of coffee by gas chromatography mass spectrometry methods [28]. PAHs in bread samples were determined by Rostampour and co-workers [29] by the use of microwave-assisted extraction and dispersive liquid-liquid microextraction (MAE-DLLME) coupled with gas chromatography-mass spectrometry (GC-MS). Solid phase extraction has been used by Ting and co-workers for determination and quantification of 24 polycyclic aromatic hydrocarbons in edible oil by gas chromatography coupled with tandem mass spectrometry [30]. Mohamed and co-workers [31] determined the content of 13 polycyclic aromatic hydrocarbons in different type of the most commonly consumed milk products from Egypt market by the application of gas chromatography with high resolution mass spectrometry. They used the QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) method [32] for the extraction of PAHs. QuEChERS has become an crucial and extensively used technique in the analysis of various chemical residues with diverse matrices, including fatty foods, such as milk, cheese and butter. Mohamed and co-workers reported that the highest mean levels of PAHs were detected in powdered milk, followed by ultra-heat treatment

milk and milk beverages. The lowest level was detected in unsmoked cheese and yogurt. Their results have shown that there are potential hazardous and dangerous effects posed by the consumption of milk and dairy-based products, especially for infants and babies [31]. The presence of chemical compounds belonging to polycyclic aromatic hydrocarbons (i. e. 5-methylchrysene) in infant formulas has been also reported by Nyiri and co-workers [33] on the basis of results obtained in gas chromatography and tandem mass spectrometry experiments.

In addition to providing valuable information on food quality and safety (for instance, on the content of PAHs, pesticides, or other contaminants), the use of the combination of mass spectrometry and gas chromatography enables identification of the sources of contamination. Malarut and Vangnai investigated the influence of different types of woodchips on the properties of smoked sausages, such as pH, total acidity, color, sensory properties, shelf life and the contents of carcinogenic, polycyclic aromatic hydrocarbons [34]. Using gas chromatography-mass spectrometry, Min and co-workers analyzed the factors influencing the formation of eight polycyclic aromatic hydrocarbons in heated meat, including heating conditions, existence of water, lipid precursors and antioxidants [35]. The combination of gas chromatography and mass spectrometry is also used for determination of PAHs content in non-food products, for instance in samples of tobacco products and the smoke they produce on burning [36, 37]. A considerable number of papers are known, concerning the use of HRMS methods (with or without gas or liquid chromatography) for determination of many chemical compounds (i.e., PAHs, pesticides) in a single analysis. This is an important advantage of the application of high resolution mass spectrometry methods for food analysis [38, 39].

Conclusions

Examples of the use of mass spectrometry and tandem mass spectrometry methods (in combination with gas or liquid chromatography) in the analyses of different types of food products confirm that MS has been an increasingly important tool in quality testing and in the detection of chemical contaminants, such as polycyclic aromatic hydrocarbons. The methods enable the simultaneous determination and identification of multiple chemical contaminants. Moreover, the typical mass spectrometry experiment is relatively uncomplicated and takes just a few minutes, and the analysis of the resulting HRMS and MS/MS spectra using the available chemometric methods is a simple and fast process. The use of mass spectrometry methods in the analysis of food products has a serious limitation: food samples are usually very complex and complicated extraction processes are often required before proceeding to the proper analysis. An important limitation is related to the properties of polycyclic aromatic hydrocarbons: since PAHs are non-polar, neutral and hydrophobic compounds, the ionization process which is necessary for the HRMS analysis is often difficult.

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ASSESSMENT OF REVENUE VOLATILITY OF PHOTOVOLTAIC AND WIND POWER PLANTS USING METHOD OF HISTORICAL SIMULATION

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Abstract

The objective of this paper is to assess the volatility of revenue of photovoltaic power plants, wind power plants and control group (which is generator producing constant output with random interruptions in continuity of operation), assuming that sale of produced energy takes place on Polish Day-Ahead Market for electricity. The probability distribution of revenue is calculated using historical simulation method, which uses data about prices on Day-Ahead Market (from 2008 to 2018) and non-public production data describing hourly production volumes. Volatility is measured using Value at Risk. The thesis of the paper is that, due to different production characteristics, photovoltaic and wind power plants will differ in revenue volatility. An element of novelty is applying the method of historical simulation to production data with high temporal resolution. The results of the study confirm the adopted thesis.

Keywords:

historical simulation, renewable energy, energy markets, revenue forecast

Introduction

Countries of European Union are obliged to stimulate the development of renewable energy sources (later called RES), each committing to certain share of renewable energy in gross final energy consumption by 2020 [1]. Since RES generally do not achieve profitability in free market conditions, the way to achieve growth is public aid, which can take two basic forms: investment and operational. Investment aid aims to reduce capital costs of the project by covering some of the costs. Operational aid increases revenue by additional payments to the investor. It usually takes form of contracts (between the investor and the state), in which the state undertakes to cover the difference between the market price and the negotiated price, for the indicated number of years. From the perspective of the government, operational aid is favourable, because it offsets financial commitments into the future (compared with investment aid). From the perspective of investors, it not only guarantees profitability, but it also reduces the risk of revenue fluctuations. Fluctuations of revenue of any energy plant stem from two factors: changes in price and changes in produced energy volume. Operational aid almost completely eliminates changes in price.

Being granted operational aid does not mean, however, that the state is the buyer of produced energy. Since regulations of European Union emphasize free market and competition, such situation would only be possible in special circumstances (such as difficulty of finding a buyer of energy from a very small energy sources). In Poland, the beneficiary of operational public aid must sell produced energy on the free market. Assuming that the investor would sale produced energy on the regulated power exchange market, he would sell energy in the form of contracts. In Poland the only regulated power exchange market is *Towarowa Gielda Energii SA* (later called TGE), which offers multiple standard contracts, with different time of delivery. One of the standard contracts (common in many markets across the world) are day-ahead contracts traded on Day-Ahead Market (called *Rynek Dnia Następnego* on TGE).

The Day-Ahead Market (later called DAM) is a forward market for electricity, where contracts are concluded for energy supplied at every hour of the next day. The physical delivery of energy contracted today takes place the next day at established hour. Thus, it actually consists of twenty four independent markets [2], on which participants of the exchange can freely buy and sell electricity according to their needs. The price is determined separately for each hour, according to the reported supply and demand. In the summer months, the highest average prices on DAM occur in the midday hours (the highest average price at 13:00, see Fig. 1). In the winter months, the highest average prices occur in the evening (the highest average price at 18:00). In both cases, prices are characterized by the highest volatility in these hours (measured by standard deviation). Prices during the night are lower and less volatile than during the day, both in the summer and winter months.

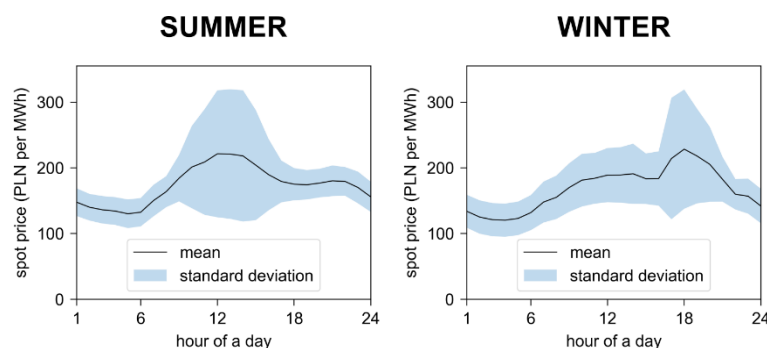


Fig. 1. Average hourly prices on DAM on TGE and their standard deviations in the summer months (June, July, August) and winter months (December, January, February) in years 2010-2017

Source: own elaboration based on data published by TGE

Having been granted operational aid, the investor may assume almost constant revenue in each year in the future (since the price is guaranteed by the state). The only variability in revenue would stem from changes in the output volume of energy. However, if the investor is not granted operational aid, future revenue must be determined by forecasting. The accurate forecast of revenue is particularly important for renewable energy sources, such as photovoltaic plants or wind turbines, due to the very small share of variable cost in the cost structure. The production of both photovoltaic power plant (later called PV) and wind power plant (later called WIND) depends solely on environmental factors: sun radiation and wind force. By definition, renewable energy sources do not use any non-renewable resources, such as coal. Therefore, there is no relation

between variable cost and output volume, as would be the case in the coal plant (the more coal it burns, the bigger the output). Since most of the costs in RES are fixed, changes in energy prices affect RES more than traditional plants (which could hypothetically manipulate the output depending on the price). Therefore, accurate forecast of revenue is very important for any investment in PV or WIND.

We propose forecasting the revenue of photovoltaic and wind power plants using the method of historical simulation [3]. The idea is to calculate probability distribution of revenue by simulating it many times using the Monte Carlo method. Simulations are based on historical data describing production (energy output of different photovoltaic and wind power plants) and historical prices on Day-Ahead Market. The revenue is calculated for each day of the year, by randomly selecting day from the production data and day from the prices data and then multiplying it. Results of such forecasting can be used in investment profitability analysis, because of aforementioned cost structure of photovoltaic and wind power plant (prevailing fixed costs). Had that not been the case, we would have to include variable cost in the simulation.

The main objective of this paper is to access the volatility of revenue of photovoltaic power plants, wind power plants and control group (which is generator producing constant output with random interruptions in continuity of operation) selling produced energy on Day-Ahead Market. The probability distribution of revenue is calculated using historical simulation method. It is then analysed using measure of Value at Risk. The secondary objective is to show how results of the simulation can be used in an investment profitability analysis. The thesis of the paper is that, due to different production characteristics, photovoltaic and wind power plants will differ in revenue volatility.

Methods

Input data

Data on production volume of photovoltaic and wind power plants were obtained from three different companies trading electricity on regulated polish power exchange market. The data describes production output of different energy plants in each hour of the day in the period. Altogether, data from six different PV and five different WIND was obtained (Tab. 1), describing in total 5238 days or 62856 hours of production.

Tab. 1. Production data used in historical simulation calculations

Type of RES	Symbol	Max. power	Starting date	End date
PV	PV-1	1	01.08.2016	31.07.2017
	PV-2	1	01.08.2016	31.07.2017
	PV-3	1.4	01.08.2016	31.07.2017
	PV-4	1	01.09.2015	31.09.2016
	PV-5	1	08.07.2015	01.01.2018
	PV-6	1	02.08.2018	31.10.2018
WIND	WIND-1	1	01.01.2016	31.03.2017
	WIND-2	4	01.01.2016	31.12.2016
	WIND-3	8	01.01.2014	05.01.2016
	WIND-4	10	01.01.2014	09.10.2014
	WIND-5	7.5	01.01.2014	31.07.2016

Source: own elaboration

Production characteristics of both PV and WIND vary throughout day, with wind blowing most strongly at night when sun does not shine (Fig. 3). Differences occur both between hours of a given day and between different months (Fig. 2). Because price on DAM also changes throughout day (with highest prices in summer around noon, see Fig. 1) different production characteristics of PV and WIND are important sources of revenue variability. We will explore how this specific production characteristics affects generated revenue. However, adhering to the best scientific practices, there should be a control group, in which production does not vary throughout day. Therefore, apart from historical production data, we have generated third dataset, describing production of control plant (later called CONTROL), producing constant and maximum output throughout day. However, to make CONTROL somewhat more plausible, we have introduced volatility in the form of random downtime in production. The rate of this downtime is the same as downtime of 858 MW generator in Bełchatów Power Station (one of the biggest generator in Poland) in 2012, based on indicator called *capacity factor* (data were obtained from [4]). Data for fictional 1826 days was generated (Fig. 3), describing altogether 43824 hours (including 7608 hours of downtime). In order to be comparable with PV and WIND, we assume that CONTROL has also very small variable cost.

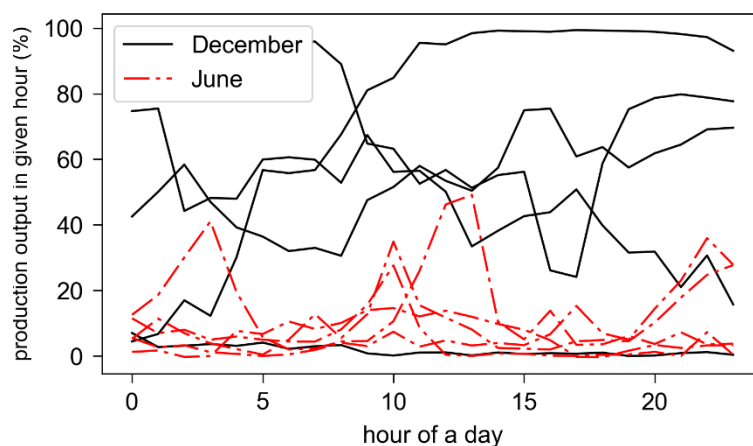


Fig. 2. Production of WIND in randomly selected days of June and December
Source: own elaboration based on non-public production data

Data on hourly prices on Day-Ahead Market were obtained from the TGE power exchange. Only data from 1 January 2008 onwards were chosen, because before that date prices on the DAM had a very different characteristic, being lower and less volatile (Fig. 4). Including prices before 1 January 2008 would distort the results. Because considered prices are from long period of time, they were adjusted for inflation. All prices were divided by index (Fig. 5) based on CPI inflation data (month to month) for polish currency. Therefore, nominal prices were converted to real prices (relative to November 2018, Fig. 6). We assume here that any financial plan based on results of the study would be based on nominal prices (each year increased by projected inflation), all relative to November 2018 (in which case real and nominal prices are the same).

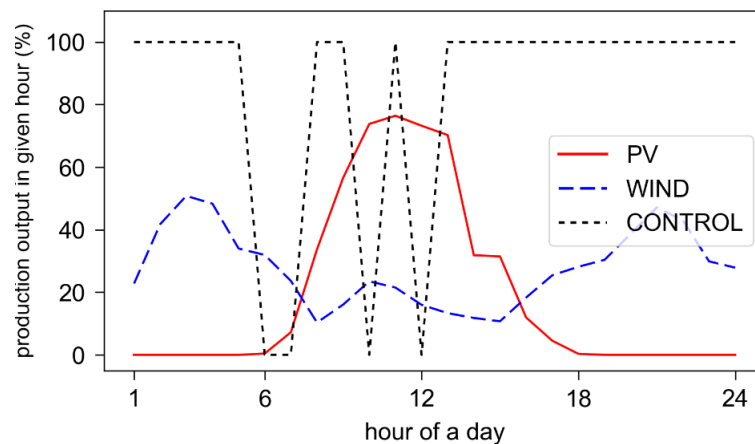


Fig. 3. Production of PV, WIND and CONTROL in randomly selected days

Source: own elaboration based on non-public production data (PV, WIND) and generated dataset (CONTROL)

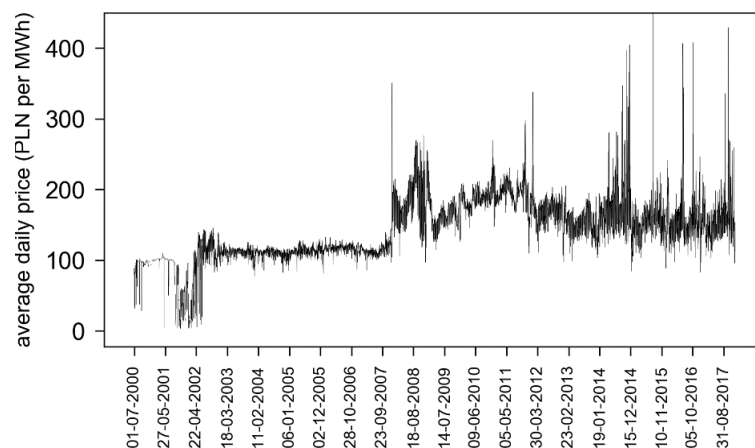


Fig. 4. Production data of PV, WIND and COTROL of randomly selected days

Source: own elaboration based on data published by TGE power exchange

Revenue calculation

In order to access the volatility of revenue, one needs to define its distribution of probability. We have applied method of historical simulation, which is *a transformation procedure [that] employs the Monte Carlo method with historical realizations* [3]. We have performed calculations using data about historical prices and production volumes to simulate possible revenues of PV, WIND and CONTROL during fictional twelve months of operation. The revenue (for one fictional year) was calculated as follows: (a) for each month, thirty days from dataset about historical prices and from dataset about production was randomly and independently selected (the dataset has been narrowed down to the days that occurred in a given month); (b) revenue for each fictional day was calculated by multiplying production volume and the price (adjusted for inflation) for each hour of the day, subtracting a commission (collected by the intermediary) of 5% from the result; (c) this operation was repeated for 365 days, calculating revenue for full year. Simulation was repeated 5000 times, resulting in revenues for 5000 different fictional years. Revenue was calculated for PV, WIND and CONTROL. This allowed to define probability distribution. Apart from the revenue, production volume for each fictional year was established (by summing production volumes for

each hour) and average price per unit of energy (by dividing annual revenue by annual production volume). All calculations were done using *R* statistical package.

When randomly selecting thirty days in each month, the dataset has been narrowed down to the days that occurred only in a given month. To calculate revenue possible to achieve by WIND in February, we would have first narrowed datasets of both production and prices to all days that occurred in February. Then we would calculate the revenue generated in February by multiplying production volume and price for each hour of each day and adding it together. For given day of the month, one day was randomly selected from all days that occurred in the month (regardless of the year) and therefore we assume that each occurs with equal probability, both in production and prices datasets. We calculate revenue only for full years, because: (a) revenue is characterized by seasonality and this allows to eliminate this seasonality as the source of variance; (b) any investment profitability analysis based on the results of this research would be long-term and therefore would analyse revenue only in annual time sections.

We should point out that this method of calculation ensures that distribution of revenue (simulated many times) captures not only variability of price, but also variability of production. Each simulated year is combination of days of possible production volumes and hourly prices on Day-Ahead Market (with the restriction of month, which ensures capturing any seasonality). Since there are only two important factors that influence variability in revenue – production volume and price – this method captures nearly all variability of revenue.

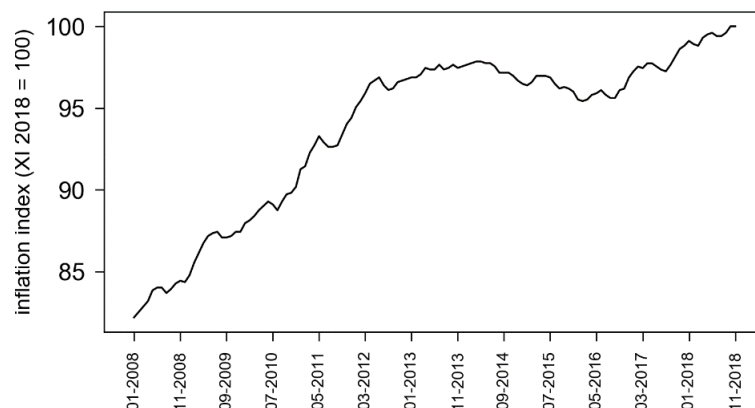


Fig. 5. Inflation index (month to month) used in calculations, relative to November 2018
Source: own elaboration based on data published by Główny Urząd Statystyczny (GUS)

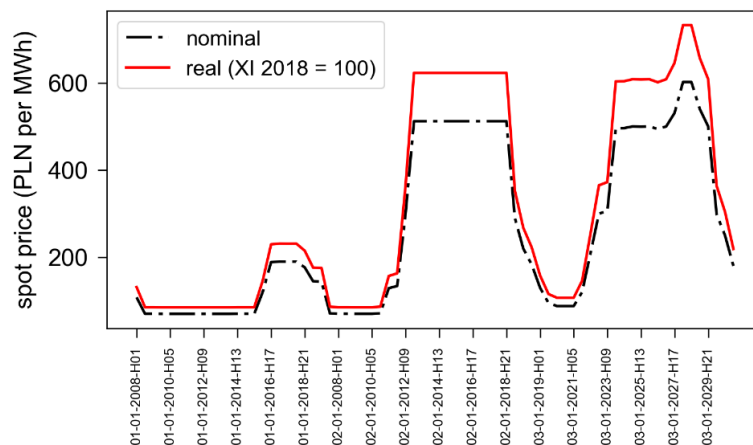


Fig. 6. Nominal and real (adjusted for inflation) prices on DAM from 1 to 3 January 2008
Source: own elaboration

Value at Risk

Value at risk (later called VaR) is a measure of the risk of loss for investments. It is typically used by investors to describe portfolio of stocks or by market regulators to define the amount of assets needed to cover possible losses. VaR estimates how much, with a given probability, an investments might lose in a given time period, given normal market conditions [3]. VaR is a function of the quantile of the value distribution. Assuming normal distribution, VaR can be interpreted as the difference between the current value of a financial instrument and an appropriate quantile of the probability distribution (corresponding to a given probability):

$$P(W_T < VaR) = \alpha \quad (1)$$

$$VaR = W_0 - W_\alpha \quad (2)$$

where:

$P(\dots)$ – probability operator;

α – tolerance interval;

VaR – Value at Risk;

W_T – the value of the investment at the moment of T;

W_0 – the expected value of investment;

W_α – the quantile of the value distribution that corresponds to the given tolerance interval α .

We have applied VaR in analysis of revenue variability. Revenue distribution (calculated as described in the previous chapter) was used to calculate VaR, which would be interpreted in this case an *in minus* deviation from expected annual revenue (with a given probability). The time period is one year, which is accordance with time period of historical simulation and revenue calculation. The quantile of the value distribution (W_α) can be regarded as minimum annual revenue (assuming probability of α). Calculations were made for PV, WIND and CONTROL.

Results

Historical simulation

Revenue was calculated using method of historical simulation for photovoltaic power plant, wind power plant and control plant (Tab. 2, Fig. 7). Apart from revenues, annual production volumes and average prices per unit of energy were calculated. The distribution of both revenue and production is normal, as indicated by Shapiro-Wilk test (Tab. 2; quantile plots in Fig. 7).

Tab. 2. Descriptive statistics for revenue, production volume and average price per unit of energy for three different types of power plant: photovoltaic (PV), wind (WIND) and control plant (CONTROL)

Value	Property	PV	WIND	CONTROL
Revenue	Mean [PLN]	200904.58	355416.33	1309800.58
	Median [PLN]	200851.89	355356.6	1309492.64
	Standard dev. [PLN]	6330.51	17279.57	16534.54
	Coefficient of variation [%]	3.15	4.86	1.26
	Shapiro-Wilk test (p)	0.47	0.34	0.27
Production volume	Mean [MWh]	976.67	1965.69	7239.12
	Median [MWh]	976.71	1964.69	7240
	Standard dev. [MWh]	24.9	89.14	36.21
	Coefficient of variation [%]	2.55	4.53	0.5
	Shapiro-Wilk test (p)	0.3	0.31	0.54
	Avg. capacity factor (h) *	976.67	1965.69	7239.12
Price per unit of energy (MWh)	Mean [PLN]	205.84	181.18	180.94
	Median [PLN]	205.74	180.93	180.92
	Standard dev. [PLN]	8.37	11.96	2.47
	Coefficient of variation [%]	4.07	6.6	1.36
	Shapiro-Wilk test (p)	0.014	< 0.01	0.76

* Capacity factor is defined as annual production divided by maximum power. Since all considered power plant are normalized, we can assume they have 1 MW of output power. Therefore, average capacity factor will be always the same as mean of production volume.

Source: own elaboration based on own calculations

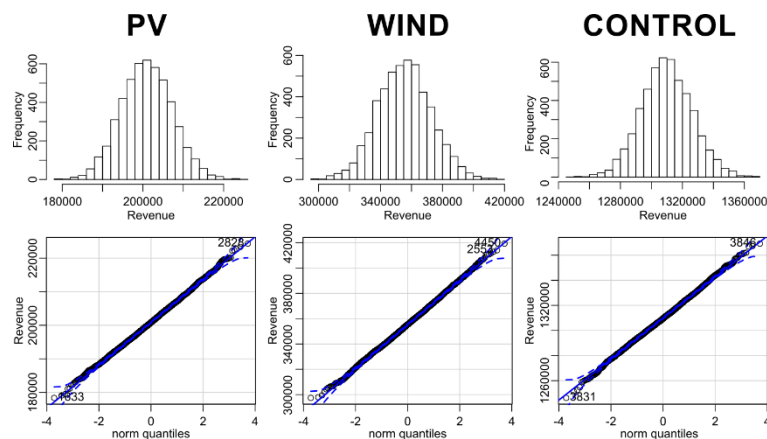


Fig. 7. Distributions of revenue for PV, WIND and CONTROL (upper row) and quantile-quantile plots (bottom row)

Source: own elaboration based on own calculation.

Value at Risk

Since calculated distribution of revenue of photovoltaic power plant, wind power plant and control plant are normal (Tab. 2), we can use standard formula (Formula 2) to calculate Value at Risk. Calculations were made for confidence intervals of 95% and 99% (Tab. 3). Apart from

nominal Value at Risk, two other measures were calculated: relative Value at Risk (divided by expected revenue, later called RELVaR) and minimum annual revenue with assumed confidence interval (expected revenue after deducting VaR, later called MIN). MIN is equal to the quantile of the value distribution (W_α) for a given probability α . Calculations were done using *qnorm* function from *R* statistical package.

Tab. 3. Descriptive statistics and risk measurements for three different types of power plant: photovoltaic (PV), wind (WIND) and control plant (CONTROL)

Property	PV	WIND	CONTROL
Mean [PLN]	200904.58	355416.33	1309800.58
Standard deviation [PLN]	6330.51	17279.57	16534.54
Coefficient of variation [%]	3.15	4.86	1.26
VaR (CI = 95%) [PLN]	10412.76	28422.36	27196.9
RELVaR (CI = 95%) [%]	5.18	7.9	2.08
MIN (CI = 95%) [PLN]	190491.82	326993.97	1282603.68
VaR (CI = 99%) [PLN]	14726.97	40198.29	38465.09
RELVaR (CI = 99%) [%]	7.33	11.31	2.94
MIN (CI = 99%) [PLN]	186177.61	315218.04	1271335.49

Source: own elaboration based on own calculations

Applying results in practice: revenue forecasting

We could use the results of the study for the purpose of revenue forecasting, for example as part of investment feasibility study. We extrapolate calculated historical distribution of revenue and assume that it will be the same ten years from now. Since we have calculated prices in real terms (relative to November 2018), calculated annual revenue distribution is also in real prices. Since November is almost the last month of the year and the year is not over yet (at the time of writing this paper), we will adopt a simplifying assumption that inflation until November is the same as throughout 2018.

When constructing the revenue forecast, we could use value of expected revenue from the calculations (assuming that this is the revenue that the investment will bring with highest probability). While such forecast would definitely be useful, we should also consider scenario in which the revenue is not equal to expected. For that purpose, we could use Value at Risk, subtracting it from expected revenue (which would be equal to MIN in Tab. 3). In such case we would assume revenue that we could expect with given confidence interval.

We propose revenue forecast for photovoltaic power plan with the capacity of 1 MW for years from 2019 to 2028 (Tab. 4). We assume annual inflation of 2%. Since productivity of photovoltaic plant decreases over time, we assume one percentage point reduction (relative to first year of operation) in revenue each year. We have constructed year-to-year index capturing this drop in productivity, called *Productivity index*. Revenue accounting for all aforementioned factors (called *Nominal revenue*) is calculated by multiplying base revenue (calculated for 2018) by *Inflation index* and by *Productivity index*. Calculation are made for base revenue being mean revenue and mean revenue after subtracting VaR (MIN in Tab. 3), assuming confidence interval of 95 percent.

Tab. 4. Revenue forecast for years 2019-2029 for photovoltaic power plant with the capacity of 1 MW (revenue in 1000 PLN)

Year	Inflation index	Prod. index	Nominal revenue (assuming mean)	Nominal revenue (assuming MIN)	Difference
2019	102	100	204.92	194.3	10.62
2020	104.04	99	206.93	196.21	10.73
2021	106.12	98	208.94	198.11	10.83
2022	108.24	97	210.94	200	10.93
2023	110.4	96	212.93	201.89	11.04
2024	112.61	95	214.93	203.79	11.14
2025	114.86	94	216.91	205.67	11.24
2026	117.16	93	218.9	207.56	11.35
2027	119.5	92	220.87	209.43	11.45
2028	121.89	91	222.84	211.29	11.55

Source: own elaboration

Conclusions

Photovoltaic plant reaches the lowest annual revenue and control plant reaches the highest, with annual revenue of wind power plant being over 1.7 times higher than of photovoltaic. Similarly, annual production volume of PV is the lowest and that of CONTROL is the highest. However, due to specific production characteristic of PV (producing highest volume around midday when prices are highest, Fig. 1) average price per unit of produced energy is the highest for PV (Tab. 2). At the same time, annual revenue of PV is less volatile than that of WIND (as indicated by coefficient of variation). Both revenue and production volume of CONTROL is least volatile (measured by coefficient of variation), indicating that changes in production affect changes in revenue. Value at Risk (in nominal terms) is highest for WIND and lowest for PV (Tab. 3). Relative to mean revenue, Value at Risk is also highest for WIND, but lowest in case of CONTROL (because of much higher mean).

From capacity factor being higher for WIND than PV we can conclude that WIND produces more energy per unit of power installed. However, this does not mean that WIND is more efficient. In order to compare the two in terms of efficiency, we should also include investment costs per unit of power and production characteristics. Capacity factor is the highest for CONTROL, but since it consists of data that were artificially generated with assumptions about capacity factor, we cannot draw any conclusions from this fact.

With confidence interval of 95%, the annual revenue of photovoltaic power plant is 200.9 thousand PLN or more and revenue of wind power plant is 355.4 thousand PLN or more.

Taking into account two different measures of risk (coefficient of variation and relative Value at Risk), we can conclude that, assuming energy sale takes place on the Day-Ahead Market, revenue of wind power is more volatile than revenue of photovoltaic power plant. Such results confirm the adopted thesis. Control plant has least volatile revenue, but since the data were artificially generated, we cannot draw any general conclusions from this fact. These results are true for considered time period. Should we extrapolate the results into the future, we would have to assume that volatility of both prices and production volumes will be similar. While such assumption is fairly safe when it

comes to production volumes (especially that we can take into account declining productivity), it might be problematic when it comes to prices. We included long period (almost eleven years) in our calculation, which definitely helps making such extrapolations (since the longer the period, the more external factors influence the value). However, had new factors emerged in the future, they would undermine the credibility of the analysis. One such factor could be rapid development of renewable energy, which could affect daily price characteristics. Development of photovoltaic plants can lead to a drop in prices in the midday hours on Day-Ahead Market (since this is when sun radiation is highest). Overall, development of renewable energy could lead to increased volatility of prices. In order to account for such scenario, we should perform historical simulation using prices data from more mature energy markets (with higher share of renewables), assuming that this is the direction where polish energy market is headed. Such assumption, however, can also be problematic, since energy market is highly regulated and is influenced by political decisions. We should also remember that even if we account for all aforementioned factors, the global demand for energy is increasing in a geometric-like progression [5] and we can be the witnesses of radical technological change that would invalidate any analysis.

As was shown, proposed method of calculating distribution of revenue is useful. The results can be used in revenue forecasting (for example as part of the feasibility study) and to study the volatility of revenue of photovoltaic and wind power plants. As was mentioned, revenue forecasting is important for both renewable sources, since public aid may be limited in the foreseeable future. Should that happen, proposed method could be used to forecast revenues in the future, having regarded all the aforementioned assumptions and limitations.

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REVENUE VARIABILITY OF RENEWABLE ENERGY SOURCES DEPENDING ON THE BASIS FOR SETTLEMENT

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Abstract

The aim of this paper is to assess the risk of revenue change related to the sale of electricity produced by four different renewable energy sources: photovoltaic, wind, biogas and hydroelectric. The analysed volatility will concern two dimensions: the type of source and the basis for settling the due for sold electricity. The analysed bases are: Day-Ahead Market, TGeBase (which is index based on Day-Ahead Market) and Balancing Market. The thesis of the paper is that, due to different production characteristics, the sources will differ in the basis which is optimal in terms of the ratio of volatility to average revenue. An element of novelty is applying the method of historical simulation to production data with high temporal resolution. The results of the study confirm the adopted thesis.

Keywords:

renewable energy sources, energy market, revenue variability

Introduction

In recent years there has been tremendous development in the renewable energy sector, both in Poland and in other countries of the European Union. This process is primarily determined by the presence of financial stimulants offered at the national level, which are the consequence of energy policy at the European level. Investments in renewable energy sources (later called RES) generally do not reach satisfactory profitability without the participation of public aid.

The global demand for energy is increasing in a geometric-like progression [1]. Satisfying the demand for energy in the EU member states depends more and more on imports, while the fuel structure is not diversified. In order to guarantee their citizens energy security, the countries of the EU have to face these problems. The answer is the energy policy that goes back to the beginnings of European integration. We can distinguish three main themes in European energy policy [2]: (a) energy security, which is ensuring the diversification of the fuel structure, reducing dependence on imports, dispersion of electricity production and increasing the share of RES in the energy balance; (b) liberalization of the energy sector, through the disintegration of enterprises in this sector (separation of production, transmission, distribution and sale) and Third Party Access (access to transmission infrastructure); (c) natural environment protection through development of RES and gradual abandonment of coal as the source of energy.

Polish energy policy until 2030 [2] defines the following main objectives: increase in the share of renewable energy in the final gross energy consumption to at least 15% in 2020 and further increase of this indicator in the following years; protection of forests against excessive exploitation; sustainable use of agricultural areas for RES purposes, including biofuels, so as not to lead to competition between renewable energy and agriculture; increasing the degree of diversification of supply sources and creating optimal conditions for the development of distributed energy based on locally available resources. The way in which the goal of increasing the share of renewable energy is to be achieved is by stimulating private investment in RES by public aid programs. These programs take the form of investment aid (co-financing and preferential loans) and operating aid (Tradable Green Certificates system, auctions for the sale of electricity).

Wholesale electricity market in Poland

The electricity market, which was created as a result of the liberalization of the energy sector, is a commodity market with the commodity being electricity. However, this is a specific market, significantly different from other commodity markets, such as the grain market, precious metals and minerals market or the currency market. It is also significantly different from other commodity energy markets, such as the oil, gas or coal market. Some specific features of the electricity market are as follows [3, p. 30]: (a) there is a very limited possibility of electricity storage, because currently existing storage technologies are inefficient economically or have very limited technical capabilities; (b) electricity is characterized by low price elasticity of demand, which means that the demand for electricity does not change significantly, even in the case of significant price changes; (c) energy is of strategic importance for the country and its security. Therefore failure-free operation of the power system is in the interest of the state.

The basic assumption of the implementation of market liberalization is the separation of production from transmission. This enables independent pricing for the goods (electricity) and services (delivery of goods). To guarantee competitive trading rules, the market must ensure: equal treatment of all its participants, free access to the market (technical and financial restrictions are allowed), price regulation for network activities (so-called tariffs) and priority treatment of energy supply in relation to financial transactions concluded on this market. The market must, therefore, pursue the main objective (reduction of production and delivery costs), while taking into account the imposed restrictions (see Fig. 1).

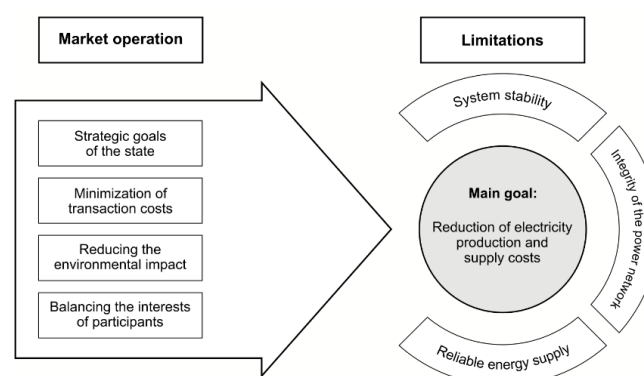


Fig. 1. The objectives of the electricity market operation and ways to achieve them
 Source: own elaboration based on [5]

The electricity market in Poland operates on two levels, the wholesale market and the retail market [4]. We can distinguish the following segments of the wholesale market: over the counter market (contracts concluded directly between market participants); power exchange market (contracts concluded on regulated power exchange market); balancing market (which is technical market, existing due to the need to balance demand and supply on the electricity market). In this paper only the wholesale trade in electricity will be discussed, and only in the scope of power exchange market (which in Poland is *Towarowa Gielda Energii S.A.*, later called TGE). Since balancing market can also be the basis for settling due for sold electricity, it will also be discussed.

Day-Ahead electricity Market in Poland

The main goal of the power exchange market is to facilitate electricity trading by offering various types of contracts [4]. Trading is carried out through the purchase and sale of contracts. TGE brings together entities interested in entering into transactions and determines (in an objective way) the price as an equilibrium price between the offers for sale and purchase (see Fig. 2). Importantly, this price is public information, so it can be reference point for considerations regarding the market price in other transactions [4]. The transactions are carried out from 8:00 am to 15:30 all days of the year. One of the standard contracts related to the electricity market are day-ahead contacts traded on Day-Ahead Market (*Rynek Dnia Następnego* on TGE).

The Day-Ahead Market (later called DAM) is a forward market for electricity, where contracts are concluded for energy supplied at every hour of the next day. The contracts concluded today will be filled tomorrow (the physical delivery of the energy will take place the next day at the given hour). Thus, it actually consists of twenty four independent partial markets, on which participants of the exchange can freely buy and sell electricity according to their needs [4]. The price is determined separately for each hour, according to the supply and demand in a given hour.

The DAM market in Poland is related to the TGeBase index, which is a comprehensive source of information on prices on the DAM, including all types of instruments on the market. TGeBase is an arithmetic average of the volume-weighted average electricity price transaction for individual hours of a given delivery day (for transactions concluded on the Day-Ahead Market). Because it is an average, it is characterized by lower volatility than hourly prices on the DAM.

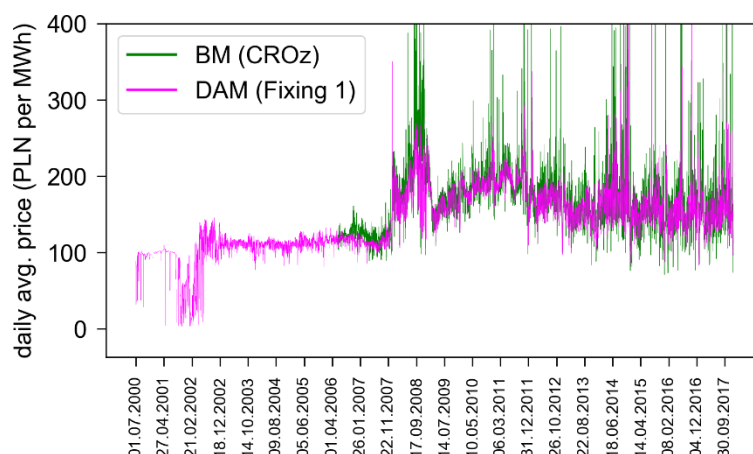


Fig. 2. Daily average prices on Day-Ahead Market and Balancing Market in Poland in years 2000-2017
Source: own calculations based on data from TGE

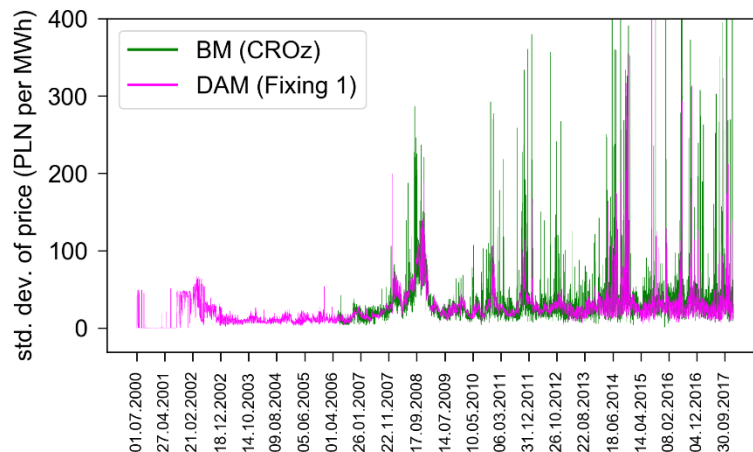


Fig. 3. Standard deviation of price on Day-Ahead Market and Balancing Market in Poland in years 2000-2017
Source: own calculations based on data from TGE

The Balancing Market in Poland

The Balancing Market (later called BM) is that part of the electricity market, where the transmission system operator makes a final balance of production and demand, taking into account contracts and transactions previously concluded by market participants in other segments, as well as system limitations [4]. The BM is therefore a technical market, where demand and supply result from surpluses or shortages of electricity owned by market participants. It is intended to trade electricity only in order to balance the electricity system, and it differs from other energy markets such as the DAM market. However, the due for sold electricity can be established in relation to BM, which is why it must be considered.

Prices on DAM and BM are correlated ($r = 0.625$, see Fig. 4). While average prices on RB are close to the average prices on the DAM, they are characterized by greater volatility (see Fig. 3). While the price on the DAM is calculated in a completely free manner, the price on the RB is administratively limited. The minimum price is PLN 70 per MWh, and the maximum price is PLN 1500 per MWh. Prices on RB always remain in this range.

The basis for settling the due for sold energy

The due for sold energy can be determined in various ways. It can be determined on the basis of a fixed price for each unit of energy produced, over the entire term of the contract. However, one can use variable prices based on power exchange market indices. They are characterized by a higher risk of revenue changes than in the case of a fixed price, but they potentially offer the benefit of higher revenues when energy prices increase. Establishing the due based on the variable price is significantly more complex than in the case of a fixed price. Possible ways to set the due based on the variable prices include DAM, TGeBase and BM.

If the settlement is based on the DAM or RB, the due will be calculated as multiplication of the production volume in a given hour and the price in the same hour. In the case of billing based on TGeBase, the settlement method will look different. TGeBase is an index calculated for each day separately. TGeBase is not a price at which anyone makes a transaction, but only a value used for billing purposes. In this case, the due will be the energy produced in each day multiplied by the value of TGeBase calculated for given day.

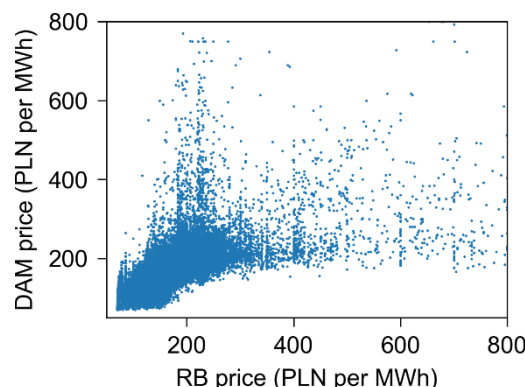


Fig. 4. Daily average prices on Day-Ahead Market and Balancing Market in Poland in years 2000-2017
Source: own calculations based on data from TGE

Methods

The due for the sold electricity produced in a renewable plant can be determined based on various indicators. It can be based on a fixed price, hourly price on DAM, hourly price on BM or TGeBase index. Choosing the right of the above can be crucial for revenue generated by given RES. In the case of a fixed price, the revenue will also be constant. In the case of a variable price (DAM, BM, TGeBase), the revenue will have some risk related to the volatility of the indicated prices. This creates an opportunity for increase in generated revenue (related to the increase in prices), but also creates a risk associated with a decline in revenue, due to falling prices.

The risk of revenue variability is of practical importance due to the presence of fixed costs related to the operation of each power plant. In the case of a significant share of fixed costs (as for example in the case of a photovoltaic plant), the decrease in revenue has a significant impact on the investment's profitability.

The purpose of this paper is to assess the risk of revenue variability. The risk will be analysed for each of the four renewable types of RES separately. The analysed basis for settlements will be the DAM, BM and TGeBase. A particularly important research problem here is whether the revenue variability depends to a greater extent on the type of RES source or on the choice of the form of settlement.

Production characteristics of considered RES

Each type of power plant has its own specific production characteristics, depending on the type of primary energy that is transformed into electricity. In the case of conventional power plants it can be, for example, hard coal or natural gas. In this paper the production characteristics of four different renewable energy sources will be considered: photovoltaic power plants (producing electricity from solar energy), hydroelectric plants (producing electricity from water energy), biogas plants (producing electricity by burning biogas, often coming from agricultural waste) and wind farms (generating electricity using wind-powered generators).

Each of the above sources is characterized by a specific variation in production volume, depending on the variability of the energy source which is transformed into electricity. Such variability can be analysed in different temporal resolutions: annual, monthly or daily. Individual

sources may differ in volatility in particular periods; some may have volatility in production volumes only in some of the indicated periods, while in others it will remain relatively stable.

In order to determine the variation in revenue, two elements are needed: the volume of electricity production and its price. In order to determine the first of these elements, production data with an hourly cross-section for four different considered RES were obtained: five photovoltaic power plants, five wind farms, two biogas plants and two hydroelectric plants. The data was obtained from three different companies trading electricity on polish power exchange market.

The data obtained are raw production data, specifying the production volume of every hour of the period in a given location (detailed information about the location of the installation are not available, but all are known to be located in Poland). The amount of production in every hour depends on many external factors, such as weather conditions. Raw data is characterized by high volatility and cannot be used to draw general conclusions nor to be used for the purpose of revenue forecast. To make such a forecast, the data has to be processed in order to determine the most probable production volume in the given hour of the day. In the ideal case, we could do this by averaging data from all installations of a given type (e.g. photovoltaics) for each day of the year separately. However, due to the small size of the sample and the short time span (production data refer to the period 2014-2018), the results of such activity would be biased by the local weather conditions and they could not be generalized to all installations of this type. Therefore, a decision was made to average production volumes for each hour of the day, separately for all the months of the year. Such action allowed to eliminate the bias of the results due to local weather conditions and, at the same time, it allowed to capture the volatility of production during a year (see Fig. 5, Fig. 6). The calculations were made using the *R* statistical package.

We assume that the average of production volume in each hour of a given month is the most probable production volume in this hour of the given month, taking into account weather conditions (in contrast to the theoretical production volume given by the manufacturer, which will present an overstated production volume, not taking into account the decrease in output resulting from e.g. limited sun radiation). The effect of the described calculations was generated for each of the four considered RES (photovoltaic, wind, biogas and hydroelectric) and for each month, resulting in twelve daily production curves (see Fig. 5, Fig. 6) which were then used to calculate revenue. Data were normalized, i.e. the variability associated with different maximum power of each plant in the sample was eliminated.

Calculation of revenue

For each type of renewable energy source (photovoltaic, wind, biogas and hydroelectric) the average revenue generated from the sale of electricity in 2010-2017 was calculated (together with its standard deviation). The calculations were made using *R* statistical package.

In the case of the basis for the settlement of sold electricity being prices on the DAM or BM, the estimated production volumes (daily production curves) were multiplied by the actual energy prices. Multiplication was made for each hour of the period, multiplying the price by the production volume for a given hour of a given month (the production volume for the same hour of the same month in different years was therefore always the same). In the case of the basis for settlement of energy being the TGeBase index, the index value for each day of the analysed period was

multiplied by the total volume of production in given day. Such operation is equivalent to multiplying production in every hour by the value of the index valid on a given day, because the index value for each hour of the day is the same.

The above activities were performed for all four types of considered RES and three considered basis for settlements. It should be pointed out that the variability of the calculated revenue is a reflection of historical price changes, but not a reflection of historical changes in production volume (because the daily production curves for each year are the same). It was expected here that the revenue would be different for different types of RES and for different basis of energy sales settlements. For example, it was expected that in the case of photovoltaics, the revenue generated by selling at the variable price (DAM or BM) will be higher than in case of sales at a price equal to TGeBase, due to the convergence of the production curve with the daily curve prices in the summer months.

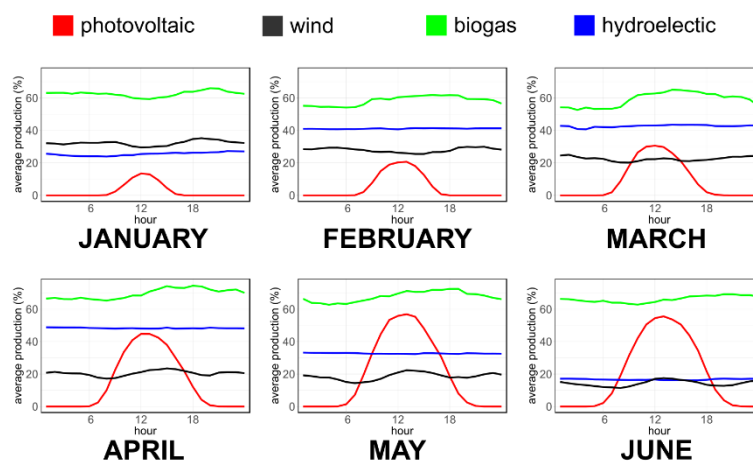


Fig. 5. Production characteristic of each considered RES from January to June

Source: own calculations based on non-public data obtained from three different companies trading electricity

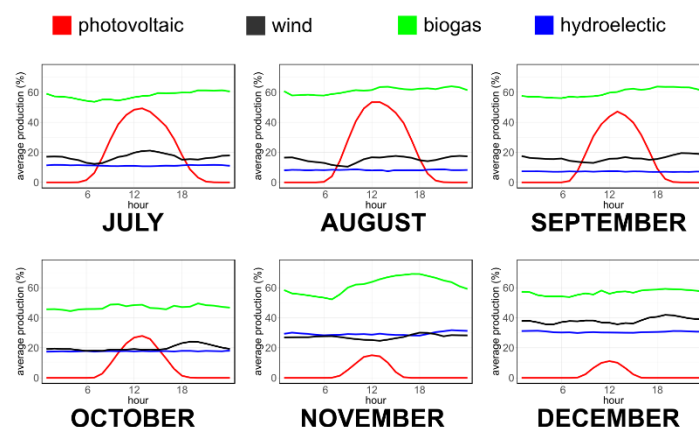


Fig. 6. Production characteristic of each considered RES from July to December

Source: own calculations based on non-public data obtained from three different companies trading electricity

Estimation of the historical values of the TGeBase index

The TGeBase index is published from 1 January 2016. To calculate the revenue obtained from the sale of energy at a price equal to TGeBase in the period 2010-2017, it is necessary to calculate the value of the index before 2016. The value of TGeBase is defined as the arithmetic mean of average transaction prices (weighted by the volume of trade), in each hour of given delivery day. To calculate the value of the TGeBase index, we need information about the prices at which individual transactions were concluded. Unfortunately, TGE does not publish such data, therefore it is not possible to calculate the index exactly. However, TGE publishes data on hourly energy prices and turnover volumes in specific hours. We can therefore calculate the approximate value of the index as follows:

$$XYZ = \frac{\sum_{i=1}^{24} (P_i V_i)}{\sum_{i=1}^{24} V_i} \quad (1)$$

where:

XYZ – the approximate value of TGeBase index [PLN per MWh];

P_i – the price for given hour of delivery [PLN per MWh];

V_i – the energy volume contacted on the market for given hour of delivery [MWh].

The approximate value of the TGeBase index for the years 2010-2017 was calculated. Based on the above approximation, a linear regression model (ordinary least squares method) [5] was built using the *gretl* program. The dependent variable was the actual TGeBase value, and the independent variable was approximated value. The goodness of model fit was determined ($R^2 = 0,987$), which was accessed as very good. The equation obtained by the ordinary least squares method was applied to the period 2010-2015. In the further analysis a dataset combined of actual TGeBase values (for the period 2016-2017) and estimated values based on the approximate values of the index (for the period 2010-2015) was used.

Coefficient of variation as a measure of risk

In addition to the absolute values of average revenue, one should consider the ratio of revenue variation to its average size. Therefore, one should consider *what the revenue variation for each unit of average revenue is, i.e. the value of the coefficient of variation*. The smaller the coefficient value, the better, because it means minimizing variability for a given amount of average revenue or maximizing revenue for a given volatility. This is true regardless of the absolute value of revenue. Even if the average revenue is very high, its high volatility causes that this option is not optimal.

The coefficient of variation as a measure of risk is referred to as *unitized risk* [6, p. 104]. For each type of installation, the revenue was calculated by multiplying the production volume (calculated as described in the previous section) by actual prices on the DAM or BM in 2010-2017 (TGeBase values for 2010-2015 are approximated, as described in previous section). This period was chosen because it was considered the most representative (before 2008 prices on the DAM and BM had a different characteristic than after 2008; in 2008-2009 there was a significant increase, prices stabilized only in 2010, see Fig. 2). Due to the variability of production volumes over the year, revenues were only analysed in full years. Revenue was calculated for each hour of each day (for each combination of the RES type and the basis for settlement). Revenue for each year was

calculated as the sum of each hour of the year. The average revenue and its standard deviation were calculated for the entire period. Then, the coefficient of variation was calculated by dividing the standard deviation of the revenue by its average. This resulted in a total of twelve measures (three forms of settlements times four types of RES).

The rationale for choosing the coefficient of variation as a measure of risk is that it allows one to determine the variation in revenue per each unit. This allows to determine the relative level of risk, regardless of the size of the revenue. It is far better measure than average revenue, because the latter does not take into account variability. According to this line of reasoning, the investor should choose not the form that provides the highest average revenue, but the one that ensures the least volatility per monetary unit of average historical revenue.

Results

To illustrate the volatility of revenue, its size was calculated for each month of the analysed period, for each type of RES. This showed the variability of revenue in the period under consideration and the differences between revenues obtained using different basis for settlements. The average annual revenue and its deviation in the examined period were calculated for each type of RES and for each analysed basis of settlements (see Tab. 1). The coefficient of variation was also calculated for each combination of RES and the settlement base.

Results were visualized in the form of a Risk-Return Graph, where the average revenue has been put down on the x axis, and the standard deviation of revenue was postponed on the y axis (see Fig. 7). The points on the chart are the types of RES sources that sell electricity assuming indicated basis for settlement. The blue line marked on the chart passes through the origin of the coordinate system and the *wind DAM* point. All points lying on this line have exactly the same value of the coefficient of variation as *wind DAM*. Points below the line have a lower value of coefficient than *wind DAM*, while the points above have a higher value.

Tab. 1. Average revenue, its standard deviation and coefficients of variation for four types of RES and three different basis for settlement (revenue in 1000 PLN, coefficient of variation per 1000 PLN)

Type of RES	Basis	Avg. revenue	Stand. dev.	Coefficient
photovoltaic	RDN	188.87	16.24	85.96
photovoltaic	RB	195.99	18.03	92
photovoltaic	TgeBase	167.28	15.86	94.82
biogas	RB	935.81	90.17	96.35
biogas	RDN	916.31	91.02	99.33
biogas	TgeBase	912.36	90.92	99.66
wind	RB	344.52	34.38	99.79
wind	RDN	338.06	34.66	102.53
wind	TgeBase	336.72	34.57	102.67
hydroelectric	RB	391.12	41.51	106.13
hydroelectric	RDN	383.71	40.83	106.41
hydroelectric	TgeBase	384.55	41.15	107.01

Source: own calculations based on data from TGE and non-public production data

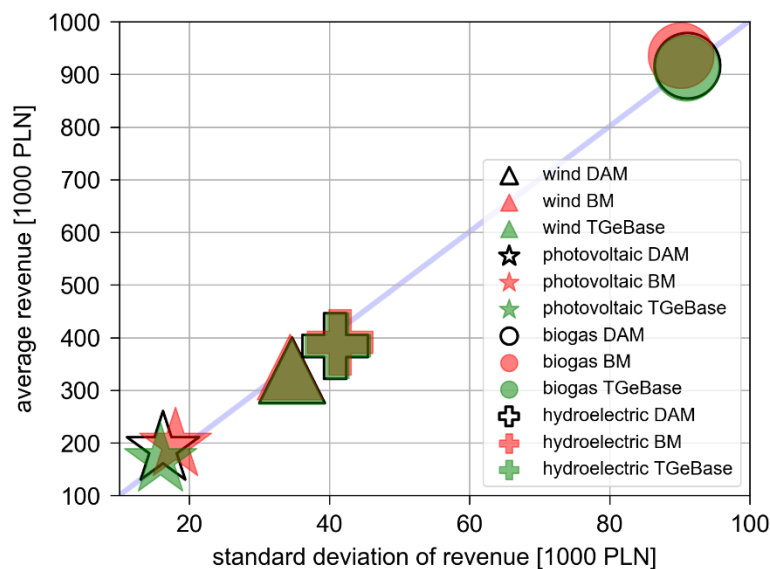


Fig. 7. Visualization of coefficients of variation for four types of RES and three different basis for settlement
 Source: own calculations based on data from TGE and non-public production data

Conclusions

Based on the obtained results, conclusions can be drawn regarding four different aspects of the risk of change of revenue of each RES: (a) the amount of absolute revenue and its variability depending on the type of RES source, regardless of the basis for settlements; (b) the amount of absolute revenue and its variability depending on the basis for settlements of sold energy (considered independently for various types of RES); the impact of each of the above elements on the absolute amount of revenue, i.e. which of these elements (type of RES or the chosen basis for settlement) has greater impact on the amount of revenue; regarding the ratio of revenue variation to its average height (the magnitude of revenue variation for each monetary unit) and the link between this value and the type of source or the basis for settlement.

As for the absolute value of revenue depending on the type of RES, the highest average revenue is generated by the biogas plant. The biogas plant is also characterized by the highest variability (measured by standard deviation) of annual revenue. The lowest revenue from all considered RES is generated by the photovoltaic power plant (the types of sources can be compared between each other because they have been normalized). The photovoltaic plant is also characterized by the smallest variation in annual revenue. The other types of sources are characterized by higher revenues than the photovoltaic plant.

Within each of the RES sources considered, the average revenue and its variation differs between the considered basis for settlements. These differences are greatest in the case of a photovoltaic plant. The largest difference (for photovoltaic power plant, between BM and TGeBase) is 14.6% of annual revenue (higher for BM). In the case of other types of RES, the differences are smaller, but still occur. Therefore, the choice of the form of settlements affects *ceteris paribus* the amount of revenue obtained and is one of the methods of its maximization.

The amount of revenue depends, however, on the type of RES rather than on the form of settlements used. Even the application of the most favourable, in terms of absolute revenue, form of

settlement will not cause that the revenue of a photovoltaic plant will be equal to the revenue of a wind farm or any of the others. The use of the most advantageous form of settlements for any source will not cause that its revenue will rise above the difference between the revenue of a given installation and one that generates more revenue. The differences in revenue between groups (determined by the type of renewable energy sources) are larger than those within groups.

The wind farm would achieve the highest average nominal revenue using the BM settlement as the basis, and the lowest in the case of TGeBase. The same applies to biogas plants. In the case of a hydroelectric plant, the highest average nominal revenue would be achieved using BM as the basis for calculating the due, and the lowest in the case of DAM. Since TGeBase is a weighted average of prices on DAM, this suggests that the buyer will not offer an energy purchase price equal to or greater than TGeBase.

Differences in the coefficient of variation between the various settlement bases are the highest in the case of a photovoltaic plant. The most advantageous basis for settlements is the Day-Ahead Market. The difference in the value of the coefficient of variation between the two remaining settlement bases is much smaller than between the DAM and any of them. In the case of a photovoltaic plant, the Day-Ahead Market should be selected as the basis for settlements for the sold electricity, because it will allow to obtain the highest possible revenue with the smallest possible volatility.

In the case of the remaining types of RES (wind, hydroelectric and biogas plants) the use of TGeBase as the basis for settlements causes that the absolute average revenue value is the lowest of the three considered basis for settlements, and the least favourable coefficient of variation. In case of the aforementioned types of RES, the application of a basis for electricity sales other than TGeBase will contribute to an increase in revenue with the most favourable ratio of revenue volatility to its average amount. The use of a basis for settlements for electricity sold other than TGeBase will therefore improve the economic situation of such investments.

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DIAGNOSIS OF THE CONDITION AND PROSPECTS OF THE DEVELOPMENT OF THE MATERIAL BASE BIESZCZADY

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Abstract

Tourists are increasingly choosing areas of Bieszczady as their travel area. In recent years, a high increase in the number of accommodation facilities has been observed.

The aim of the research was to check the tourist development status of Bieszczady by tourists in the opinion of tourists. The tool used was a questionnaire independently prepared by the authors of this work. The research technique used in the work was a questionnaire. The questionnaire contained questions of single or multiple choice and was anonymous. 100 respondents took part in the study.

The Bieszczady Mountains as a tourist region are well developed, which does not change the fact that their further development can be properly targeted. According to the analysis of the research carried out by the authors, it can be concluded that the accommodation is suited to the tourist visiting this region.

Keywords:

Bieszczady, material base, tourist region

Introduction

Bieszczady are one of the most magnificent areas of Poland, they are part of the Beskidy Mountains. They are located on the territory of Poland, Slovakia and Ukraine. It is the southernmost part of our country. They are part of the main Carpathian arch and are the first part of the Eastern Carpathians, which begin in the valley of San, Oslawica, Laborca and Oslawa. On the territory of Poland, only the Western Bieszczady Mountains are located, which go westwards into the Low Beskids, while towards the East into the Eastern Bieszczady. On the Slovak side they bear the name Bukovské Vrchy, so it is the southern side of the Carpathian watershed [1].

Tarnica (1346 m above sea level) is the highest peak of these mountains on the Polish side, it is the main attraction of this place. It enjoys the interest of visitors not only domestic, but also foreign. Despite the fact that it can not compete with the highest peaks of Poland, it is visited by tourists every year. There are two routes to the top of Tarnica: red and blue, they give you the opportunity to start your journey from Ustrzyki Górne or from Wołosata. Solińskie Lake is another popular tourist destination. In its surroundings are the largest tourist towns in Bieszczady, including Polańczyk, Solina and Myczkowce. The area of the lake is approximately 22.5 km². In these areas

there is a well-developed tourist infrastructure. Tourists can take advantage of a large number of beds, restaurants, marinas and bathing areas [2].

One of the most attractive elements in the Bieszczady Mountains are forests. The fertile Carpathian beech forest is an area of forest complexes widespread throughout the world. It is the dominant group of the low-lying forest and occurs in several variants [3].

Poland has many recognizable tourist brands, one of them is Bieszczady. Apart from the fact that these are areas well developed in terms of tourism, we can still call them one of the "wild" areas in our country. This region is appreciated not only in terms of landscape, but also for numerous cultural tourist attractions [4].

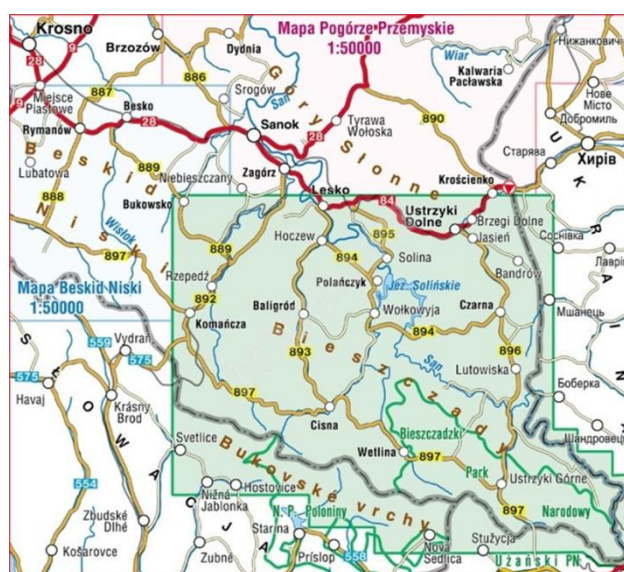


Fig. 1. Bieszczady mountains
Source: [5]

The natural form of protection is the Bieszczady National Park, which stretches in this picturesque corner of Poland is one of the most visited places by tourists in our country. It was founded in 1973. It became part of the International Biosphere Reserve "Eastern Carpathians" in 1992. It is the largest national park in the Polish mountains and the third largest national park in the country. Bieszczady National Park is located in the south-eastern part of the Podkarpackie Voivodeship, in the Bieszczady and Lesko poviats in Lutowiska and Cisna municipalities. A small part of it is located in the municipality of Czarna. In its area is the southernmost point of Poland, located next to the border with Ukraine, the peak of Opołonek (1028 m above sea level). In Ustrzyki Górne is the seat of the Park Directorate. There is a lynx on the coat of arms of the park. The area of the Bieszczady National Park is currently 292.02 km². Its buffer zone is the Ciśniań-Wetliński Landscape Park and the San Valley Landscape Park. Bieszczady National Park is part of the International Biosphere Reserve "Eastern Carpathians", created by UNESCO as part of the "Man and Biosphere" program. The International Biosphere Reserve "Eastern Carpathians" also includes the Slovak Poloniny National Park and the Ukrainian Ujanski National Park. The Bieszczady National Park and the lagoon are part of the Natura 2000 area: PLC180001, a pan-European network of protected areas, which consists of special bird protection areas (OSOP) and special habitat protection areas (SOOS) established in all EU member states. Bieszczady, whose

area is 111 519,5 km². This is both the Special Protection Area of Birds and the Special Area of Conservation of Habitats [6].

Bieszczady National Park is a place of occurrence of more than 230 species of vertebrates, they include 58 species of mammals. Almost all large mammals inhabiting Poland occur in its area. They include predators: bear, wolf, lynx and wildcat, as well as herbivores: bison and karpacki deer. The 1960s became a breakthrough when it came to bison breeding in these areas. At that time, about 20 individuals were brought from the centers in Pszczyna and Niepołomice. These animals quickly acclimatized and adapted to the conditions prevailing there. Currently, their number is about 280 individuals. Dozens of them are in the park. It is the largest wild mountain bison herd in the world.

The history of the Bieszczady starts from the East Slavic peoples, Bojków and Lemkos, who inhabited the Ośława valley. These peoples began to disappear after the action of displacing the Vistula. The highlander world has been dispersed and decimated. However, to this day, descendants who try to preserve their culture by publishing their own newspapers or organizing the Łemkowska Watra festival have survived. To this day, remains of huts that can be found in Bieszczady are preserved. Bojkowskie huts, as well as Lemko, are traditional wooden single-market farms that used to be found all over the Bieszczady. It is characterized by the fact that under one steep, gable roof covered with thatched roof, there were living rooms with economic ones. Bojkowskie buildings were chickens' cottages until the end of their presence in the Bieszczady Mountains. This means that the central room in which the stove was located did not have a chimney. Apparently it is from these times comes the saying that the guests arrived immediately after entering the room they sat down, it was about that they would not let themselves [7].

Krzysztof Szpara conducted research on the accommodation base in the Bieszczady Mountains. It follows from them that the largest part of the accommodation there is near the Soliński Reservoir. There we can find large objects, consisting of several hundred beds, as well as smaller ones, being part of a rural accommodation base, including agritourism farms. A significant part of them was created at the end of the nineties, but new beds are still being built. The research showed that tourists are mainly attracted by the Bieszczady National Park and the Soliński reservoir. A year-round accommodation base is created, thus extending the tourist season. This allows for a better use of the accommodation base, in particular agritourism farms and private accommodation. The ever-increasing standard of accommodation facilities can attract foreigners who want to relax in the Bieszczady Mountains. However, for this to happen, changes are needed in many respects. Above all, increasing the number of catering facilities with a higher standard. Another problem is the lack of foreign language skills by the hosts. You would also have to think about the attractions available in bad weather. These studies show that there may be even more tourists with small changes [8].

Research carried out by Diana Mazek and Ewa Bogusz makes us realize that for tourists is very important accessibility of road and communication infrastructure, but it is not yet well developed in the Bieszczady. In these studies, the respondents pointed to the lack of enough toilets, car parks and beds for larger organized groups. This is a big obstacle for the organizers of larger trips. The Bieszczady Mountains are not yet prepared for such a large tourist siege, which began to appear there in recent years. Lack of observation towers and the world adversely affect the attractiveness of the places visited. You could also increase the attractiveness of the winter season by increasing the number of ski lifts and cross-country skiing trails.

GUS data from 2017 about the Bieszczady powiat confirm that there are:

- hotel facilities: 11
- hostels: 2
- school youth hostels: 3 (all-year-round: 2)
- holiday centers: 5 (all-year: 3)
- training and recreation centers: 3
- tourist bungalows: 9 (all-year: 6)
- campsites: 1 (all-year: 0)
- campsites: 2 (all-year: 0)
- guest rooms: 16 (all year: 9)
- agrotourism lodging: 6 (all-year-round: 5)
- other unclassified facilities: 7 (all-year: 5) [9] .

As you can see, the accommodation base in the Bieszczady Mountains is quite large and varied but not sufficient for the demand in this area. Chatka Puchatka is very popular, it is the highest located hostel in the Bieszczady Mountains. It is located on Polonina Wetlińska (1228m above sea level). There are 20 beds there. Due to its location, it is deprived of electricity, sewage or running water. If you want to feel the typical mountain climate, this is the perfect place. Lack of luxury does not encourage everyone, but the visible sunrises and sunsets seen from such a location can reward everything.

Assumptions and objectives of research

The aim of the research was to check the tourist development status of Bieszczady by tourists in the opinion of tourists.

The research was aimed at examining:

- a) How do the respondents assess communication availability in Bieszczady?
- b) What type of communication do tourists use when traveling to the Bieszczady Mountains?
- c) How do tourists assess the condition of marking tourist routes in the Bieszczady Mountains?
- d) From what type of accommodation base do tourists visiting Bieszczady most often use?
- e) How do you assess the availability of accommodation facilities?
- f) What are tourists guided by when choosing accommodation?
- g) What type of catering facilities do you use during your stay in the Bieszczady Mountains?
- h) How do they assess the availability of catering facilities?

Analysis of test results

The research was carried out by the authors using a survey on tourists visiting the Bieszczady region. The authors conducted them in 2017 in the months of July and August and in 2018 in January and February. 100 respondents took part in the research. Analysis of test results The first goal of the authors of the work was to determine how respondents assess the accessibility of the Bieszczady Mountains. As many as 60 respondents (60%) believe that communication accessibility is good, 21 respondents (21%) determine accessibility as very good while 19 people (19%)

indicated that communication accessibility is poor. The authors of the work illustrated the above results on graph number 2.

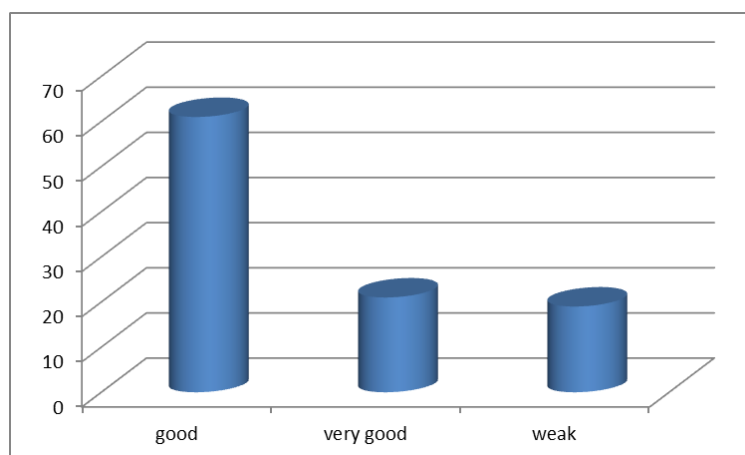


Fig. 2. How do you assess communication accessibility in the Bieszczady Mountains?

Source: Based on own research.

Another issue in the questionnaire was to check what type of communication the respondents use when traveling to the Bieszczady Mountains. Private transport is the most common choice among respondents, 87 people responded (87%), one of the more frequent transports is a bus, 31 respondents (31%) indicated such a means of communication. 24 respondents decided to hitchhike (24%). The worst among the answers given in the questionnaire was rail transport, it is the type of transport that one respondent was moving. The results are illustrated in the graph below.

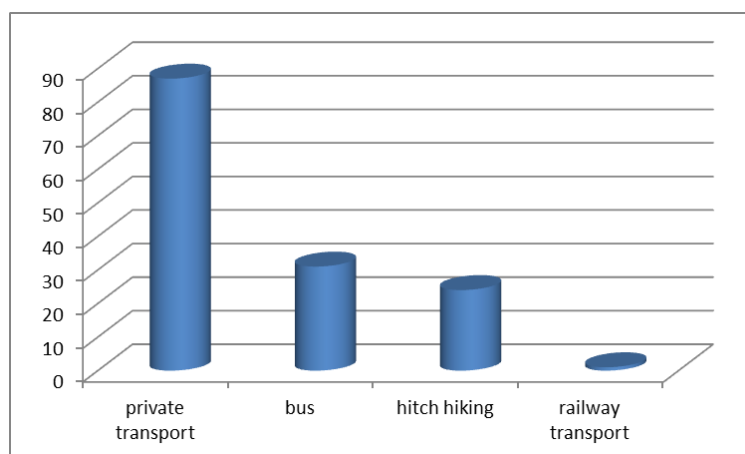


Fig. 3. What type of transport do you use during your trip to Bieszczady?

Source: Based on own research.

The next goal set by the authors of the work was to check how the respondents evaluate the condition of marking tourist routes in the Bieszczady Mountains. The results presented by the authors of the work are as follows. 61 respondents believe that the routes in the Bieszczady are well marked, according to 32 respondents the routes are very well marked, while the answer is poorly marked trails were chosen by 8 people. The results are shown in diagram number 4.

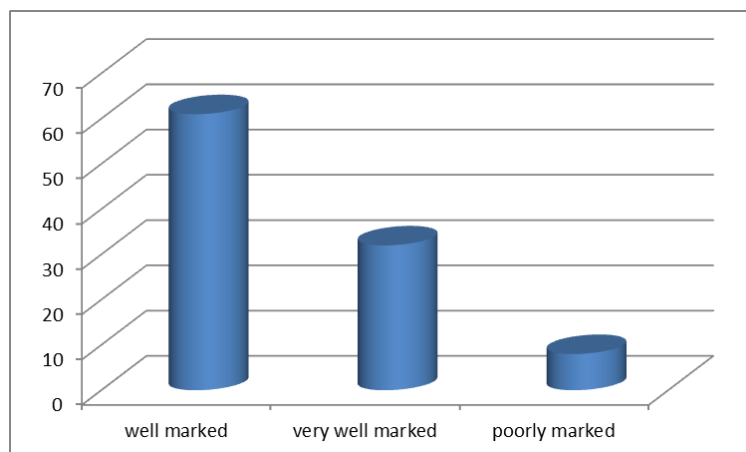


Fig. 4. How do you assess the condition of marking tourist routes in the Bieszczady Mountains?

Source: Based on own research.

The next question was "What type of accommodation do you use most often in the Bieszczady Mountains?" The respondents most often decided to stay in summer houses, 50 respondents chose such a reply, while 47 respondents use mountain huts. Private accommodation and agritourism is a selection of 44 respondents. In the guest houses and holiday centers, 41 respondents stayed in hotels 22, while 18 chose campsites.

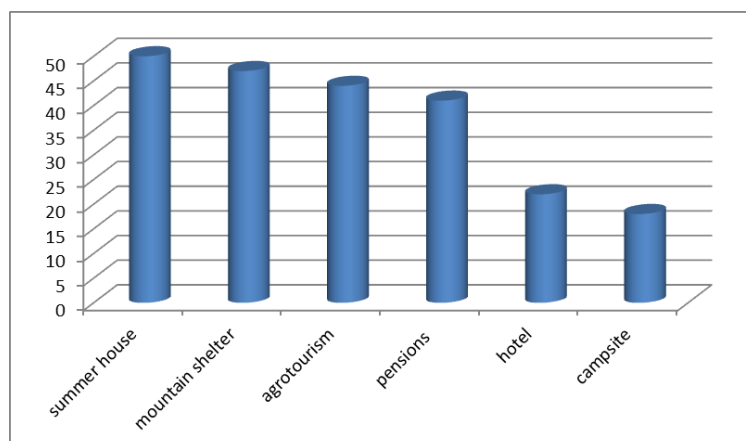


Fig. 5. What type of accommodation do you usually use in the Bieszczady Mountains?

Source: Based on own research.

The chart below shows how respondents assess the availability of accommodation facilities. According to the research, sufficient accessibility to accommodation facilities is the answer of 55 respondents for 37 people, availability of facilities is high, while 9 respondents believe that the availability of accommodation facilities is small.

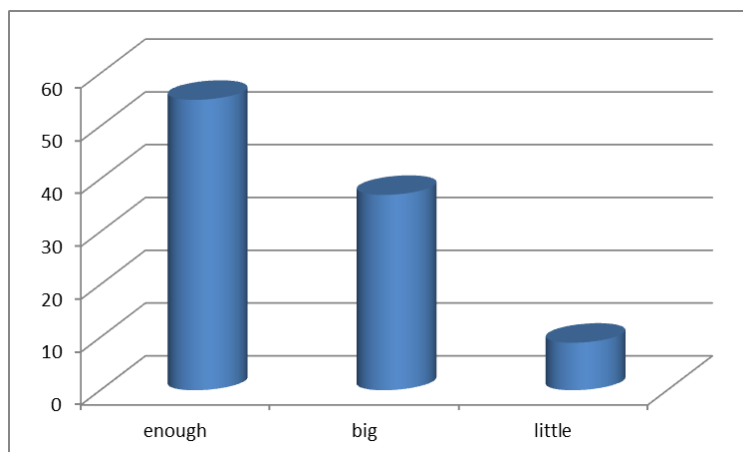


Fig. 6. How do you rate the availability of accommodation facilities?

Source: Based on own research.

In the next section of the questionnaire, the respondents were asked what catering facilities they used during their stays in the Bieszczady Mountains. Self-catering means a selection of 73 respondents used 54 restaurants, 46 people indicated bars, 41 respondents used meals served in hostels, and 16 polled respondents. The data is presented in the graph below.

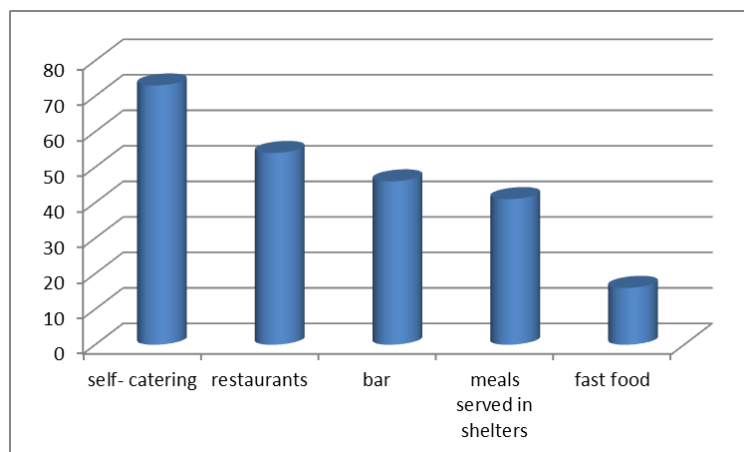


Fig. 7. What gastronomic facilities did you use during your stay in the Bieszczady Mountains?

Source: Based on own research

As another application, the authors of the study decided to check how respondents assess the possibility of practicing the chosen form of tourism in the Bieszczady Mountains. According to 54 respondents there are enough places for this type of tourism. 43 respondents answered that there are quite a lot of places to do this type of tourism while one person stated that there are definitely not enough places for this type of tourism.

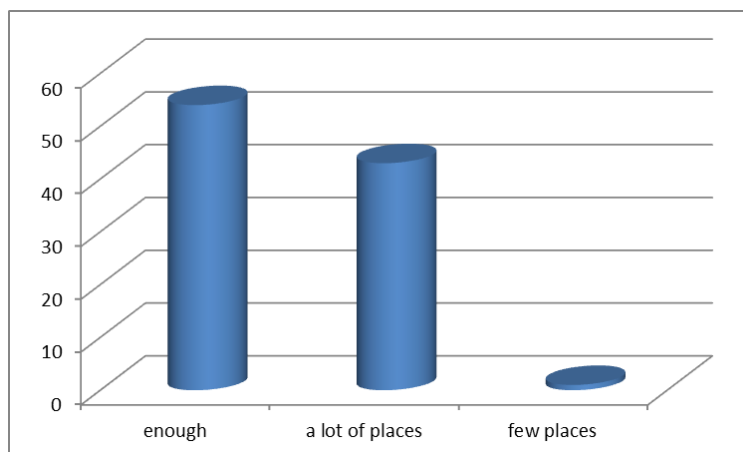


Fig. 8. How do you assess the possibility of practicing your chosen form of tourism in the Bieszczady Mountains?

Source: Based on own research

Summary

To sum up the considerations, the Bieszczady Mountains as a tourist region are well developed, which does not change the fact that their further development can be properly targeted. Probably in the future, the accommodation base in the Bieszczady Mountains will be slightly dispersed. The tendency to create a year-round accommodation base, and thus to extend the tourist season, will also be maintained. This will result in better use of the Bieszczady accommodation facilities (especially in agritourism farms and other rural private lodgings).

The increasing standard of accommodation facilities offered to letniks may affect the increase in the number of tourists spending holidays in the Bieszczady Mountains, but the infrastructure of this place can not yet offer much to visitors during bad weather.

As can be seen from the analysis of the research carried out by the authors of the above work, it can be concluded that the accommodation is suited to the tourist visiting this area. That is why, in this region, there are summer cottages, mountain hostels and private accommodation as well as guest houses and holiday centers. However, a small percentage of the infrastructure are hotels. Respondents when choosing guest rooms and agritourism farms, which are still being created, are guided by the price and distance from tourist routes, which according to them are well marked. However, careful consideration of the causes and effects of the discussed phenomenon requires further research. The above work and the studies that have been carried out can show how the level of development can be increased.

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FREE-TIME BEHAVIOR OF HIGH SCHOOL STUDENTS ON THE EXAMPLE OF STUDENTS OF THE 5TH HIGH SCHOOL IN RZESZÓW IN THE 2017/2018 SCHOOL YEAR

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Abstract

The main purpose of the work was to diagnose research on the amount of free time of high school youth from Rzeszów in 2017/2018. The basic concepts related to free time, what are its forms, and how the school organizations and outside schools have to spend their free time are explained.

The tool used in a questionnaire independently prepared by the authors of this work. The survey technique used in the work was a questionnaire. The questionnaire contained questions of single or multiple choice and was anonymous.

To sum up the considerations, the amount of free time determines how the high school youth spend it. According to the analysis of the research carried out by the authors of the work, young people choosing passive spending of free time, decide to meet friends or listen to music. However, when actively spending free time, young people choose sports fields or cinemas.

Keywords:

free time, free time behavior

Introduction

Free time accompanies people every day, how we spend it affects health and well-being. During high school, a very important aspect is how students spend their free time, because teenagers are becoming more and more independent, during puberty they manifest various kinds of emotional imbalances. Both the family and the school shape passions and interests in the young people.

The aim of this work is to determine the amount of free time available to high school students, and what determines them to undertake specific activities.

Taking up the subject of free time, the authors of the work wanted to find out whether secondary school students are aware of the importance of physical activity during leisure time, the main motive was to check how much free time students have and how they prosper.

In the common sense, free time is a time without duties, intended for any classes.

In the book "The phenomenon of free time" M Truszkowska-Wojtkowiam writes that "from the beginning of the shaping of the concept of free time we have several ways of interpreting it: as "freedom from work ", as "freedom to free time "and finally as a state of mind accompanying free activity, usually intellectual" [1].

W. Okoń defines free time as a moment which is completely at the disposal of the individual, after fulfilling all duties related to work, household duties or education. According to Okon, free time in a rational way should be spent on:

- Rest in this regeneration of strength,
- entertainment that gives pleasure,
- voluntary and unselfish social activity,
- development of interests through the acquisition of knowledge, artistic, technical as well as scientific or sports activities [2].

Z. Dąbrowski, studying the possibility of spending free time and managing it among children, distinguished three groups:

- The first group also presents parents who want their child to have a carefree and longest childhood. In later life, it can affect children because they can be clumsy and selfish.
- The second group are children who perform certain duties on a casual basis, where the parents do not want to shape their attitudes and skills in them, they only take care of their children. The result in later years may be a lack of a sense of responsibility and perseverance.
- The third group - are children who have assigned responsibilities and a certain free time for their own disposal. Parents choosing activities for their children are guided by educational goals. Children later become resourceful, systematic, able to appreciate the results of their work and organize their free time well [3].

Among the factors determining the amount of free time among young people there are:

- age and status of young people,
- type of school,
- proper organization of spending time of the student both at school and at home, properly selected schedule of classes for the school, home and activities undertaken in leisure time,
- fashion, which is readily copied by young people,
- material conditions of parents,
- possession of mass media,
- level of parents' education and their personal culture,
- ways of taking time off by the family,
- traditions and habits created in the field of active rest,
- local environment, recreation centers located in this environment, such as school and sports grounds, swimming pools, ice rinks, recreation centers [4].

Functions of free time

Thanks to many definitions and assumptions, a lot of free time concepts have been created. As aptly noticed by E. Wnuk - Lipiński, this is due to the diversity of ways to use free time and the accompanying motives.

In studies and theory, functions that can be considered as basic by E. Wnuk - Lipinski are repeated:

- educational functions - instilling or assimilating certain views to someone,
- integration functions - related to satisfying the need to belong,
- recreational functions - which rests both physical and mental,
- cultural functions - the purpose of which is to create and assimilate cultural values,
- compensation functions - that is, matching the unmet needs [5].

Free time as educational values

People take their free time in many ways, some prefer to spend it actively others passively. However, they often choose to change classes, the possibility of contact with other people, the choice is rarely to spend free time alone. Generally, they choose to spend their time actively more often than passive. The ability to choose forms of free time is very important because everyone can find the right one for themselves. It has been shown that passive leisure is no less effective than active leisure. Recreation activities help reduce nervous tension and reduce stress [6].

The table below shows the effects of taking physical activity.

Tab. 1. The health significance of working on oneself as a function of free time

Movement activity	Effects
Little	Lowering the physical efficiency of the body and impairing its adaptation to change living conditions. Decreased maximum cardiac capacity and a tendency to orthostatic collapse (fainting when taking a vertical position). Disturbances in the functioning of internal systems. Obesity, which involves the risk of many diseases. Acceleration of the body's aging processes.
Big	Obtaining and maintaining high physical fitness and health as well as the ability to constantly adapt to changes. The chance of achieving high physical efficiency exists only until 20-25 years of age. If during this period, as a result of high physical activity, we reach a high physical capacity, we will obtain a good prospect of maintaining it until late age, provided even moderate but constant activity.

Source: [7]

School and out-of-school forms of spending time

In the twentieth century, modern forms of spending free time took shape. Nowadays there are many opportunities for spending free time.

The contemporary forms of spending free time include:

- tourism - it is a form of active rest away from the place of permanent residence of the mass media - we include the press, cinema, radio, television
- sport - in the modern world there is a fashion for practicing sports as well as attending various sports spectacles
- theaters and philharmonics, exhibitions and museums - They satisfy the cultural needs of a fairly small number of recipients.
- self-study - depends on independent undertaking of various fields of science most often not related to professional work
- DIY and technical amateurism - in the XXI century it becomes a very popular form of spending free time, eg when decorating a home

- amateur breeding - considered to be useful forms of spending free time consisting in self-cultivation of animal species or cultivation of various plants
- fun and social contacts - young people mostly choose disco as a form of rest, spreading the dance, which is very widespread in all world cultures
- collecting - is a hobby and cognitive form. Special features for collecting are collecting various items of everyday use as well as works of art. Everyone can collect and what they want because the collector's intention determines the value of a given collection
- social activity - manifests itself during the activities of each of the above-mentioned forms of spending free time.

Factors affecting the quality of free time: level of education, environmental and family traditions, marital status, age and sex, and material situation [8].

The role of social organizations and associations in the organization of free time of young people

It has always been argued that parents are primarily responsible for bringing up children. In the 21st century, it should be noted that in the period of major social changes, technological development, computerization, longer working hours and other factors, parents have little time off to devote it entirely to the child. That is why more and more often teaching facilities join in the process of bringing up a child, which are aimed not only at education, but also at the personal development of the student. Teachers have great opportunities in this field.

The activity of educational institutions in spare time focuses on:

- organizing various events,
- access to the library, reading room of the school room,
- organizing sport and recreational activities,
- creation of interest groups,
- opening new student organizations,
- organization of various clubs,
- organizing hiking [9].

Assumptions and purpose of research

The aim of the research was to diagnose the work of high school students in Rzeszów in 2017/2018, as well as spend their free time. Therefore, detailed research questions were developed.

The detailed objectives of the study were to check:

- a) What is the total amount of free time available to high school students?
- b) How much free time does secondary school youth have over the weekend?
- c) What forms of spending free time are actively chosen by high school students?
- d) What forms of passive free time are chosen by high school students?
- e) What part of your free time is spent by young people on physical activity?
- f) In which company do you usually spend your free time?

Stuff

The research group consisted of students of the Secondary School Complex No. 2 in Rzeszów, which includes the High School No. 5. 121 high school students participated in the diagnostic survey, including 68 boys and 53 girls. The study was conducted in January 2018.

Analysis of test results

As one of the main goals of the questionnaire was to check how much free time high school students are able to find during the day, after taking lessons, extracurricular activities or fulfilling other duties.

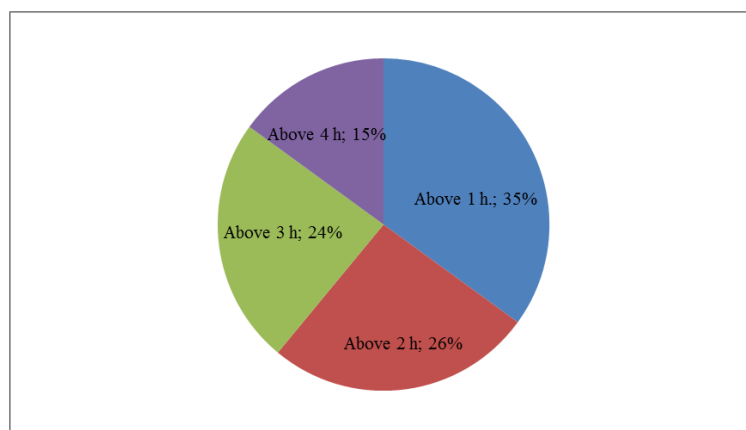


Fig. 1. How much free time high school students are able to find during the day, after taking the lesson, and household duties.

Source: Based on own research.

The graph shows that out of 121 respondents, 35% think that they have more than 1 hour of free time a week, 26% of respondents answered over 2 hours, 24% answered over 3 hours, the answer was more than 4 hours, which resulted in 15%.

The amount of free time of high school students during the weekend is shown in Fig. 2. 15% of the respondents indicated that they had up to 6 hours of free time on weekends, 29% of respondents indicated 6-12 hours. From 12-16 hours of free time on weekends, it has 23% of respondents, while more than 16 hours have 33% of respondents.

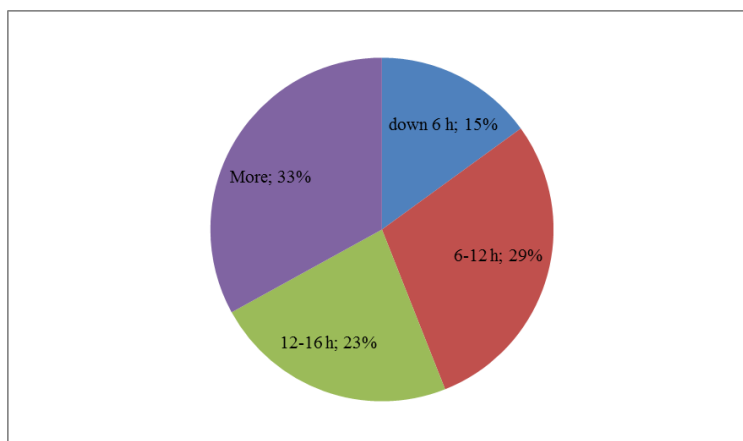


Fig. 2. Number of free time of high school students during the weekend.

Source: Based on own research.

The next question in the questionnaire was to check how high school students usually spend their free time. According to the analysis of the questionnaire, it appears that young people most often choose walks as a form of spending free time. Answers were given by as many as 69 respondents, 58 respondents choose a gym, a large minority attend the pool, which gives answers to 22 respondents. Some of the more often marked forms of spending free time were team games, this answer was marked by 63 respondents, 44 people completing the questionnaire choose cycling and fitness classes 16 respondents. The surveyed students in this question could also write out other forms of spending free time, which they prefer. Answers such as: running, roller skating, dancing and martial arts or athletics were the most common. The results are presented in the graph below.

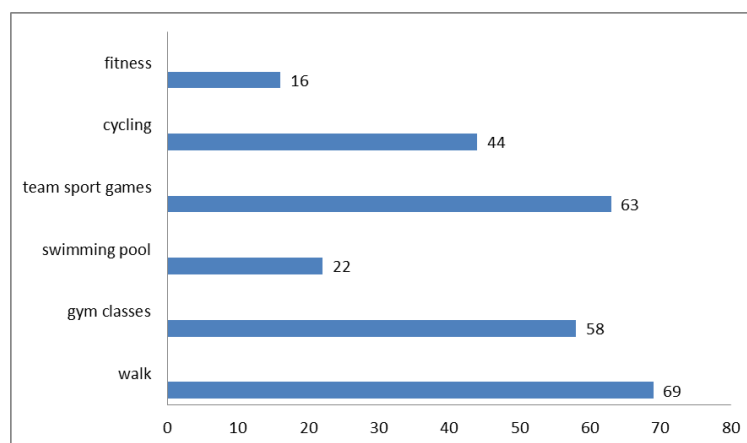


Fig 3. How respondents spend their leisure time actively.

Source: Based on own research.

The questionnaire contained a question that was supposed to check which forms of spending free time offered in the place of residence are used by the respondents. Respondents in the questionnaire, as in the above question, could select several answers. After analyzing the questionnaires, the results are as follows. The most frequently chosen answer was sports fields / eagles as many as 72 respondents (59%). Cinema was found very high, as many as 62 people (51%) filling in the questionnaire indicated this answer. Amusement parks are a place where 14 (11%) of

respondents decide to devote their free time, while in discos as many as 51 respondents (42%). Trampoline park is a place where 24 respondents (19%) attend, 29 respondents (23%) decide on the ice rink. High school youth often chooses bowling, such answer was given by 19 high school students. Street workout is a place where 18 respondents (14%) often stay, the marina is chosen by 10 high school students (8%). As the least frequently chosen places of spending time by high school students turned out to be museums / exhibitions / theater or skate park because only 4 respondents (3%) indicated this answer. The least frequent respondents use hockey on skates, only 3 respondents (2%) chose this form of spending free time offered in their place of residence. The above answers are illustrated in Fig. 4.

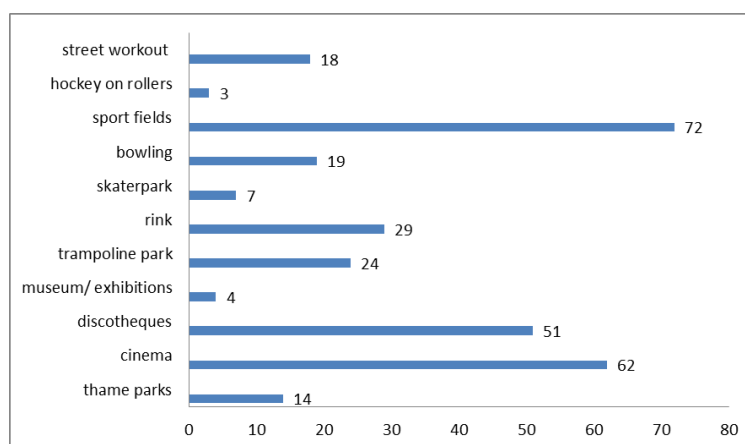


Fig. 4. What forms of spending free time in the place of residence do people use?

Source: Based on own research.

Another goal of the work was to determine how high school students spend their free time passively. According to the analysis of surveys, the majority of respondents choose 92 respondents as spending passive time with friends. Reading newspapers / books is the job of 25 respondents, while consoles, a TV set, or a computer selects 73 respondents. 52 respondents chose to spend time with their family, while 91 - the vast majority of respondents choose to listen to music as passively spending free time. Solving the crosswords selects 5 people and the chess game is the answer of 7 respondents. The results of the above question are illustrated in Fig. 5.

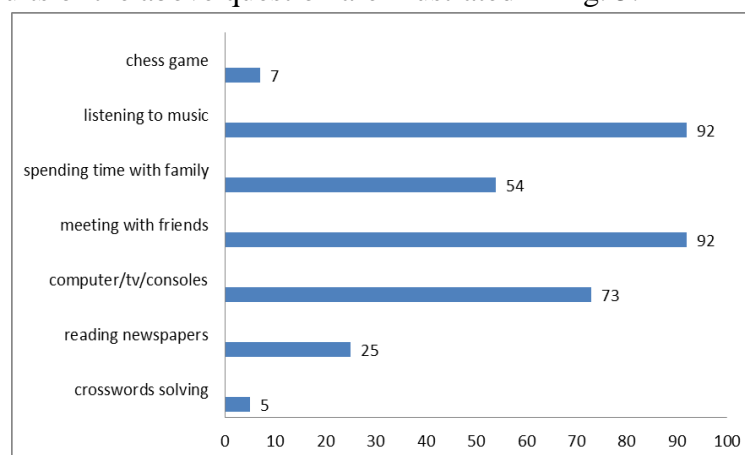


Fig. 5. How does high school students spend passively?

Source: Based on own research.

Summary and Conclusions

Summing up the considerations, the amount of free time determines how the high school youth spends it. According to the analysis of research carried out by the authors of the work, young people choosing passive spending of free time decide to meet friends or listen to music. However, when actively spending free time, young people choose sports fields or cinemas.

The results of the above work should show how important in the life of a young person is the proper taking of free time and awareness of the benefits that result from the proper taking of free time. As the above studies show, students have much more free time during weekends than during the week and school activities, what forms of free time they take in a given period of the week is strongly conditioned by the amount of free time. The research also showed that students, despite much more free time during the weekend, also mostly passively pass the weekend. When analyzing the research, it turned out that the students choosing to spend their free time actively prefer to go for walks and team games, but passively choose listening to music and playing on consoles. Comparing the results of the research with the results of Ewa Dybińska and Grzegorz Przywar contained in the article entitled "Slowly pre-eminent behavior of junior high school students of selected Jasło schools with regard to gender and place of residence", it can be noted that young people prefer to listen to music as spending free time both in the studies mentioned above authors and authors this work. The above work and studies that have been carried out can show how parents and educators could organize classes for their children and students so that they would spend their free time properly.

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SATISFACTION WITH LIFE, STYLES OF COPING WITH STRESS AND AFFECTIVE TEMPERAMENTS

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Abstract

This study investigates a relationship amongst life satisfaction, styles of coping with stress and affective temperaments and so far no study of measuring the phenomenon has been carried out. This study involved 110 non-clinical Polish adults and it is based on life satisfaction, assessed with the Satisfaction with Life Scale and styles of coping, measured by the Coping Inventory for Stressful Situations. The Polish version of the Temperament Evaluation of Memphis, Pisa, Paris and San Diego Auto-questionnaire was used to assess affective temperaments (depressive, cyclothymic, hyperthymic, irritable and anxious). Its results showed a positive correlation of life satisfaction, task-focused coping and hyperthymic temperament, although the negative correlation with emotion-focused coping and the other temperaments was also noticed. The task style correlated positively with hyperthymic temperament and negatively with depressive, cyclothymic and anxious temperament. The emotional coping showed the opposite relationship with hyperthymic temperament and a positive relationship with other temperaments.

Keywords:

satisfaction with life, styles of coping with stress, affective temperaments

Introduction

Satisfaction with life

Many scientists having been interested in the issue of life satisfaction would like to detect factors that affect its level and the possible effects of low or high intensity of satisfaction with life. For the vast majority of society, satisfaction with life becomes equal with health, self-esteem, professional or social successes and the ability of coping with problematic situations [1]. A higher grade of life satisfaction is associated with a greater degree of activity and self-efficacy as well as better coping with stressful situations [2]. However, the level of life satisfaction also depends on constant factors such as genetic and psychological differences [3]. In the field of psychology, the term known as life satisfaction is combined with happiness, quality of life and a sense of mental well-being [4]. One of the most popular tool measuring the sense of life satisfaction is the Satisfaction with Life Scale (SWLS) created by Ed Diener, Robert A. Emmons, Randy J. Larson and Sharon Griffin in 1985. The authors of the scale shared the view that life satisfaction should be assessed as an overall judgment by the respondent in comparison to his or her standards, not as

a general, abstract concept [5]. That is why satisfaction with life consists of three main elements: the level of life satisfaction, positive feelings and lack of negative feelings [6].

Styles of coping with stress

Stress is a wide concept that could be considered in both biological and psychological aspects. The biological aspect of stress includes all reactions of a human body, which activate the sympathetic nervous system as a response to a stressful situation [7]. Those actions are crucial in order to prepare the human body for physical effort and energy expenditure associated with it [7]. Stress is a term equally strongly comparable to human psychology, meaning the lack of balance between environmental requirements and the individual ability to fulfill them [8]. Coping with a stressful situation is a specific, dynamic form of activity aimed at attempting to restore mental and physical balance [8]. The style of coping with stress could be understood as a feature, which means a relatively constant tendency to use specific ways of dealing with stress in different stressful situations [9]. However, it is crucial to remember that styles of coping with stress are affected not only by the individual preferences, but also by the internal factors, for example temperament, and external factors, for instance the specificity of the stressful situation [10]. A popular tool to study the ways of coping with stress in Poland is the Coping Inventory for Stressful Situations (CISS) created by Norman S. Endler and James D. A. Parker in 1990. The inventory includes three different scales: task-focused coping, emotion-focused coping and avoidance coping. People with the domination of task-focused coping style are willing to take actions actively, which leads them to planning and taking real attempts to solve the problem [11]. Emotion-focused coping style characterizes people with the tendency to focus on themselves and their own feelings to reduce negative tension being a result of the experienced stressful situation [11]. Avoidance coping style may be manifested in two ways: engaging in substitute activities and seeking social support in order to avoid thinking of the stressful situation [11].

Affective temperaments

Temperament is considered to be an important element conditioning human behaviors [12]. Temperament is the foundation on which the human personality is shaped and includes features that have been present since early childhood [13]. Temperament manifests itself in plenty of activities, but its role in reference to human relations revealed mainly in difficult and stressful situations [14]. Modern theory of temperament, created in the 1970s, is the concept of affective temperaments established by Akiskal and co-workers. The Temperament Evaluation of Memphis, Pisa, Paris and San Diego Auto-questionnaire (TEMPS-A) measures types of affective temperaments: depressive, cyclothymic, hyperthymic, irritable and anxious [15]. Affective temperaments showed a good long-term stability and that is the main reason why those traits may be deliberately treated as permanent [16]. The way of expressing affective temperaments reveals a person's specific emotional state, which affects its general mood [15]. The intensity of every affective temperament has a significant role in determining the tendency to affective disorders, for instance bipolar disorder [17]. Affective temperaments are also crucial in determining a predisposition to self-destructive behaviors, including suicidal attempts [17]. Each of affective temperaments contains both positive and negative aspects for good functioning and human health [15]. People with the domination of depressive temperament have low energy levels and the tendency to stiffness in thinking and

blaming themselves, but they are also reliable and persevering [15]. The cyclothymic temperament distinguishes people with a high liability, especially in terms of self-esteem and mood [15]. Positive feature of this temperament is a great grade of creativity [15]. People with a dominant of irritable temperament are perceived as dissatisfied and skeptical, they are also willing to get angry immediately [18]. However, critical thinking may be considered as a positive aspect [18]. People with a high level of an anxious temperament are constantly accompanied by mental and physical tension, they are also willing to worry [15]. The hyperthymic temperament seems to be the most healthy and favorable temperament of all affective temperaments because it distinguishes optimists as well as social and self-confident people. Otherwise, people with a high domination of hyperthymic temperament are more likely to show the lack of objectivity in thinking, which increases the tendency to risky behaviors [15].

The aim of this study was to assess the relationship between life satisfaction measured by SWLS, styles of coping with stress assessed by CISS questionnaire and affective temperaments assessed by TEMPS-A scale in nonclinical Polish population.

It was assumed that: (a) life satisfaction would be positively correlated with task-focused coping and hyperthymic temperament; (b) life satisfaction would be negatively correlated with depressive, irritable and anxious temperaments; (c) task-focused coping would be positively correlated with hyperthymic temperament; (d) emotion-focused coping would be positively correlated with depressive and irritable temperaments; (e) avoidance coping would be positively correlated with anxious temperament.

Method

Participants and procedure

The sample consisted of 110 nonclinical Polish adults (55 women and 55 men). The study did not assume an upper age limit, the youngest participant was 18 years old and the oldest one was 73 years old ($M = 33,00$; $SD = 14,41$). All participants were volunteers and the study was anonymous. The characteristics of the researcher had been presented, including the name of university, field of study and the reason for the survey. An informed consent was received from all participants before the beginning of the study, including all information about the group form of feedback. Any of the people consenting to take part in the study, did not resign from their participation. All questionnaires were self-reported and conducted in a standard manner.

Measures

Life satisfaction was measured by the Polish version of the Diener's SWLS scale adapted by Zygryd Juczyński [19]. The SWLS is a short self-report homogeneous tool which consists of five statements to which the examined person responds by marking the appropriate position on the seven-point scale [5]. All answers in the scale are summed up and the final result determines the level of participant's satisfaction with life [19]. The Cronbach alpha coefficient of the original version of the scale is 0,87, while the Polish version equals 0,81.

Styles of coping with stress were assessed by the Polish version of the Endler and Parker's CISS questionnaire, which is recommended as a valid and reliable tool [9]. Polish adaptation was set by Piotr Szczepaniak, Jan Strelau and Kazimierz Wrześniewski. The self-report instrument

consists of 48 items referring to various activities taken by people in stressful situations [11]. The participant determines the frequency which he or she undertakes a specific behavior on the described problem situation. Subsequently, the examined person marks the responses to each of the questionnaire items on a five-point scale [9]. The CISS questionnaire consists three main coping styles: task-focused coping, emotion-coping and avoidance coping [9]. The Cronbach alpha coefficient of the original version of CISS questionnaire ranges from 0,72 to 0,92. The Polish version has a lower Cronbach alpha values that amount from 0,74 to 0,88 for each scales.

Affective temperaments were measured by the Polish version of the Akiskal's TEMPS-A scale adapted by Janusz Rybakowski, Alina Borkowska and Daria Dembińska-Krajewska. The TEMPS-A scale is the self-report tool containing 110 items (109 for men) with a yes-no response format [15]. The participant agrees or disagrees with each statements and marks answers in the scale. The TEMPS-A scale consists of five scales that represent five affective temperaments: depressive, cyclothymic, hyperthymic, irritable and anxious [15]. The Cronbach alpha coefficient of the original version of TEMPS-A ranges from 0,65 to 0,81, while the Polish version oscillates from 0,69 to 0,83 for each temperaments.

Statistical analysis

Statistical analysis was conducted using IBM SPSS Statistics 23 program. Skewness and kurtosis values in the examined sample were in accordance to the accepted norms of a normal distribution which amount from +1,5 to -1,5 [20]. Relationships between examined variables were measured with Pearson's correlation coefficient and based on interpretation of Cohen's correlation [21]. Multiple linear regression analysis showed that coping styles and affective temperaments could be used as predictors of life satisfaction.

Results

Tab. 1 presents ranges, means, standard deviations and also skewness and kurtosis values for life satisfaction (SWLS), styles of coping with stress (CISS) and affective temperaments (TEMPS-A) of all participants in the study.

Tab. 1. Descriptive Statistics for SWLS, CISS and TEMPS-A

Variables	Range	M	SD	Skewness	Kurtosis
SWLS	9-35	22,49	6,03	-0,20	-0,43
CISS: Task-focused coping	38-77	58,75	8,46	-0,39	-0,36
CISS: Emotion-focused coping	21-79	44,84	10,62	0,45	0,50
CISS: Avoidance coping	22-69	42,28	9,25	0,08	-0,07
TEMPS-A: Depressive	0,05-0,86	0,35	0,18	0,59	-0,17
TEMPS-A: Cyclothymic	0,00-0,81	0,30	0,19	0,66	-0,23
TEMPS-A: Hyperthymic	0,00-0,90	0,50	0,22	-0,11	-0,61
TEMPS-A: Irritable	0,00-0,75	0,20	0,16	1,06	1,52
TEMPS-A: Anxious	0,00-0,85	0,27	0,21	0,87	0,13

Source: own calculations

Tab. 2 shows the correlations between life satisfaction (SWLS), styles of coping with stress (CISS) and affective temperaments (TEMPS-A) of the whole sample. Satisfaction with life was positively correlated with task-focused coping and hyperthymic temperament. Additionally, life satisfaction was negatively correlated with emotion-focused coping and depressive, cyclothymic, irritable and anxious temperaments. Task-focused coping with stress was positively correlated with hyperthymic temperament and negatively correlated with emotion-focused and avoidance coping styles as well as with depressive, cyclothymic and anxious temperaments. A negative correlation was also found between emotion-focused coping and hyperthymic temperament. Moreover, emotion-focused coping with stress was positively correlated with avoidance coping and depressive, cyclothymic, irritable and anxious temperaments.

Tab. 2. Person's Correlations between SWLS, CISS and TEMPS-A

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.SWLS		0,52***	-0,30**	0,05	-0,42***	-0,28**	0,40***	-0,26**	-0,45***
2.Task-focused coping			-0,32**	-0,21*	-0,38***	-0,28**	0,42***	-0,18	-0,42***
3.Emotion-focused coping				0,27**	0,36***	0,38***	-0,25**	0,21*	0,50***
4.Avoidance coping					0,02	0,18	-0,01	-0,10	0,02
5.Depressive						0,50***	-0,53***	0,30**	0,71***
6.Cyclothymic							-0,17	0,49***	0,53***
7.Hyperthymic								-0,04	-0,42***
8.Irritable									0,33***
9.Anxious									

Note. * $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$

Source: own calculations

Tab. 3 demonstrates the results of regression analysis of coping styles measured by the CISS questionnaire as predictors of life satisfaction measured by the SWLS scale. The study revealed that two variables could be significant predictors of life satisfaction (task-focused coping: $\beta = 0,49$; emotion-focused coping: $\beta = -0,19$). The standardized β coefficient showed that task-focused coping style could be considered as the best predictor of life satisfaction of all styles of coping with stress. Additionally, a lower level of emotion-focused coping may determine higher level of satisfaction with life. The result of the squared semi-partial correlations presented that task-focused coping explained 19% of the variance in life satisfaction, while emotion-focused coping explained only 3% of the dependent variable. The sum of both independent variables, task-focused style and emotion-focused style, explained 22% of the total variance of satisfaction with life.

Tab. 3. Multiple linear regression analysis of coping styles measured by the CISS questionnaire as predictors of satisfaction with life measured by the SWLS scale

Variables	B	SE	β	Semi-partial Correlations
Task-focused coping	0,35	0,06	0,49**	0,44
Emotion-focused coping	-0,11	0,05	-0,19*	-0,18
Avoidance coping	-0,11	0,20	-0,17	-0,05

Note. * $p < 0,05$; ** $p < 0,001$

Source: own calculations

Tab. 4 presents the results of regression analysis of affective temperaments measured by the TEMPS-A scale as predictors of life satisfaction measured by the SWLS scale. The standardized β coefficient demonstrated that two variables could be considered as significant predictors of life satisfaction (hyperthymic temperament: $\beta = 0,26$; anxious temperament: $\beta = -0,26$). The result of the squared semi-partial correlations presented that hyperthymic temperament explained 5% of the variance in life satisfaction, whilst anxious temperament explained 3% of the dependent variable. The sum of both independent variables, hyperthymic and anxious temperaments, explained 8% of the total variance of satisfaction with life.

Tab. 4. Multiple linear regression analysis of affective temperaments measured by the TEMPS-A scale as predictors of satisfaction with life measured by the SWLS scale

Variables	B	SE	β	Semi-partial Correlations
Depressive	-1,78	4,27	-0,05	-0,04
Cyclothymic	0,27	3,43	0,01	0,01
Hyperthymic	7,11	2,73	0,26*	0,22
Irritable	-5,70	3,56	-0,15	-0,13
Anxious	-7,34	3,50	-0,26*	-0,17

Note. * $p < 0,05$.

Source: own calculations

Statistical analysis did not show significant gender differences.

Discussion

The main goal of this study was to detect the relationship between life satisfaction measured by the SWLS scale, styles of coping with stress assessed with the CISS questionnaire and affective temperaments measured by the TEMPS-A scale. Most of study's hypotheses were confirmed by the results. The empirical directional hypothesis included the assumption that there is a positive correlation between the sense of life satisfaction and the style of coping with stress focused on the task [22]. The analysis of the results confirmed the hypothesis of a positive relationship between these factors, showing a high correlation strength. The replication of statistically significant correlations was possible because of using the same tools as in the previous studies [22, 23, 24].

The results of the study also showed the existence of a negative correlation between satisfaction with life and emotional style. Emotion-focused coping style does not allow to solve problems so that the level of stress may grow. On the other hand, lower level of stress may indicate the use of effective strategies in problem situations. Unsolved conflicts could be a source of stress and as a result may contribute a reduction of a perceived level of life satisfaction. Therefore, the emotion-focused style correlates negatively with life satisfaction, and the task-focused style correlates positively with this variable.

The theoretical directional hypothesis assumed a positive correlation between life satisfaction and hyperthymic temperament [5, 15] and it was also confirmed by the results of the study. Hyperthymic temperament describes people who are joyful, self-confident optimists, which is largely associated with the perceived level of life satisfaction, thus both variables showed a positive correlation.

The hypothesis of the study also included the assumption that there is a negative correlation between the sense of life satisfaction and depressive, irritable and anxious temperament [5, 15]. Analysis of the results of the study confirmed this hypothesis, additionally demonstrating the occurrence of a negative correlation between life satisfaction and cyclothymic temperament. The level of satisfaction with life is characterized by a negative dependence with temperaments, which could be described as opposite to a hyperthymic temperament, which also coincided with the theoretical basis of the concepts of both variables.

The study's results confirmed the hypothesis of the existence of a positive relationship between task-focused style and hyperthymic temperament [11, 15]. People with a domination of hyperthymic temperament easily generate new ideas and solutions, so the task-focused style is the most appropriate for them. In addition, the research results indicated a negative dependence of the style focused on the task with depressive, cyclothymic and anxious temperament, which only confirmed the theoretical explanation of the above hypothesis.

The hypothesis, assuming the existence of a positive correlation of the style of coping with stress focused on emotions with a depressive and irritable temperament [11, 15], was also confirmed in the study. People with a high intensity of depressive and irritable temperament are focused on their negative emotional experience, which is why the emotional style is the closest to them. Moreover, the emotion-focused coping was positively correlated with cyclothymic and anxious temperaments. Concentration on emotions related to the problem, and not on the real attempt to change the stressful situation, is characteristic both for people with temperaments who focus on experiencing emotions as well as for the style of coping with stress focused on emotions. The results also showed a negative correlation between emotion-focused coping and hyperthymic temperament, which was consistent with the theory mentioned above.

The only theoretical hypothesis that did not find any confirmation in the study was the thesis about the existence of a positive relationship between the style of coping with stress focused on avoidance and anxiety temperament [11, 15]. Avoiding style characterized people who avoid thinking about the problem and experiencing emotions associated with it, while anxious temperament is specific to all who have the tendency to become worried, which is accompanied by constant psychological tension. This incompatibility may have been the cause of the lack of correlation between the avoiding style and anxious temperament.

Summing up, the study proved the existence of many correlations between three variables: the level of life satisfaction, styles of coping with stress and affective temperaments.

Limitations

The study does not remain free of the limitations. The main limitation is the size of the sample. Analyzing the results of the study, it is possible to conclude that with the participation of a larger number of respondents, the correlations obtained would be significant. A higher sample size could also show significant gender and age differences.

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ENOTOURISM IN PODKARPACIE

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Abstract

In recent years, a lot of vineyards have been established in Poland and new ones are being established. They are distributed in various provinces but their number prevails in Małopolska and Podkarpacie. The revival of Polish viticulture caused a sudden increase in interest in this tourism. In Poland, enotourism is developing at a rapid pace. This is a great idea for the tourist promotion of the regions.

The main purpose of the work was to determine what is adult knowledge about enotourism in Podkarpacie. The method of diagnostic survey was used in the work. The questionnaire was used as a tool.

The results of the research have shown that enotourism is still in the development phase. Tourists are increasingly using services related to wine tourism. They take part in festivals, try regional delicacies and drinks. After analyzing the research, it can be concluded that there is an increasing interest in wine routes and visiting vineyards.

Keywords:

wine tourism, vineyards, Podkarpacie

Introduction

Podkarpackie wine is like the Podkarpacie - unique, enigmatic, tempting with its natural and cultural diversity, still being rediscovered by masses of tourists looking for impressions and highly appreciated by those who have already met them. It is in Podkarpacie that the revitalization of modern Polish viniculture has begun, and this is where it is developing most dynamically. This position of the pioneer, no one will pick up Podkarpacie, no matter how rapidly other wine regions in Poland develop in the future [1].

Enotourism, in other words wine tourism (from Greek oinos - wine), has recently become very fashionable. According to statistics, this is one of the fastest growing areas on the tourism market. It is most widespread in countries with a variety of wine cultures [2]. Especially in Italy, France and Germany.

For many, viticulture is a passion, but for others it has changed in a way of life [3].

Many winemakers are not yet sufficiently educated in the subject of cultivation and production, but this is going in the right direction. Increased awareness is born in this area. There are better and better wines that are appreciated not only in the country. Thanks to this, Poland is perceived as a country producing good quality products, and thus, interest in these regions. It gives the

possibility of occurrence of these areas on a national scale. So it's safe to say that enotourism has a future.

We note compliance with the statement that wine is the main reason for making tourist movements. Getz and Brown primarily focus on the aesthetic and taste experience as a significant factor that tourists are looking for. However, they also point out that taste is not everything. A very important, and even the most important is the place of tasting a product that emphasizes its qualities [4].

The enotourism includes trips to wine areas, during which visitors visit at least one branch related to the wine product, for example a vineyard or wine farms. These are trips, the idea of which is to visit popular areas of vine plantations, walk along marked wine routes, visit vineyards and wineries, cost products, buy wine, even branded species and yearbooks in the so-called. enotekach and participation in thematic events [5].

The systematically quoted opinions and statistical data show that the development of enotourism is particularly high and is nowadays the best-developed branch of the global tourism industry [6].

Enotourism in Poland

In 1314, the first mention of viticulture in Poland was recorded. Winery developed then in the vicinity of Zielona Góra. Throughout Europe, Polish sparkling wine products have been recognized. The historical complexities that occurred in the following years resulted in the disappearance of viticulture in Poland. The revival of viticulture falls in the 1990s. At the beginning, vineyards began to appear mainly in the Lubelskie and Podkarpackie voivodships. Roman Myśliwiec-winemaker from Jasło became the initiator of the re-development of winemaking. Jutrzenka, it was the first grape variety in Poland, which he created.

A proper climate is required for viticulture. Wine tourism has been given a chance for its development thanks to global warming, for which the border of the wine-growing zone shifts the boundary of the range to the north, which gives it a chance to develop it also in Poland [7].

The main area of grape breeding is the Zielona Góra region, around Wrocław, and the Wisłoka valley and around Jasło. There are several professional vineyards [8].

The majority of the most favorable areas in the country where the vineyards are located are to the southwest of the line linking Gorzów Wielkopolski with Chełm Lubelski [9].

Contemporary vineyards are located mainly in the areas of former multi-territorial areas, eg Wielkopolska, Lower Silesia, the Kraków-Częstochowa Upland, Podkarpacie and Małopolska [10].

The vineyard owners in Poland are usually enthusiasts of viticulture, aware of the difficulty of growing it in this country. The basis for the development of wine tourism in Poland is primarily the introduction of fashion for wine and everything related to it, as well as investments in infrastructure, support of local authorities and cooperation of winemakers. However, the vintners agree that it is only the beginning of enotourism in Poland [11].

Enotourism in Podkarpacie

For a long time in Podkarpacie the vine was noticed only in gardens, near fences, barns and walls. However, from these varieties it was not possible to produce good quality wine. Roman

Myśliwiec changed it, establishing the first vineyard in Podkarpacie - "Golesz". It was established in 1982 in Jasło. He started by planting several rows of vines he brought from Slovakia and Hungary. Some of these varieties did not work in this climate. So he began to wander around neighboring countries in search of suitable grape varieties to the Podkarpackie climate. Thanks to it, the so-called varieties appeared, hybrids which contributed to the further development of viticulture in this area.

Becoming a winemaker in Poland was more complicated than in other countries where the wine traditions were already rooted. The specialist literature there contains detailed stages of wine production, and the secrets that are well guarded are often passed down from generation to generation. Cooperation with research centers gives winemakers the opportunity to use the most advanced technical and scientific achievements. Roman, using foreign literature himself, had to acquire this knowledge. He published his first book on viticulture in 1992, and in subsequent years published further publications in this field.

To this day, there are no large multi-hectare vineyards in Podkarpacie, which are established in western Poland. Winery in Podkarpacie is a medium-sized and over one hundred small or very small vineyards with a total area of probably no more than 30 hectares. In several vineyards, attempts are being made to organic (biological) cultivation, however, due to the too humid climate of the foothills, as well as little experience in this type of cultivation, it is difficult to implement [12].

Podkarpacki vineyard route

The renaissance of Polish viticulture originated in Podkarpacie. Winemakers started from experiments in home gardens, until after hard work they came to professional crops and wonderful vineyards with a large tourist offer. The Podkarpackie Route connects almost 40 very diverse vineyards. The offer starts with the tasting itself and ends with a full package with accommodation and restaurant. The Podkarpacie region is diverse in every aspect. Each vineyard is different from the previous one. Not only the appearance of the wine changes but also the taste or aroma. The Podkarpacki Wine Route is worth exploring along the Podkarpackie Smaki trail. It includes places with the tastiest dishes in the region, as well as a patron of many events taking place in this area [13].

The Podkarpackie Wine Route consists of 39 vineyards. The largest of them is the Płochocki vineyard, which covers an area of 4.5 hectares. It is located in the enchanting valley of the Opatówka river on the upland in the village of Daromin. Its owners Barbara and Marcin Płochoccy founded it in 2005. Initially, the vine was planted 2.5 hectares, now it is larger. This is the first such a large vineyard in this region. As well as one of the first in Poland that launched the official sale of wine in 2009. The family grows 20 varieties of vines, which is aimed at selecting the best for the habitat. After making an appointment by phone, you can take part in tasting combined with visiting the vineyard and cellars, and later buy wine. From 2014, from May to September, guest rooms are available for visitors [14].

In Podkarpacie, we can distinguish the second smaller route, which is part of the Subcarpathian Wine Route. This is the Jasielski Wine Route. Such a trip is best planned at the end of August. Where is the "International Wine Days in Jasło" during the last weekend of the holidays. This is one of the largest wine events in the country. Every year, vintners from the country as well as from

abroad come to the Jasło market. You can then taste wine, participate in wine workshops, shows and presentations, as well as visit the nearby vineyards. The fair organizes a fair and various concerts [15].

Aim and methods of research

The aim of the conducted research was to check to what extent the concept of enotourism is known among adults participating in the study. As a result, research questions were developed to test:

- a) Is the concept of enotourism known to adults?
- b) What part of the people was ever in the vineyard?
- d) How many people took part in events promoting regional wines?
- e) What part of the respondents knows that the wine route runs through the Podkarpacie route?

The authors put forward a hypothesis based on the research questions formulated above, which is: What is the knowledge of enotourism in Podkarpacie among adults. The research group was made up of adults from various regions of the Podkarpacie region. The method of diagnostic survey was used in the work. The tool used was a questionnaire independently prepared by the authors of this work. The research technique used in the work was a questionnaire. The questionnaire contained questions of single or multiple choice. The survey was conducted anonymously via the Internet, 100 people participated, including 44 men and 56 women. The study was conducted in April 2018. Then all the answers were thoroughly analyzed by the authors.

Analysis of test results

The initial questions concerned the respondents in order to compare the results of the research. The study was carried out adults. The first chart concerned the gender of the respondents. 56 women and 44 men answered the questions.

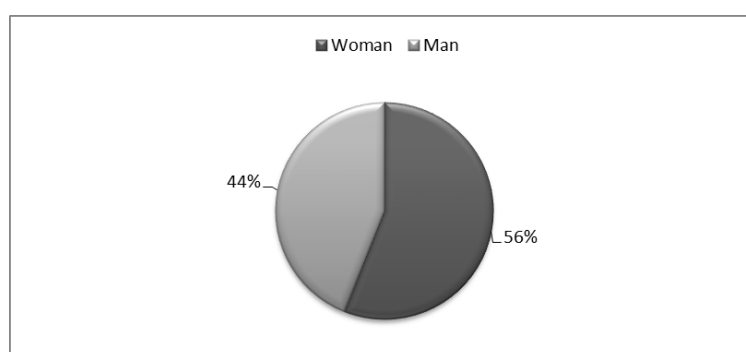


Fig. 1. Sex
Source: own research

The second chart concerned the age of the respondents. For the most part, there were people in the range from 18 to 25 years old, up to 69 people. Much less responses were obtained from older people. In the age range from 26 to 35, as well as 46 and more, it was only 11 people. However, between the ages of 36 and 45, only 9 people.

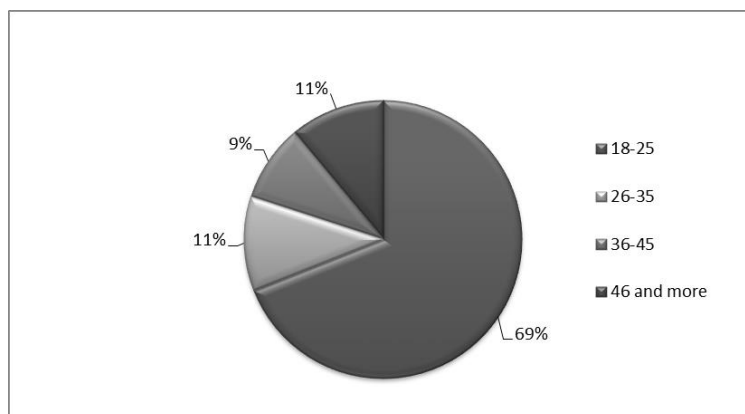


Fig. 2. Age
Source: own research

Chart number three concerned the place of residence. The respondents were divided into those who come from the city or from the village. There are 51 respondents in the village, and 49 in the city, which is presented in the next graph.

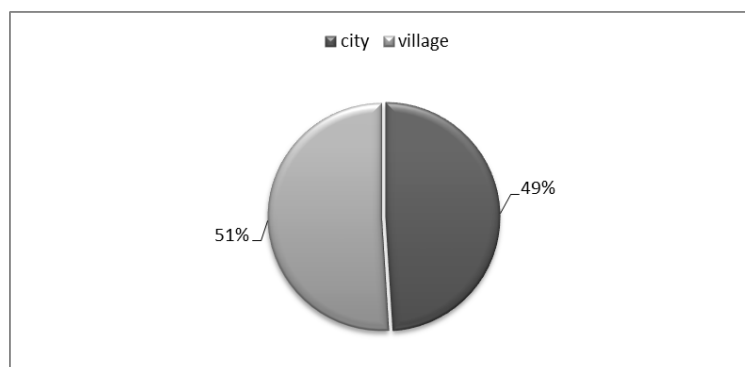


Fig. 3. Place of residence
Source: own research

The fourth chart concerned the education of our respondents. The largest part of them are people with secondary education, it is 55 people. A slightly smaller but equally large part are people with higher education, it is 40 polled. The basic education has 5 respondents.

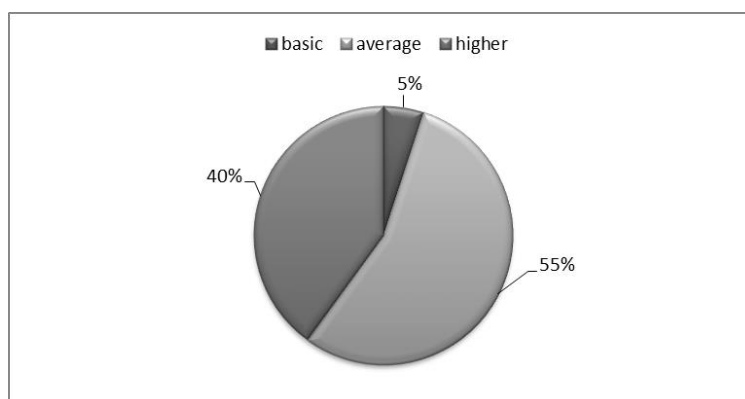


Fig. 4. Education
Source: own research

The fifth chart concerned the subject of the work. The authors asked about the knowledge of enotourism among the respondents. Almost half of respondents know what this concept means. 49 respondents constituted this group. Unfortunately, as many as 51 people did not know its meaning. This is shown in the graph below.

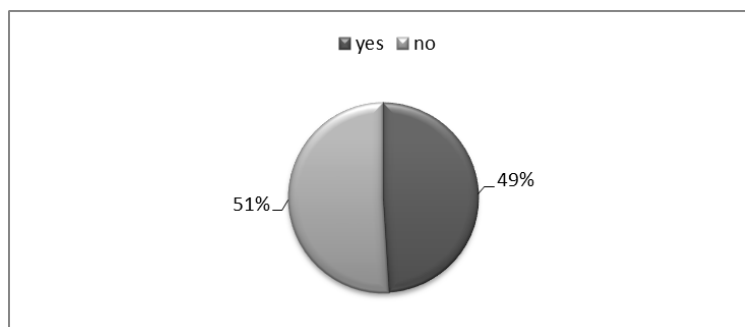


Fig. 5. Knowledge of enotourism
Source: own research

The sixth chart shows associations with the concept of enotourism. 58 people, which is the majority, answered this question well. However, 11 people associate tourism with specialist tourism. 4 people considered it a culinary tourism, 2 for leisure tourism. For 3 people it is landscape tourism, for 6 cultural tourism. The remaining 16 people said that they do not associate with anything.

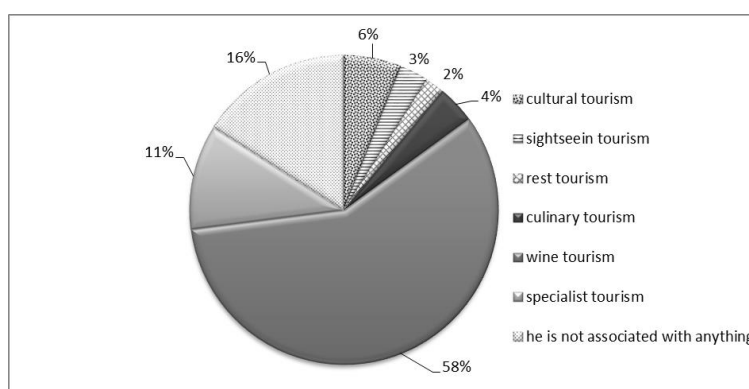


Fig. 6. What is the concept of enotourism associated with?
Source: own research

There are many events promoting Podkarpackie wines in Podkarpacie. The authors asked the respondents for their knowledge, as shown in chart number seven. 38 people do not know any of this kind of event. The Galician Wine Festival is known to 22 people, the Festival of Good Cheese Festival only 9 people. Quite well known among our respondents is the Festival of Good Taste, 31 answers. As well as Wine Days in Jasło, there were 32 people. Other, not mentioned events in the survey, are known by 14 people.

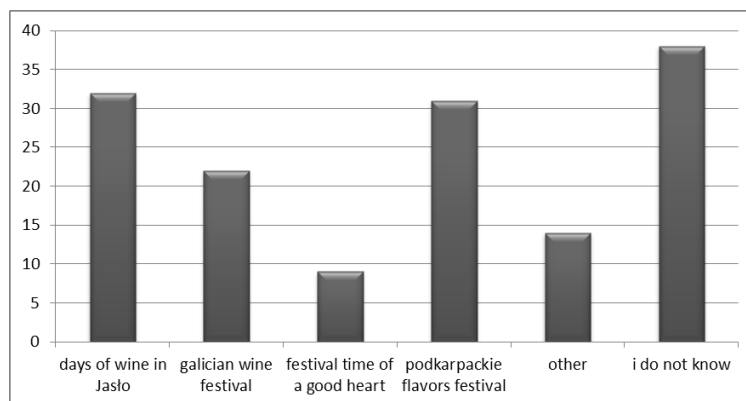


Fig. 7. Knowledge of events promoting Podkarpacie wine

Source: own research

Subsequently, the respondents were asked if they had ever participated in such an event. Only 22 people participated in this type of event, the rest, or 78 people, did not have the opportunity to participate in them. This is represented by a graph with the number eight.

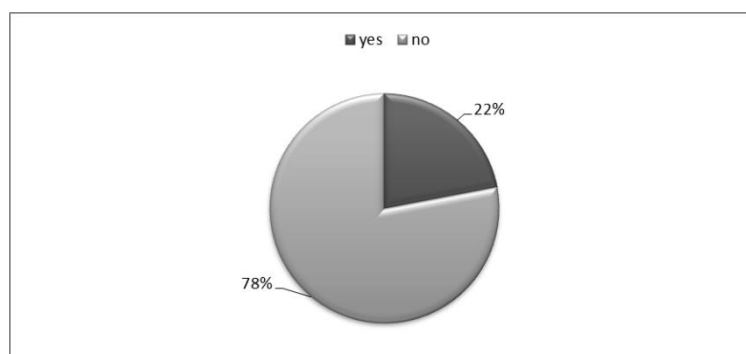


Fig. 8. Have you ever participated in such an event?

Source: own research

Next, the authors asked if the respondents were ever in the vineyard. A large part answered that yes. It was 67 people. 33 people were not in the vineyard yet. This is represented by graph number nine.

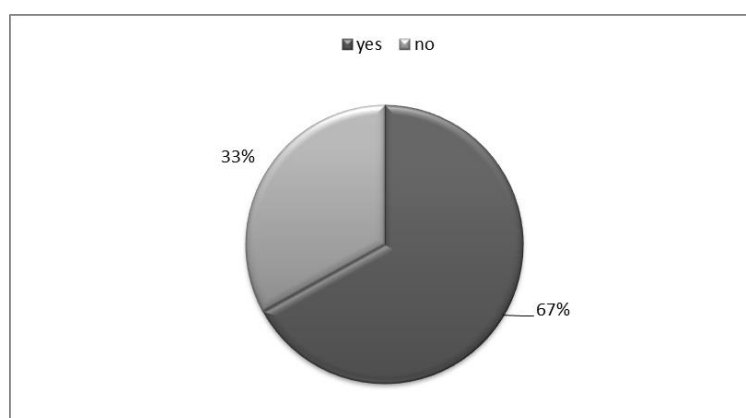


Fig. 9. Have you ever been in a vineyard?

Source: own research

If someone was in the vineyard, he would answer another question regarding whether it was a vineyard in Podkarpacie. The survey shows that most were in a different area. Podkarpackie vineyards were visited by 24 respondents (36%). The rest of 43 people were in other vineyards (64%). This is shown in graph number ten.

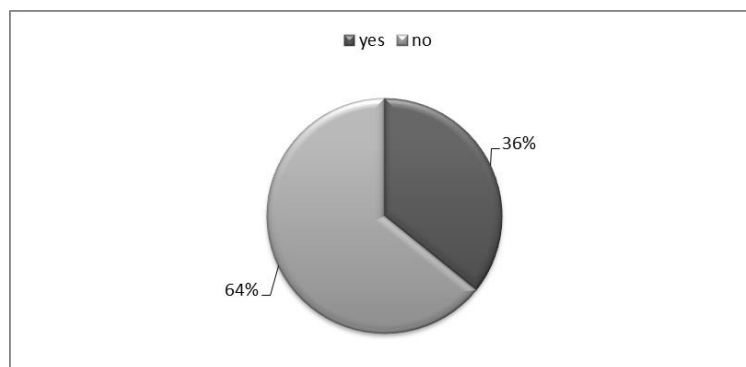


Fig. 10. Was this a vineyard in Podkarpacie?

Source: own research

Summary and final conclusion

Considering that enotourism in Poland is still in the development phase, we can conclude that the knowledge of the respondents is satisfactory. This is confirmed by research, because almost half of the respondents know this concept. This knowledge is not dependent on age or education. However, a significant number of people can not assign this concept to any field of tourism, which indicates that it should be promoted even more. In particular in Podkarpacie, because here is one of the very well developing regions in terms of winemaking. Most of the respondents who knew the festivals promoting local products in the study indicated Wine Days in Jasło. As you can see, "the heart of Podkarpackie wines" is known among tourists, but it still requires a lot of promotion and encouragement for visitors. A lot of people have heard about this great festival but were not its participants. More than half of the respondents visited the vineyards, however, which is unsatisfactory, most of them were not located in Podkarpacie. The idea here is to increase the offer related to visiting vineyards and tasting. The offer of the wine route is also not well known to tourists. You should think about how you can improve the awareness of tourists about such a wonderful and future-oriented branch of tourism. Poland also establishes cooperation with other countries, which underlines the reputation of our country. The winners' motivations seem to be crucial in the development of this sector, for which immediate profit is not a condition for the development of their operations, which allows to realize the postulate of quality over quantity. It would be desirable to improve institutional conditions, not only in administrative and legal terms, but also related to the education of both producers and consumers. Let's hope that in the future everyone will hear about Polish viticulture and try delicious products from the vineyards of Podkarpacie.

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ACTIVE TOURISM AS AN ESSENTIAL PART OF THE LIFESTYL ON THE BASIS OF STUDENT OF ACADEMIC YEAR 2017/18

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Abstract

Active tourism is a way of life that lets you know the "taste of adventure". This means that active tourism is composed of many activities. It's not just sport or recreation. An important element is also the surrounding nature. So we can use various forms without focusing only on one and this aspect decides on generalization in active tourism.

The main objective of the work was to determine how active tourism is practiced by the students from the academic year 2017/2018 affecting their awareness of the basic elements of health. The method of diagnostic survey was used in the work. The tool used was a questionnaire. The questionnaire contained questions of single or multiple choice, it was completely anonymous.

The research shows that in the majority of respondents prefer to practice it in the company of other people with family or friends. They are also aware that it has a very big impact on health. For the most part, young people choose hiking or climbing.

Keywords:

active tourism, students, tourism, physical activity

Introduction

Active tourism is a way of spending time allowing to get to know the "taste of adventure". An important element is the nature surrounding the tourist. Therefore, you can use various forms of spending free time, without focusing only on one and this aspect decides on generalization in active tourism. Nowadays, taking care of health has become a trend. Some try to combine various forms of active tourism, to also diversify their free time, that is, one that is left to us after fulfilling professional, school or home duties. Young people are increasingly experimenting, thanks to which the majority choose active tourism as an interesting form of entertainment combined with a healthy lifestyle.

The results of the conducted research are reflected in the literature on the subject - the positive impact of active tourism on health and high awareness of academic youth in this matter has been confirmed. Research problems oscillated around the subject of active tourism, health and the health of young people on issues.

The phenomenon of tourism has already appeared in Antiquity. Every four years the Olympic Games were organized there. Learned the value of physical fitness, which, as the Greeks believed, had a huge impact on the health and personality of man. In the Middle Ages and the Renaissance, it was begun by sea, to discover further lands, an example can be the discovery of America in 1492 by Christopher Columbus. The following years show how people began to notice the needs of traveling for health, leisure or cognitive purposes. Aristocrats on the Gran Tour journey, being curious about the world, reached the Alps, where in 1786 his highest peak was obtained by Michel Paccard and Jacques Balmat. Through industrial revolutions, people began moving from the countryside to the cities at the end of the 18th century.

Despite many other travel difficulties, the breakthrough took place in the 19th century. At that time, the first railway network was built in England, which began to develop quickly. This is how Orient Expres was born, who traveled from Paris to Constantinople, and its route was 2,800 km. Mostly, travelers were business people or diplomats. A very important moment was the opening of the first travel agency, founded by Thomas Cook. Among others, mountain and coastal areas, monuments in historic cities and spas were visited. After the Second World War, in the winter period, ski tourism appeared. Even in these times, the positives and negatives of tourism began to be seen [1].

There are many definitions of "tourism" in the literature. One of the most defined is the definition of the World Tourism Organization (UN WTO), where tourism is the activities of travelers, private or business vacationers outside their daily environment without a break, no more than a year and not for commercial gain [2]. The classical definition was proposed by Władysław Hunziker and it reads as follows: "tourism is a set of relations and phenomena that result from the travel and stay of incomers, unless it is settled and undertaken for gainful employment" [3]. Both these definitions are linked by the sphere of travel without a profitable goal, as also mentioned by Aleksander Kornak, describing "tourism as a set of socio-economic relations and phenomena that result from travel and stay of incomers if it is not settled and earned" [4].

One of the shorter definitions of tourism is given by Marc Boyer, who, in his opinion, defines tourism as leisure activity as a change of place of residence. It already draws attention to activities performed in free time, i.e. that which remains after the performance of domestic, business or professional duties, voluntarily. This is to develop our interests, deepen our knowledge about the topic chosen by us, which affects our cultural, mental and physical development. The contemporary definition of tourism is presented in such a way that all the activities that we perform outside of our surroundings are to influence the understanding of the social or cultural environment in which we are staying. The phenomenon of tourism has already appeared in Antiquity. Every four years the Olympic Games were organized there. Learned the value of physical fitness, which, as the Greeks believed, had a huge impact on the health and personality of man. In the Middle Ages and Renaissance, it was begun by sea, to discover further lands, an example can be the discovery of America in 1492 by Christopher Columbus. The following years show how people began to notice the needs of traveling.

Active tourism as one of the forms of tourism

There are many types of tourism, which allows everyone to choose something for themselves. If we want, we can combine several types to suit our own needs and expectations. We stand out for both passive and active tourism. An example of this is a trip to the seaside for recreation centers, where various types of additional attractions for recreation are organized, and this form is most often chosen by families and older people. It is also possible to mention medical and health tourism, which most often occur in towns with the status of a health resort or where there are curative mineral waters. Tourists usually choose it when they want to strengthen or improve their health.

To rest, people leave the city to the countryside. This type is called ecotourism, otherwise it can be understood as communing with pure nature. This influenced the wider development of agritourism. Knowledge of the farmer's work and active participation in it as communing with nature, the animals that surround us. When using accommodation and meals. A big advantage are also attractions in a given village that may be there as open-air museums [5].

Subsequently, geotourism, which involves learning about, finding interesting landscapes, rocks, terrain. This form of tourism requires appropriate equipment and awareness of being in difficult conditions. For more interesting speleological tourism began to develop, which consists in penetrating caves and sightseeing. However, you should choose these caves, which are appropriately adapted and secured for visiting tourists.

People who work and visit belong to business tourism. In this case, we depart from the popular definition of tourism, where a business trip disqualifies them. It is a typically profitable form of tourism [6]. Trips for employees in leisure time as an incentive or reward, called motivational tourism. In some places of work, various types of subsidies for children of employees for camps or summer camps have been used. This tourism, called social, created so that families with the lowest income could also spend time together.

Ethnic tourism is also very often met, consisting in returning to the place where we were born or where our family lived. Trips to other places may also have a religious or pilgrimage context. It involves contact with God, prayer, knowledge of history, architecture, as well as participation in religious rites. For one-off or cyclical events, tourists go to a cultural destination such as festivals. In this way, cultural tourism was established, which every now and then at events or concerts gathers a crowd of its fans [7].

For the curious about the world, cognitive tourism has begun to develop, which is based on learning about things that we ourselves want to see or learn about them. It may refer to architecture, place and monuments. We get to know the world around us and we can also join adventure tourism, which is based on learning about nature, but this form requires much larger observations, patience, which affects the formation of personality. This type is ideal for children, showing them that not everything can be seen here and now, and the effects are obtained only after a long or long observation.

Perfect for both families and a group of friends, you can go sailing. Sailing is now also treated as a water sport powered by wind power. To this form of tourism, you need to have appropriate permits [8]. A similar form is canoeing, in which the main propulsion are oars and the canoe was built at the beginning from a tree or bones, leaving only a small entrance to be placed in a canoe [9].

After mentioning the types of tourism, I will draw attention to the basic type of tourism most often performed, which is qualified tourism. This variety is chosen both by younger elders as well as by families and groups. Most sources include qualified tourism for active tourism. An important determinant is practicing sport recreationally or hobbyistically. In qualified tourism, however, the intensity of sport is higher than in active tourism. It requires a proper mental attitude as well as physical preparation. Appropriate equipment for the selected type will also be necessary. In qualified tourism, we distinguish hiking in both mountain and lowland. It is so much better that sometimes we can not reach some places by car or bus, and walk on foot in theory at any angle, of course with caution. Walking, we can also see more than sitting in a vehicle, thanks to which we have direct contact with nature. In this form, the appropriate tools will be comfortable shoes and layered clothing, as well as a backpack. Preferred routes are usually mountain trails [10].

Another variation is cycling tourism on roads or terrains. It serves mainly for viewing landscapes or can be performed professionally. Interesting and therapeutic is also lowland and mountain riding tourism, cultivated in special centers or in the field. It turned out to be a form of rehabilitation for disabled people. Skiing is developing in the winter period. We distinguish two varieties of running and downhill tourism in it [11].

In addition to the previously mentioned examples of qualified tourism in active tourism, we can also distinguish motor tourism, where the main transport is a motor and thanks to it we get to the places that we want to see [12]. Fishing and hunting are also popular, but there are places where these forms of tourism are forbidden.

The aforementioned types have been enlarged with additional modern forms. These include rafting or rafting on the rushing mountainous rivers, the hydrospeed, which is similar to the previous one, only goes on a board with handles. Another form is windsurfing, which consists in using a board and a sailboat propped to it.

An interesting group form can be survival, which consists in staying in difficult conditions when using the "gifts" of nature. It is an interesting adventure for both adults and children

There are many more suburban tourism and it depends on our interests. In general, active tourism is linked to sport and recreation. We can include qualified tourism, adventure tourism as well as modern or extreme tourism. This type of tourism does not require much experience. An important goal is getting to know, traveling. In general, the concept was given by A. Andrejuk, claiming that active tourism is the type of tourism that we have chosen, suited to our interests. And it should be the main goal of the trip [13]. However, this concept belongs to general. A. Gordon describes this in more detail. "Active tourism includes elements of the so-called risk tourism. Activity in tourism is associated not only with physical activity but also with intellectual and natural sciences. This range of tourism includes bird watching and recording of nature sounds. There are also program trails in it, for example, walking in the footsteps of militaria "[14].

In summary, the activity is in the way of moving, programming and experiencing. Active tourism is a way of life that lets you know the "taste of adventure". This means that active tourism is made up of many forms. It is not only sport or recreation that is also important to the surrounding nature. We can therefore use various forms without focusing on only one and this aspect decides on generalization in active tourism. It is she who is a broader concept than qualified tourism. So if

someone thinks that he is engaged in qualified tourism, but does not meet all the requirements of proper mental, physical and independence preparation, it belongs to active tourists [15].

The concept of healthy lifestyle in the theoretical approach

The very concept of health in literature has many meanings and at the present time they can be found around 130 [16]. The classic definition is given by the World Health Organization, according to which health is not only a lack of disease, but full physical, social and mental fitness [17]. In this definition, it is noticeable that three aspects of health are distinguished: physical, mental and social. Thus, physical health is defined as the proper functioning of organs and body systems. The so-called interpersonal relations are responsible for the state of interpersonal contacts. social health. On the other hand, mental health has been divided into two spheres, the first covers the mind responsible for rational thinking, and the second is emotionality that distinguishes our feelings, such as anxiety, various types of tension, depression, stress and the way they are expressed. Besides this division, there is also spiritual health related to religion and beliefs [18].

In the field of science, which is medicine, health is qualified as a lack of disease, that is various deviations from the accepted norm or physical, psychological or even biochemical damage [19].

Talcott Parson also presented theories on this subject, stating that health is the ability to perform various activities or roles that a person chose, and the disease can disturb them [20]

The division into domains, or various aspects, increases the volumetric definition of health. Delving into literature, you can find various disciplines dealing with health. In this study I will focus only on physical health, which is the most close to the topic of my work and will serve to verify the hypothesis, as well as make the youth aware of mistakes in health care or choosing ways of spending free time.

Youth lifestyle and its impact on health

To confirm the fact that every man has his own lifestyle, I will quote the term "lifestyle" found in literature "is the scope and form of everyday behaviors of individuals or groups, specific to their social position, i.e. manifesting social position and perceived as characteristic for this position, and thanks to that enabling the wider social location of other people "[21]. Generally speaking, lifestyle includes human behavior, motivation, values and needs.

The lifestyle consists of various health behaviors that people shape in themselves from an early age. These are definitely physical activity, taking care of hygiene, taking care of interpersonal contacts, proper nutrition, preventive examinations, as well as avoiding drugs such as alcohol, drugs or cigarettes. Unfortunately, at a young age, he does not pay much attention to all this, for various reasons, for example because he wants to try everything that can sometimes only have negative effects in the future. Such is the nature of a young man who likes, and sometimes simply needs to experiment, try what is good and bad for him, and then draw the appropriate conclusions at a later time. Therefore, it is important to shape the awareness of a young person from an early age so that he can avoid some mistakes.

In the literature on healthy lifestyle, everyday habits have been mentioned that have a major impact on health. The first basic habit is physical activity, which supports our metabolism and can

eliminate diseases of civilization, such as obesity [22]. Unfortunately, nowadays technological advances have a big impact on abandoning physical activity. People are absorbed by various types of media, which means that free time is spent on various types of social networks or on modern games entering the market.

Another important element of well-being is healthy and regular nutrition. Thanks to this, you can also avoid some diseases, such as atherosclerosis, tooth decay or diabetes. There are many types of diets that are dependent on your lifestyle. Nevertheless, it is recognized that a person should consume five meals a day at a more or less specified time. The pyramid of nutrition and physical activity can be a great help in arranging the right proportions.

The third aspect, extremely important for health, is the right amount of sleep, thanks to which our body regenerates and rests. It is difficult to generalize how much sleep a person needs, because every organism is different. One may need more other less hours of sleep, which is why it is an individual matter. It is estimated that the sleep time is about 6 hours a day for an adult. It should be remembered that an average person is able to remember more, is more resolute, does not make too many mistakes, can concentrate longer and has more energy, and usually a better frame of mind.

You can not forget about drugs, such as alcohol and cigarettes, which significantly affect our body. They cause damage and affect the functioning of most organs. They often lead to addictions spoiling our general health. People lose social contacts, they destroy the family, which can cause negative effects on the psyche and loss of control over life.

For the proper functioning of the body is also important level of stress, which every day accompanies practically everyone. It affects the hormones, and thus the functioning of organs. Short-term stress can have a positive effect, stimulating activity, but long-term stress can lead to various disorders of the body.

When choosing a lifestyle, you need to consider these factors to be successful and be proud that everything has been done for your health.

Health consequences resulting from active tourism

In order to prove the thesis about the positive effects of active tourism, one should first distinguish two existing modes of life, ie active and passive.

Active people are characterized by people who are creative, looking for impressions, strive for self-improvement, and prefer active participation in tourism. For passive living in tourism, on the other hand, we include people who expect specific or previously prepared plans or programs for leisure activities. Such persons become inactive, prepared only for the reception of pre-determined content.

Positive factors flowing from active tourism and its impact on health include elements commonly known to us, as well as those to which we pay no particular attention. The main one, affecting selected tourist forms, is the weather, because a person is more likely to opt for some kind of active tourism when the sun is shining than when it rains. Thanks to the sun, we provide our body with a decent dose of vitamin D. It affects both the strengthening of our bones and the state of our teeth. Active tourism is generally positive for our body, also because of the special role of immunity, which primarily protects against harmful microorganisms [23], and thanks to such activity, the incidence of various infections is reduced.

The advantage of active tourism may also be the improvement of the condition and figure, muscle strength or condition of the spine, which is also very important. A man should feel good "in his skin" and constantly improve it in a natural way. This will slow down, among other things, the aging process of the organism, which the youth are not thinking about yet.

Another benefit will be oxygenation of the body. This is an important process for the brain, heart and all tissues. There is also a general improvement in blood circulation

An important piece of information is also the fact that through selected forms of active tourism, whether the possibility of combining them, we stimulate and improve the functioning of our senses. There are five senses for every human being: sight, hearing, taste, smell and touch. The sense of touch includes the following categories:

1. Nociception - the sense that is responsible for the sensation of pain.
2. The sense of temperature - feeling the body cold or warm.
3. The sense of balance - the organ responsible for this sense is the labyrinth in the ear.
4. Proprioception - consists in the proper arrangement of each part of the body in relation to each other, as well as maintaining muscle tension.

One could mention even more benefits from active tourism. However, focusing on the health aspect of only young people, these elements seemed to me the most important.

Methodology and area of research

The questions asked in this work are aimed at demonstrating whether active tourism students are aware of its impact on health.

The research problems identified in the work were:

- Do students know what this concept is for active tourism?
- What health-oriented activities are undertaken by students?
- What forms of active tourism do academic youth prefer?
- What motive is the most popular among students in the selection of active tourism?

In this work the method of the diagnostic survey was used, which were questionnaire questionnaire containing questions of single or multiple choice.

The research presented in this paper was conducted in the academic year 2017/2018 at students of various universities in Rzeszów. 100 students took part in the study, including 70 women (70%) and 30 men (30%), between 20 and 25 years old.

Analysis of test results

Research carried out on students from various universities in Rzeszów aimed to diagnose and verify the hypotheses set in this work, which were:

- The surveyed students are aware of the impact of physical exercise on health.
- The surveyed students study active tourism in the company.
- The surveyed students limit participation in active tourism.

The first question in the questionnaire concerned the knowledge of the concept of active tourism among the respondents presented in the first fig. The right question was answered by 74% of respondents, which indicates a conscious choice of how to spend free time and physical activity.

However, there have been people who have mistakenly understood tourism, which is a much broader concept with active tourism. 23% of the surveyed mixed up the importance of active tourism with tourism. On the other hand, 3% of them recognized active tourism as traveling for sightseeing purposes.

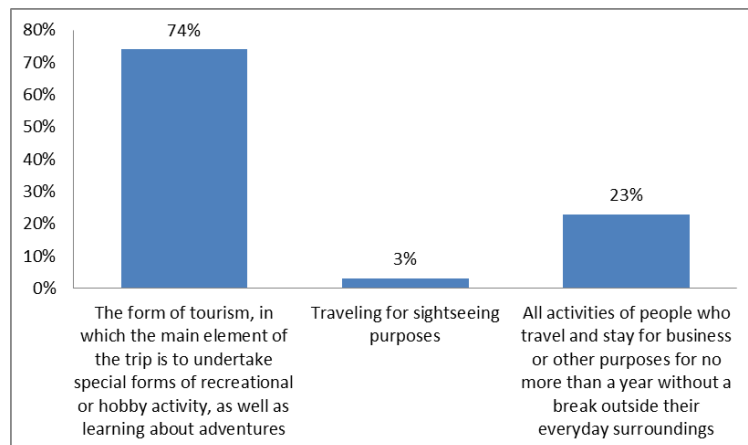


Fig. 1. Definition of active tourism

Source: own research

The concept of active tourism was correctly understood by the majority of the respondents, so the respondents were asked if they were doing it, which was confirmed by 82% of people. However, 18% do not engage in active tourism. The results are shown in the second fig.

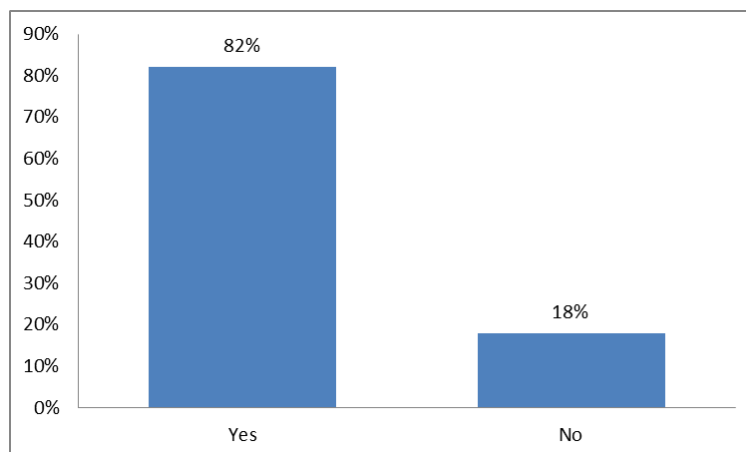


Fig. 2. Selection of active tourism

Source: own research

The third fig also presents a question about how often students engage in active tourism. Almost all answers gave a similar result: once a year, 36% of respondents decide to active tourism, 33% prefer it during holidays and long weekends, and 31% prefer it twice a year.

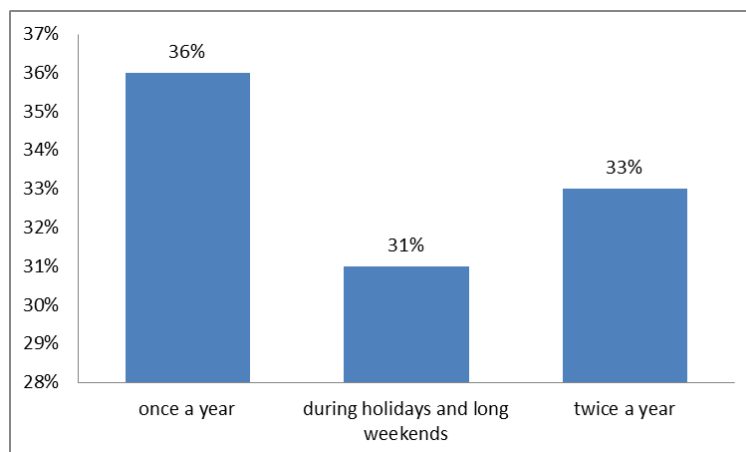


Fig. 3. Frequency of practicing active tourism
Source: own research

Answers to the next question drew attention to the one with whom most students practice active tourism, and they were presented on the fourth fig. In the active tourism, the group was most often accompanied by a group of friends - 45% of respondents and family - 44%. Only 11% of active turnip is grown individually.

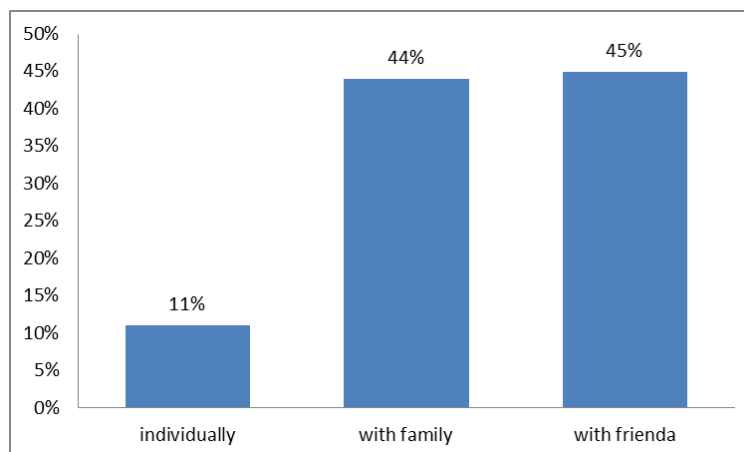


Fig. 4. Active tourism- accompanying persons
Source: own research

After getting answers to the questions about active tourism, interviewers were asked about the forms they choose when deciding on this type of leisure time presented in fig five. Here, mountain hiking is definitely dominating, which was indicated by as many as 59% of people. Next, there are: cycling tourism - 52% and lowland hiking - 50%. According to students, skiing is less likely to be undertaken - 28% of respondents and canoeing - 23%. Less popular are fishing and climbing tourism - 10% of students and sailing tourism - 6%. The most rarely chosen forms are underwater tourism, motorboating tourism, equestrian tourism, chosen by 3% of respondents, and speleological tourism and hunting - 2% each.

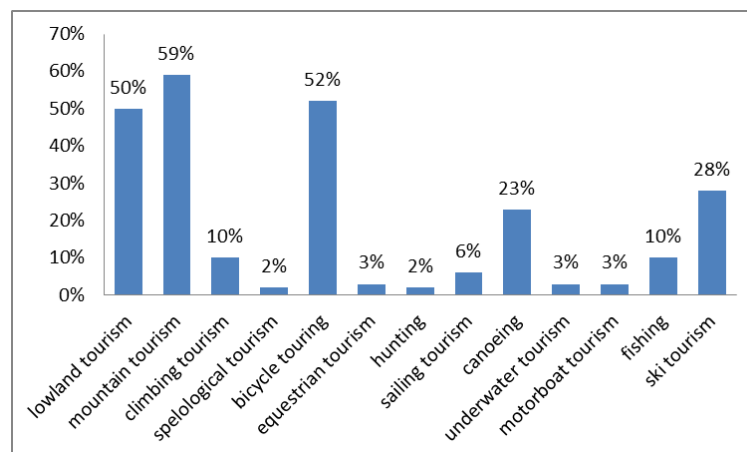


Fig. 5. Preferred forms of active tourism

Source: own research

Then the question appeared in the survey about the motives of students that influence the choice of forms of active tourism. The results are shown in the sixth fig. For the majority of respondents, the impetus for taking the chosen methods was: an active motivation, which is declared by 64% of respondents and a cognitive motif - 63%. An important aspect was also the health motive, which was chosen by 47%. 38% of the participants were interested in choosing active tourism. A small number of people chose a social motif - 23% and an ambitious motive, constituting 19% of all respondents. An analysis of the conducted research has shown that not once was a cathartic motif chosen (means that the person who is guided by him in the selection of activities expects that it will result in psychological solace, isolation from stress and tension, as well as detachment from everyday life). This could be due to the use of an incomprehensible word, because this motif should be the closest to students, due to their lifestyle.

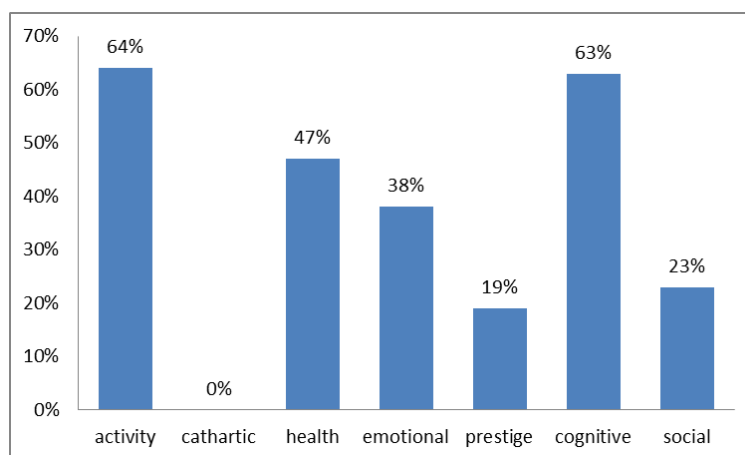


Fig. 6. Motivation for the selection of active tourism

Source: own research

After obtaining the necessary information on active tourism, a question about its impact on health was asked. Here the answers are presented in the seventh graph and were almost unanimous, because 98% of the respondents are definitely aware of the impact, and only 2% of people stated that this form of spending free time does not affect health in any way.

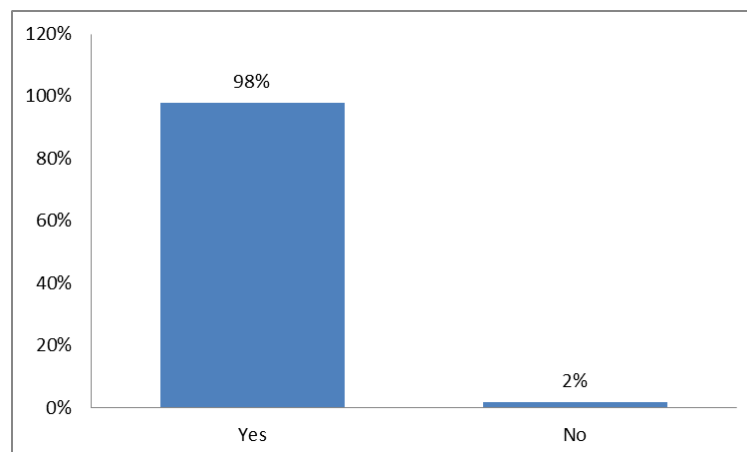


Fig. 7. Positive impact of active tourism on health

Source: own research

In the next part of the survey, there are health questions, including the actions that students take to improve it. On the basis of the presented studies, the eighth fig shows that the most important way for the respondents to influence health was the rational nutrition, which was chosen by 61% of respondents. The avoidance of stimulants was 58%. On the other hand, 48% decided to respond to the regularity of physical activity.

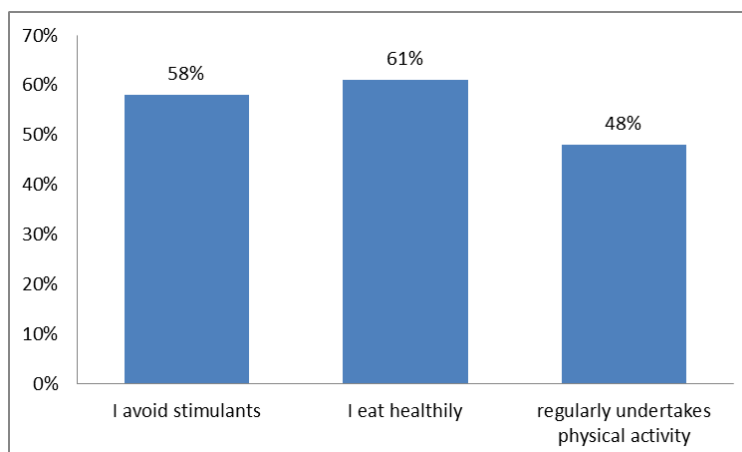


Fig. 8. Actions improving health

Source: own research

The last question concerned elements influencing the healthy lifestyle presented in the ninth graph. The most important factor that was important for health was a sufficiently long sleep - this answer was chosen by as many as 98% of the respondents. Physical activity was also an important element of good health, which is confirmed by 87% of respondents. 67% of students chose hygiene as a special way of taking care of their health. 54% think that a change in mental attitude will also have a positive effect on health. Prophylactic examinations chose 46%. A relatively small number of people (27%) admitted that the use of stimulants has a decisive impact on health.

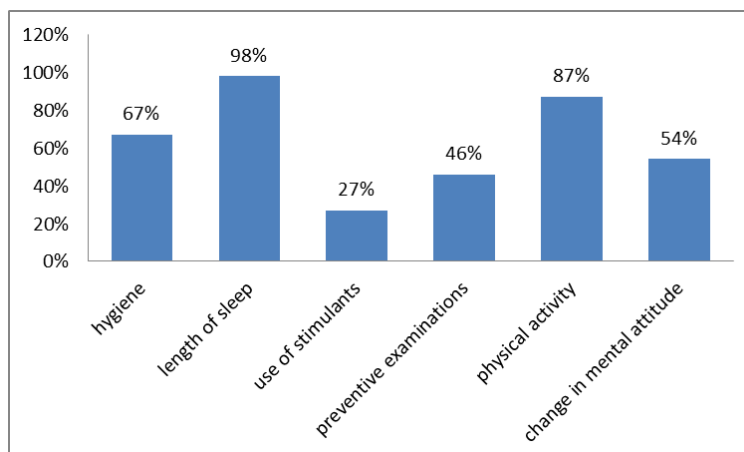


Fig. 9. Factors affecting health
Source: own research

Summary and Conclusions

Modern youth should take care of their health, because it will affect their entire life. Already in school education elements of shaping awareness about health have been introduced. It is widely accepted that the individual makes choices that translate into health, but through knowledge about the value of health and the ability to care for them, he can choose for the benefit of his person. You need to care for health and treat them accordingly. Our health is influenced, among other things, by our personality traits, but also by the environment in which we find ourselves.

The authors drew attention to the positive effects of tourism, especially active tourism and its beneficial effects on health.

Academic youth in Rzeszow is aware of both the choice of active tourism and the impact of health on it, which confirms the author's hypothesis.

Deepening the problems taken up at work, forms of active tourism were chosen by students. The most popular among the surveyed is mountain hiking, cycling and lowland hiking. However, when it comes to the motives which the respondents were guided by when making a choice, one should distinguish mainly the active motif, widely promoted in the media and the cognitive form. Youth did not show the cathartic motive of making tourism activity, most likely due to a lack of knowledge of the term.

In the future, it would be tempting to carry out research on practicing active tourism in order to learn about the trends in its practicing by Rzeszów academic youth. In spite of this, it will be possible to compare to other localities, examining in this way whether the place of residence will affect active tourism and whether the awareness of Rzeszów's students will be identical with representatives of other academic communities.

After such carried out research, the author drew the following conclusions:

1. Awareness among youth in the academic year 2017/2018 on active tourism and health or healthy lifestyle is at a high level.
2. The most common form of active tourism among youth is lowland hiking, mountain hiking and cycling.

3. Active tourism has an influence on social and family relations, improving relations between them. In this way, you can see the needs of another human being.
4. Active tourism is an important element in the overall activities related to improving health.

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THE EFFECT OF HUMIDITY LEVEL ON YIELDING PARAMETERS OF SELECTED SPRING WHEAT GENOTYPES (*TRITICUM AESTIVUM* L.)

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Abstract

The purpose of the experiment was to define the effect of humidity level on yielding parameters of selected spring wheat genotypes. The research material consisted of 7 genotypes of wheat: Harenda, Torridon, Tybalt, Ostka Smolicka, M5, M6, and M7. The experiment was established in Wagner vases in a vegetation hall in 2016 with 4 levels of humidity – 30%, 50%, 70%, and 90% – as the differentiating factor. After harvest, the following data was collected: grains number and mass of main and lateral shoots and mass of a thousand grains (MTZ) of main and lateral shoots. Data analysis revealed that in 30% humidity, Harenda showed the most negative reaction in the form of lower yielding parameters while Torridon showed the best reaction in 90% humidity in comparison to wheat that grows in field conditions. A rising trend can be noticed in almost all of the considered yielding parameters along with an increase in humidity.

Keywords:

Wheat, Drought, Humidity, Yield

Introduction

In relation to progressing climate changes, extreme weather phenomena, with increasing frequency in Poland, have appeared. It has been noticed that drought resulting from insufficient levels of precipitation and an increased temperature during the vegetation period constitutes one of the more significant causes of crop loss, reaching at least 15% [1]. Drought is generally considered a natural phenomenon but its consequences depend not only on its duration, but also on the conditions of the areas exposed to it [2].

Different types of cereal constitutes about 70% of the total sowing area, 30% of which is wheat [3]. Next to agrotechnics and soil conditions, it is the course of weather conditions that is fundamentally important for plant production [4]. Currently it seems that the most important factor limiting losses is introducing plant varieties that are resistant to water shortages to agricultural production. Varieties of this kind are obtained within the framework of the breeding programs conducted. In view of the growing demand for the production of food and feeds, the contemporary agricultural industry focuses not only on production aiming for a high yield but also on nutritional

and technological values [5]. Tolerance to water shortages constitutes and complex issue in view of the environmental interaction occurring in parallel with this phenomenon.

In this paper we focus on comparing selected varieties of spring wheat registered in Poland with wheat lines originating from the nursery of the International Maize and Wheat Improvement Centre (CIMMYT) in water shortage conditions with regard to yielding parameters. The potential lines originating from the CIMMYT should be characterised by an increased tolerance to drought stress and, in consequence, constitute a valuable material for breeding for resistance in the future.

Material and methods

The research material consisted of four wheat varieties (Harenda, Ostka Smolicka, Torridon, Tybalt) from the Polish National Register (KR) and three lines (M5, M6, M7) originating from the International Maize and Wheat Improvement Center (CIMMYT). The varieties registered in Poland are characterised by a good resistance to diseases and a high yield in the territory of Poland. The varieties used in the experiment belong to quality group A, which means that they are characterised by having a very high resistance to sprouting, have very good technological properties and can constitute a treatment agent for flour made of lower-class wheat.

The material which comes from the nursery of the CIMMYT is the lines of spring wheat adjusted through breeding methods in order to increase plant growth efficiency in unfavourable environmental conditions (drought, diseases, nutrient shortages, pests) while maintaining good technological properties of grain. The field experiments show that the average yielding of varieties registered is higher than the yield of the CIMMYT lines by almost 15 dt/ha. The varieties from KR achieved a lower mean MTZ value and were characterised by worse technological parameters of the grain. The average content of protein in Mexican genotypes was 14% (12.5% in domestic varieties), and of gluten - 31.5% (28.1% in registered varieties) [6].

The experiment was established in Wagner vases in the vegetation hall of the Wrocław University of Environmental and Life Sciences in 2016. The differentiating factor was the four levels of humidity (30%, 50%, 70% and 90%) and the control group, which consisted of plants growing in field conditions. The research samples were collected in 10 iteration with 20 plants per variation. After harvesting the crops, the following parameters were established: the number of grains from the main ear, the mass of grains from the main ear, the number of grains from a lateral ear, the mass of grains from a lateral ear, the mass of thousand grains (MTZ) from main shoots and the mass of thousand grains from lateral shoots.

Results

There are multiple factors which contribute to crop yield. One of those most important and difficult to control by humans is the soil moisture level during the cereal vegetation period. On small farms it is possible to artificially irrigate the field but this method is not economical on large plantations that take up about a dozen or so hectares. On the basis of CGMS monitoring, which is used for estimating the crop yields, the potential wheat yield in Poland is limited to 46.9% by water shortages [7]. In such a situation, the only possibility of conducting efficient cultivation of spring wheat is to apply the varieties that are resistant to stress caused by drought.

Tab. 1 presents the mean values of the examined features of selected spring wheat genotypes. On the basis of an analysis of results, it can be noticed that together with the increase in humidity level, the number of grains from main and lateral shoots also increased in the case of the following varieties: Harenda, Tybalt, and Torridon, as well as M6 and M7 lines. Ostka Smolicka developed the most grains on lateral shoots at 70% humidity while the M5 lines developed the most grains on the main shoots at 30% humidity. The tendency of increase in the mass of grains along with an increase in humidity is present in all iterations in the case of both the main and lateral shoots. At 30% humidity, the Tybalt variety and M7 line did not develop any lateral shoots.

Tab. 1. Mean values of parameters of spring wheat genotypes examined

Object and humidity level	Main ear - number of grains [pcs]	Main ear - mass of grains [g]	Main shoots – MTZ [g]	Lateral ear - number of grains [pcs]	Lateral ear - mass of grains [g]	Lateral shoots – MTZ [g]
Harenda_30%	2.95	0.11	37.43	0.50	0.20	15.00
Harenda_50%	7.61	0.24	31.33	15.5	0.96	34.79
Harenda_70%	13.08	0.81	37.79	23.00	1.21	28.13
Harenda_90%	15.20	0.81	36.94	30.67	1.36	28.03
Harenda Field	32.76	0.85	26.05	27.93	0.93	33.39
Tybalt_30%	10.35	0.39	38.02			
Tybalt_50%	10.03	0.41	38.98	29.50	0.96	29.99
Tybalt_70%	35.79	1.42	39.64	30.05	1.10	34.04
Tybalt_90%	39.59	1.44	36.58	31.75	0.98	30.79
Tybalt Field	33.07	1.19	35.89	23.43	0.73	31.19
Torridon_30%	4.53	0.13	24.97	9.33	0.18	6.31
Torridon_50%	13.10	0.57	43.32	19.00	1.06	21.63
Torridon_70%	37.51	1.61	43.01	25.50	2.23	34.28
Torridon_90%	44.56	1.78	39.84	35.75	2.66	34.90
Torridon Field	34.27	1.23	35.89	24.06	0.99	41.12
Ostka Smolicka_30%	4.68	0.15	15.59	12.00	0.31	12.92
Ostka Smolicka_50%	16.43	0.67	41.11	21.00	1.82	35.69
Ostka Smolicka_70%	28.24	1.25	44.48	32.00	1.90	41.13
Ostka Smolicka_90%	31.28	1.40	44.77	25.33	1.93	36.24
Ostka Smolicka Field	33.76	1.28	37.91	15.31	0.86	33.81
M5_30%	35.33	0.06	21.01	19.00	0.33	36.06
M5_50%	17.78	0.48	47.38	27.54	0.65	33.84
M5_70%	26.79	1.31	48.22	26.50	0.91	34.02
M5_90%	31.04	1.46	47.19	20.20	1.07	42.17
M5 Field	32.28	1.27	39.42	24.28	0.72	29.74
M6_30%	8.37	0.28	31.23	9.50	0.67	20.24
M6_50%	15.61	0.63	40.32	14.00	0.72	35.19
M6_70%	28.11	1.38	49.12	23.33	0.80	38.65
M6_90%	29.57	1.41	47.33	22.98	0.93	44.99
M6 Field	29.52	1.11	37.52	23.38	0.60	25.68
M7_30%	8.40	0.30	35.58			
M7_50%	13.40	0.61	44.04	18.00	0.56	26.93
M7_70%	26.75	1.19	44.45	22.00	0.90	34.95
M7_90%	29.14	1.31	44.82	21.37	1.11	41.30
M7 Field	30.24	1.33	43.88	16.80	0.59	35.01

Source: own calculations

The genotypes employed in the experiment that originate from the nursery of the CIMMYT did not exhibit a significantly greater crop yielding capacity in comparison to the Tybalt variety, which, when it comes to grains of the main ears collected, achieved the highest MTZ result in the induced

drought situation. It is worth noting that the spring wheat lines originating from the nursery of the CIMMYT achieved lower parameters also in field conditions, which is confirmed by results of experiments [6].

Summary

- The Torridon and Harenda varieties reacted with increased parameter values at 90% humidity.
- The mass of grains and number of grains from the main shoots was increasing along with an increasing humidity level except for the M5 line, which achieved the highest quantity of grains at 30% humidity.
- The plants of the M5 line and the Tybalt variety exhibited the greatest resistance to drought.

The wheat genotypes from the CIMMYT nursery exhibit the potential for breeding for resistance to abiotic stress. It is worth underlining that among the varieties registered domestically there are present varieties such as Tybalt, which maintain the crop yield parameters at insufficient access to water and, at the same time, are often characterised by crop yield parameters better than those of the lines originating from the CIMMYT.

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THE COMMUNICATION SIGNIFICANCE OF THE ODER AT THE TURN OF 19TH AND 20TH CENTURIES IN THE REGION OF SILESIA

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Abstract:

The Oder River has already become one of the main communication arteries running across Prussia in the 18th century. Still, despite the advantageous location and its known economic importance, it was left unmodified, and without any strategic significance. The on-going wars and the lack of development lead to its collapse. Only in the 19th century did some economic changes start out, cities started developing, and the idea of the waterway connecting Szczecin with Raciborz was made. What's more important where the political decisions, especially the geopolitical ones, leading to real projects. Some of them were able to come into fruition still in the 19th century, during the Second Reich, others were put aside and had to wait to be actualized until contemporary times.

Keywords:

Silesia, Poland, Oder, river, German Empire, development

Introduction

For the past two centuries, we have witnessed a huge civilizational, social and economic development. The industrialization processes initiated on the British Islands forced the old and falling behind the European continent to reform on all levels. The turn of the 18th and 19th centuries marked the birth of not only new enlightened European societies but also the time of changes in the obsolete economic system and more rapid entry into the era of mechanization, which affected every aspect of human life. For Silesia, the beginning of the 19th century is the time of stabilization and forging future plans for itself as the most important industrial regions in Europe. The end of the Napoleonic era left much destruction behind and brought financial and social crises to many cities in Silesia. The collapsing infrastructure and administration forced the Prussian state to a reform – one which was to become a prelude to economic development and full unification of the territory. It has changed its form radically from a feudal province to one of the most industrialized and sought-after German regions [1].

One of the main communication arteries at that time became the Oder, flowing almost all over Prussia. Despite the favourable location and the importance in the economy, until the 19th century,

the river remained unchecked and without any strategic importance. The on-going war and lack of development led to the drop of the importance of this waterway, which had been overgrown and silted. That was the cause of many floods, even with low rainfall [2]. The Renaissance of the Oder Waterway can be dated to the mid-19th century. Strong industrialization has forced the Prussian administration and industrial tycoons to find new communication routes for transport the goods into the state. Undoubtedly, the situation has begun to change in the time of German reunification and the development of modern infrastructure. The repeatedly expressed words of the Chancellor of the Reich, Otto von Bismarck about the unification with blood and iron, has made a great impression of what became the driving force for the development and modernization of all the branches of the industry and transport, including communication on the Oder River. The turn of the 19th and 20th centuries were the time when some plans for the largest waterways within the borders of united Germany and not only was made. Also the Austro-Hungarian Empire took part in it. The beginning of the new century is also the time of reflection on safety and the first concepts of the construction of retention reservoirs for flood control purposes. After fourteen years of peace, the 20th century, which has become an icon of modernity, had changed diametrically as a result of two world wars, which were divided by the twenty-year period of peace. The new order had established after the Second World War forced European countries, which now embedded in new borders, to verify previous plans and assumptions.

Significance of the communication on the Oder in the 18th and 19th centuries – Prussian hegemony

The 18th century had been a breakthrough time for Silesia. The changing reality was caused by the events of the 1840s and was related to warfare between Austria and Prussia. The small significance of the Oder in relation to the extensive multinational monarchy of the Habsburgs did not have a good reputation among sailors as well as farmers living on the river basin [3]. Silting of the river, rich vegetation as well as meanders effectively blocked navigability, and heavy rainfall favoured the floods. The conditions mentioned above were conducive to the development of fisheries. Fish were mainly sold in the Czech Republic, Bavaria and Braunschweig [4]. In spite of poor navigability, the areas of Oder River became a considerable matter of interest of the powerful and the clergy. Many monasteries were built near the river, with some housing estates made around them. Year 1740 was a breakthrough event influencing the fate of Oder as a waterway. At that time, the Prussian army crossed the border of Silesia and yet in 1741 controlled almost the entire area left in the fall of Charles VI, including the areas of Upper Silesia [5].

The Silesian Wars that took place between 1740-1763 ended with the conclusion of peace in Hubertusburg. This led to the Prussians which were permanent taking over a significant part of Silesia with access to the navigable part of the river. On the Austrian side, the areas of Cieszyn and Opava Silesia survived, from where the Oder takes its origin [6]. Prussians gained access to the river from Bohumín to the estuary in Szczecin (Fig.1). In Silesia, a new administration was quickly introduced to unify it with other provinces. The new area was divided between two departments with headquarters in Wrocław and Głogów, at the top of which so-called war cameras were formed.

The tasks of the new administration included the authority over military, police and tax matters, as well as the protection of state-owned goods, including the Oder River [7].



Fig. 1. Oder in the Hohenzollern state before the partitions of Poland.

Source: Odra-Oder. Panorama europejskiej rzeki, K. Schlögel, Beata Halicka (red.)

With the takeover of power by the Hohenzollerns in Silesia, the first work on the rejuvenation and sailing of the neglected river began. Acceleration of work took place in 1746, when a new department was established and new embankments had to be built and watched over the condition of the river infrastructure. Neuwertz became the first construction inspector in this area, the second was his son. The works that the Neuwertzes undertook were: digging curvatures, removing weirs so that they could flow through them, construction of embankments and river bank reinforcements to protect against the invasive activity of the river. The most important achievement of the turn of the 18th and 19th centuries was the regulation of the riverbed by drying quagmires and making trenches through meanders, which shortened the Oder River by 80 km. In the years 1770-1780, river structures were organized in the area of: Raciborz, Opole, Ścinawa and Zielona Góra. According to the construction inspector Neuwertz, all of the 48 crossings were made in Silesia, thus shortening the entire river course from 1020 to 860 kilometres [6].

The beginning of the 19th century was the time when the greatest powers of the European continent were occupied and facing the Napoleonic offensive. The defeat of 1806 and the conclusion of treaties of Tilsit meant that Prussia lost the considerable parts of its territory, including the Duchy of Warsaw. With the occupation of Prussia, a great process of the state repair was initiated by the ministers of Stein and Hardenberg, who contributed to the reorganization of the Prussian administration. The basis for these activities was the Royal edict issued on December 16, 1808. By virtue of its provisions, the Prussian state was divided into provinces and regions. The most important link in the new local government organization was the regents, to which all matters within the designated circuit belonged. From this time, field units were responsible for: cadastral offices, construction offices and other important positions affecting the functioning of the administration of the designated area. Initially, the entire Silesia belonged to the Wrocław district which was formed on September 23, 1809 and scarcely from May 7, 1816 to the Opole district.

During the organizational changes in the whole area of Prussia, the offices were dialled with the control of the rivers and involved in the creation of river photographs, which were used to develop projects for future river development plans. Such actions were supposed to keep the river in check so far and did not let go back to savagery. The turn of the 18th and 19th centuries was the time when the methods of coast fortifications were changing, as well as, new ways of regulation.

The Bohuminian Protocol, developed in 1819, influenced the development of river infrastructure. The document set the direction for the construction of river infrastructure from areas which were located below Raciborz to the estuary of Lusatia Neisse and Warta [8]. The provisions contained in the protocol were fully responsible for taking care of the proper course of the river and all repair and construction works, transferred to the state. This was to prevent self-healing renovations made by private owners of estates by the river. Since the adoption of the protocol, the work has significantly accelerated. These activities were such a magnitude that as early as in 1859, the Oder River, along 130 km, improved its flow. Modernization allowed increasing the transit depth to approximately 1 m, with the low water level. Regulatory work gained the importance, which caught the attention of Chambers of Commerce (Gliwice, Opole and Wroclaw). In 1861, a special association of sympathizers of work of the Oder River (*Oder Verein*) was established, whose aim was to emphasize the importance of regulation and the revival of shipping traffic. The river became an object of interest for the rapidly growing industry in Upper Silesia. This resulted in increased subsidies for further modernization works in order to improve the quality of flow. In the years 1868-1874, 7.3 million marks were transferred to water projects [6].

The importance of Oder in the economy of United Germany (1871-1918)

Since the time of the Germany union in 1871 Oder, which combined the rich industrial supply network of Silesia and Szczecin, was included to the big waterway web of the II Reich, becoming the same the third water artery after Rhine (on the western part of the country, navigable from Strasburg) and Laba River, which connected the centre of Reich from Dresden to Hamburg (Fig. 2). The end of Prussian time caused the following changes in the administration. In 1874 another separated organ was obligated, The Administration of Regulation of the Oder River in Wroclaw (*Oderstrombauverwaltung*). Its duties included only the Oder matter and as its head who controlled the all the process was the construction and Oder regulation director with the main office in Wroclaw. From 1879 it embraced the course of Oder, from the border with the Austro-Hungarian Empire in Bohumín to the Schwedt [2]. In 1879 the conditions of Oder sailing improved and the financial expenditures were raised up 7 million marks, what established the situation on the River.

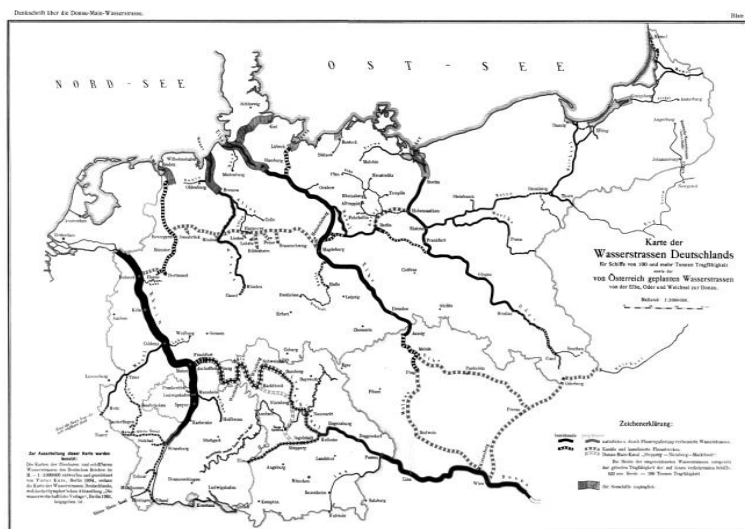


Fig. 2. A copy of the map depicting waterways in the German Reich.

Source: E. Faber, Denkschrift zu dem technischen Entwurf einer neuen Donau-Main-Wasserstrasse von Kelheim nach Aschaffenburg, Nürnberg: Verein für Hebung der Fluss-und Kanalschiffahrt in Bayern 1903.

The total amount of grants transferred for river maintenance in the Reich was 50 million marks. When comparing the number of grants that were donated to the Oder, it can be concluded that the Oder was still treated as a river with little economic significance [9]. At the turn of the 19th and 20th century, despite the construction of the railway lines, shipping in the Silesia region began to grow rapidly. The maximum number of barges at this time was 250 tons at the section between from Koźle to Wrocław. This many vessels that were operating on the Oder River at the Times were small compared to the 400-ton barges operating on the Elbe. One of the main difficulties of shipping through a river was that its state of water was dependent on climatic conditions, which meant that the river was only navigable for 250 days a year [2].

To strengthen the significance of using the Oder, plans were made to expand the waterway network at the end of the 19th century. When the Silesians tried to modernize their small section, between the German Reich and the Austro-Hungarian Empire, far-reaching plans to create a network of waterways connecting the Elbe and the Oder to the Danube were developed. This new waterway would connect the Baltic Sea with the Black Sea. In 1897, a brochure was published by the German-Austro-Hungarian Association for Inland Navigation (*Deutsch - Oesterreichisch-Ungarischer Verband für Binnenschifffahrt*), pt. *Das Donau-Oder-Kanalprojekt*, where the report of the meeting that took place on September 21, 1896 was presented. The rapporteurs were two professors from Vienna: Professors A. Oelwein and J. Böhm. Researchers in their report complain about the lack of progress made from both parties during the year, despite the 172 petitions from numerous cities, villages and landowners. Professors Oelwein and Böhm mention that this is the only innovative venture, which in a helpful way can facilitate the marketing of both industrial and agricultural materials [10]. However, as can be seen in the whole publication, the main reason for the postulates of building a strong inland road in the region of Silesia was coal. Of the 13 mines, two belonged to the Austro-Hungarian empire (Ostrava and Karvina), and the remaining eleven belonged to the German Reich. This was used as one of the arguments to change the form transportation in order to relieve railways and strengthen the role of waterways. These plans were advanced to the point that a proposal for the constructions of channels connecting not only strong

industrial districts, but also large cities located far away from each other (Fig. 2). The map below outlines Austrian plans for the construction of three large waterways: the Danube - Oder, Danube - Vltava, Morava - Elbe and two Galician channels. Such solutions were not only aimed at connecting main industrial centres with Prague, Vienna, but also with Krakow or Lviv. The planned network of inland waterways would connect the great cities of Central Europe with the Black Sea and the Baltic Sea, creating strong markets for them (Fig.3).



Fig. 3. Map showing the plans for the construction of channels: the Danube - Oder, Danube - Vltava, Morava - Elba and the Gliwice Canal.

Source: Files of the Opole regency, no. 4249.

When the Austro-Hungarian Empire was making these ambitious plans, the German state right after entering the new century continued to work on the greatening the throughput of the river from Koźle to Wrocław. One of the main threats of developing water management at this time was frequent floods. The most tragic result was the "great flood" of 1903. Changes in the regulation of the river's course significantly contributed to the improvement of flow and speed. This was not a new thing for the Germans. It should also be emphasized that from the 17th to the 19th century, river floods were nothing new. The most serious ones took place in the years 1702, 1711, 1734, 1755, 1783, 1804, 1810, 1829. It was only in 1902 and in 1903 that they became aware of the importance of flood protection [11]. Safety reasons led to the design of more than two hundred reservoirs, divided into three categories of retention: flood control, feeding the Oder riverbed and water supply (sanitation). From the analysis of maps from the early twentieth century, it appears that the largest number of tanks were to be created between the water gauges Raciborz and Ścinawa. These reservoirs were not meant to be designed for the main course of the Oder, but for its tributaries. Starting from Kłodnica, built in the early 16th century, where the reservoir Dzierżno was to be built, after the retention of Eastern Neisse in Otmuchów and Mała Panew River in Turawa [12 This is not the end of modernization flood control, as the new perspectives came with some new modernization tries. One of the main priorities became the subjugation of the element through its use. New development plans for the Oder and its tributaries were made to support retention, and the construction of new canals, bridges, power stations and modern ports. One of the leading undertakings was the construction of the Wrocław Water Junction, which included the comprehensive managing of the whole river within the city limits and the redirection of its main run from the city center. This modernization was aimed at increasing the safety of residents (Fig. 4).



Fig. 4. The drawing showing the port of Wrocław from 1905.
Source: Files of the Raciborz, no. 438.

The end of the First World War led to significant border changes. In 1919, as a result of the Treaty of Versailles, Germany and Austro-Hungary lost a considerable amount of its territories, and countries such as Poland and Czechoslovakia started to appear on the map. As a result of the Silesian Uprisings in 1919-1921, Upper Silesia started to be divided into two, Polish and German. Plans to build strong waterways to connect the main rivers of Central Europe were tossed. At the end of the war, the Upper Silesian Union of Industrialists of the Mining and Steel Industry postulated the construction of a new, larger Kłodnicki Canal in order to improve the trade of Silesian products to Berlin [9]. However, the offer was never implemented. Among the many provisions in the Treaty of Versailles was also the decision to divide Silesia. The division of Silesia took place as a result of plebiscite that intensified the situation and caused the outbreak of three Silesian uprisings. However, the final decision was made by the League of Nations Council. Despite the fact that the territorial dispute over the division of Upper Silesia was won by the Reich, gaining 71% of the area, Poland still gained access to a significant part of the plants, steel mills and mines. Such a turn of events, according to the German press, resulted in the rupturing of economic ties that had been building for decades, which led to unprecedented turmoil [13]. Coming back to matters related to water infrastructure, in this aspect also came to a standstill. The navigable Oder River from Koźle required a considerable amount of money and subsequent modernization, just like the above-mentioned Kłodnicki Canal. It must be admitted that from the beginning to the end of Weimar Republic's existence, apart from new construction plans and the completion of the already started investments, there was no further talk of building new waterways in Silesia.

The situation has radically changed since 1933, when the National Socialist German Workers' Party came to power as a result of the elections in Germany. Great plans were made to rescue the German Upper-Silesian Industrial District from the economic collapse. Therefore, by virtue of a resolution of the cabinet of January 30, 1934, construction work was immediately initiated on the Upper Silesian Canal [9]. The new authorities, headed by Adolf Hitler, made plans to build a strong network of inland waterways and channel construction, i.e. Oder-Danube and Oder-Vistula-Danube. All this has become possible thanks to the expansive policy of Germany. On March 12, 1938, Austria was annexed to the Reich. A few months later, again by virtue of the agreements, but without the consent of Czechoslovakia, the country was also annexed to the Third Reich. Such a policy made it possible to return to the old plans from the time of the Austro-Hungarian Empire and the Second Reich, assuming the re-emergence of Central Europe. This situation gained

momentum after the occupation of Poland, on September 1, 1939. From that moment, the whole course of the river from the source to the estuary was controlled by one country [14].

Work on building a strong network of inland waterways and improving the safety of the Oder continued until the last days of the war. From the analysis of the map entitled: Tanks in the upper Vistula basin (*Talsperren im oberen Weichselgebiet*), issued by the Directorate of Waterways in Wroclaw (*Der Oberprasident Reichswasserstraßerdirektion - Breslau*), April 3, 1941, you can visualize the scale of the venture. In addition to the construction of canals, large retention reservoirs were also planned to be built on the Vistula and Oder rivers. Following the plans from before World War I, one can notice a repeated operation in that new tanks were not designed for the main river, but for its tributaries. For the Oder, the reservoir was to be built on the Olza River near the present village of Věřnovice on the Czech side, and for the Vistula the main retention was to be built in the initial run near Ustroń, Brenna and Goczałkowice, on the Sole near Porąbki, on Skawa near Poręba and Wadowice (Fig.5).



Fig. 5. Map showing existing and designed water reservoirs between Koźle and Krakow and plans to build the Oder-Danube Canal (marked in red).

Source: Files of the regulation of the Odra River, no. 2224.

The lost war, huge losses in people and infrastructure, new boundaries marked by won superpowers influenced the progress of work. Oder which was recently in Germanys' hands became a new border of rebirth of Poland. After 1945 the changes were so large that it took many years before the construction of the strong waterway was once again put into practice.

Conclusion

Throughout the discussed timeframe, the Oder River became a crucial component of politics and economy in the German state of that time. The budding industry of the mid-nineteenth century created the need to connect Silesia with other parts of the German Empire. It turned out that the rivers were the cheapest means of transport, even despite the development of the construction of iron railways. The river's importance hasn't decreased, quite the opposite. It was dictated by the increase in the production of goods in the highly industrialized regions of Silesia. Numerous floodgate and weirs were built. At that time, plans were also made to enlarge the Kłodnica Canal and expand the Wroclaw waterway to export the black gold of Upper Silesia. However, it was

impossible to predict the international situation, any armed conflicts, and the very nature of the river. The turn of the 19th and 20th century is a turbulent time of European history. Numerous plans that were created had to wait a long time for their implementation. Some wait till this day. Throughout all the years of planning and modernization, the potential of the Oder River hasn't been fully utilized yet.

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THE ROMANTIC WANDERER. IN THE FOOTSTEPS OF ZYGMENT KRASIŃSKI

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Abstract:

The main aim of the article is to present Zygmunt Krasiński as a romantic pilgrim, always on the move, which greatly affected his character and personality. A particular attention was paid on the mark that historical events left on Krasiński. His romantic ideas alienated the poet from everyday life. Elementary values such as family did not play a significant role for him. However, it is not surprising that Krasiński distanced himself from his family. Dominated by his father, he was aware of his inability to follow his passions. This domination, combined with his belief in his unique destiny as a great poet, caused his permanent dissatisfaction. It turns out that travelling, despite its positive influence, can also play a destructive role in a person's life. Despite his numerous friends he met during his voyages, the author of the “Un-Devine Comedy”, paradoxically, remained lonely. His constant health problems or rather hypochondria were another reason for his continued unhappiness.

Keywords:

travelling, loneliness, Romanticism, disease, love

Introduction

Romanticism brought about a new type of traveller. What started to matter was: “not only a description of things viewed, but also a presentation of the traveller” [1], of his mind and personality. The image of the traveller in the literature of that period is rooted in the romantic philosophical anthropology and in the experiences of the contemporaries. He is a *homo duplex*, a man torn between his inner contradictions, seeking unity in vain, yearning for the paradise from which was exiled. Typical examples are the heroes of Mickiewicz or Słowacki, but also those of other romantic authors such as Malczewski, Woronicz and Goszczyński. They were trying to create a new axiological system in the process of searching or wandering on two planes: geographically and spiritually. Visiting new and unfamiliar places broadens one's horizons and contributes to personal advancement. For a true romantic wanderer, travelling was an end in itself. To travel meant to live, or rather to search for the meaning of life. Travelling was a lifestyle, and the wanderers were usually described as: “lonely, lost, confused, hungry for knowledge and self-knowledge, striving for personal perfection and desperate to make the world perfect, but uncertain about their fate, lost in the chasm of the universe or in the labyrinth of history, inquisitive researchers and adventurers, but also blind men walking aimlessly in the fog” [2].

One might even go so far as to say that penetrating the soul was more important for a Romantic than physical movement, which merely served as a pretext for exploring the mind and consciousness. External phenomena, including socio-political experiences, inspired new ideas and visions. For the 19th century Poles, they were undoubtedly the experiences of subjugation and forced emigration. It is then no surprise that the greatest romantic values were freedom and independence. That is why personal identity, freedom and fulfilment were believed to be only attainable by participating in the affairs of the nation. The task of the individual was to search for absolute freedom, the freedom that brought one closer to the gates of paradise. Achieving such state was not always possible. More often than not, the end of the way was marked by disappointment, disillusionment and bitterness. This, however, did not discourage the romantic travellers. They were driven by a constant hunger for knowledge, power and love, while their feeling of alienation and their defiance of the status quo forced them to keep travelling towards a new and better reality: “to the source, home, to the land of childhood and family, to Ithaca, to the gates of metaphysical paradises, to the mystical “promised land”, to the cradle of humanity and culture, to the origins of history, to the land of esoteric oriental mysteries, to the land of art and poetry” [2].

The romantic travellers were mainly fascinated by Europe, the Orient, America and their homeland. Embarking on a journey was often not a spontaneous decision, but a necessity, as was the case with deportations to Siberia or travels undertaken for fear of persecution by the invaders.

Travel literature became very fashionable at that time and developed on a large scale. It often contained references to the contemporary political situation that are valuable for modern historians. The popularity of this literature resulted from the desire to record written memories of travels. It was also inspired by translations of foreign travel writings, mainly 18th century French, German and English texts. A great profusion of Polish travel literature followed the defeat of the November Uprising. On the one hand, it was due to the fate of emigrants and exiles, and on the other hand, to the development of tourism. This literary form referred to authentic events and experiences shared by many people, especially those who go into exile.

Zygmunt Krasiński as a Wanderer

The motif of the journey is ubiquitous in the works of Zygmunt Krasiński. Particularly noteworthy is his extensive correspondence, to this day largely unknown and underestimated, although it contains a lot of valuable historical information. Krasiński dedicated his entire life to the ideas of Romanticism, according to which travelling was an inseparable part of life.

Krasiński travelled from an early age, mainly around his home parts, between Warsaw and Opinogóra. The latter, located near Ciechanów, was the summer residence of the Krasiński family. For Zygmunt, it was a Polish equivalent of a spa where he developed his two greatest passions: hunting and writing.

Krasiński's voyages were not limited to Poland. His first foreign trip was to Geneva where the young writer began his studies. There were various reasons for this choice: the local university enjoyed a good reputation, as the names Zamoyski, Łubieński and Mielżyński on the students' lists suggest. The location of the city also played an important role – Geneva was situated in the French speaking part of Switzerland, away from the political turmoil of the rest of Europe. Its healthy climate and the picturesque landscapes of the region also had a very positive impact on the young

writer. He admired Switzerland, although he often emphasized that the landscapes of his home country were more appealing to his imagination: „Poland with its sandy soils seemed more alluring to me than the Swiss Alps, and I would not even trade Lake Geneva for my memories of the Opinogóra Pond” [3].

Despite the many attractions he enjoyed abroad, nowhere did he feel as good as at home. However, his curiosity of the world, characteristic for the Romantics, and his relentless desire to experience new emotions, pushed him forward. Already on his way to Geneva, he was sightseeing and admiring various places. His stay in Switzerland was not limited to studying. Krasiński spent a lot of time at receptions, parties or balls, although, as he claimed, they were boring and depressing, and above all completely different from those he was used to in Poland: „About half past nine, you come to a small salon. The crowd is always separated – the ladies sit next to each other on long couches along the walls, and the men stand three hours long in another part of the salon. The ladies chat to each other while the men stay among themselves [...]. Occasionally, a man approaches a lady to say a few words about the wind, the weather, the mud or the cold, and then he withdraws to the rearguard consisting of the whole male company. Meanwhile, they bring tea, punch, lemonade, cakes, but you never hear anything about supper. Such an evening can last three hours, and then everyone leaves, tired, bored, having enjoyed no benefit or pleasure [...]” [3].

Despite the many disadvantages of Genevan balls, they were an opportunity to make new acquaintances. At that time, Krasiński met Henry Reeve, Henrietta Willan and Adam Mickiewicz. All of them were to play an important role in his life, for which there is plenty of evidence in Krasiński’s correspondence, especially in his letters to Reeve. During Krasiński’s stay in Geneva, Reeve was the recipient of the largest number of letters from him concerning, among other things, his feelings for Henrietta Willan. The writer also mentioned Mickiewicz in them; however, he wrote more about his impressions of Mickiewicz in his letters to his father. The poet confronted two completely contradictory opinions of the author of “The Crimean Sonnets”. Meeting face to face with one of the greatest representatives of the Polish Romanticism, Krasiński radically changed his opinion of him: „Oh! How falsely were the judgments about him in Warsaw! He is a man of extensive learning; he speaks Polish, French, Italian, German, English, Latin and Greek. He is proficient in European politics, history, philosophy, mathematics, chemistry and physics. No one in Poland has a better knowledge of literature. When you hear him talk, you might think he has read every single book. His opinions are very serious and reasonable” [3].

The two writers grew closer during their trip to the Alps in 1831. It was a great opportunity to exchange views and to contemplate the beauty of the Swiss Alps together. Their itinerary included Weisenburg, Thun, Interlaken, Lauterbrunnen, Grindenwald, Meiringen, Riga, and Lucerne. Those places belonged to the canon of the romantic journey. Back in Geneva, Mickiewicz and Krasiński saw each other many times. During these meetings they usually discussed literature, philosophy, politics, customs etc. Krasiński always treated Mickiewicz with utmost respect and adoration, but he did not confide in him as in Henry Reeve who seems to have been his closest friend at that time.

Krasiński and Reeve corresponded a lot with each other, which allowed them to stay in touch during their travels. They exchanged dozens of letters at that time, e.g. during Krasiński’s journey to Italy at the end of 1830. Zygmunt’s first letters were full of impressions of the places he visited, interwoven with remarks about Henrietta and his poor health, which did not allow him to do much

sightseeing in Italy. One exception was Rome, specifically the Coliseum, which strongly stirred his imagination: „Whoever believes in Jesus Christ, should go to the Coliseum on a cloudless night; and if he does not fall on his knees before this symbol of faith, I will say he has no soul or heart.” [4] His subsequent letters from Italy focused only on one event – the outbreak of the November Uprising. Krasiński was deeply affected by the fact that he could not participate in the ongoing fights. He was forced to stay abroad, first in Italy and then in Geneva. He repeatedly complained to a friend about his fate: „It would take a miracle to change my situation and bring me back to the world” [4].

Loneliness, a sense of stigma and, above all, extreme pessimism were the leitmotif of many letters. Describing his moods and experiences was one of his methods of creating a romantic biography or his own legend. However, in his correspondence to Reeve from 1832, it is evident that Krasiński gave up excessive exaltation in favour of deeper content. During the two years spent away from home he became more mature.

After his return home from Geneva in 1832, he was struggling with serious health problems. His doctors were afraid that he might become blind. The problem with his sight was undoubtedly associated with his mental state. His stay in Poland did not bring the expected relief, and his next journey to St. Petersburg with his father only made his condition deteriorate. From the very beginning of the travel, the idea of visiting the capital of tsarist Russia filled him with horror. An audience with the tsar was designed to further the young Krasiński’s career, which meant abandoning romantic ideas. In the end, his father’s plans did not come to fruition. Paradoxically, Zygmunt’s illness became an opportunity. The Tsar allowed him to travel abroad for health reasons. He was overjoyed by this turn of events.

Shortly afterwards, the young Krasiński left the country in the company of his friend and guardian, Konstanty Danielewicz. Before going abroad, however, they visited Cracow, which fascinated the poet very much. It was a meeting with the history and culture of the nation, as he wrote in a letter to Reeve: „Today is a spring day, and in this gentle air, full of light, the old churches of Cracow seem younger [...], the past extends its ancient arms towards me, gently embracing and blessing me; every tower, every turret, every belfry inspires me. [...] The whole old Poland rose to my voice: here it is! Can you see how great, how magnificent it is, how it shines its weapons, can you hear the loud cries, how melodious are the songs of this only buckler of Europe against unbelievers [...]” [5].

After leaving the country, the poet went first to Vienna to undergo his planned treatment, although judging by his letter to Gaszyński, it did not bring the desired results. Krasiński felt worse and worse, especially his mental state left much to be desired.

After their four-month stay in Austria, the two friends set out on their way through Salzburg, Innsbruck, Trent to Venice and then to Rome, where Krasiński decided to spend the winter. He finished one of his greatest works – “Nie-Boska komedia”, and started another one – “Irydion” there. The idea for “Irydion” was born in St. Petersburg, but it was not until his stay in Rome that Krasiński gave it its final form. The ancient Roman ruins inspired him. He not only wrote, but also read and thought a lot. The winter of 1833/34 was marked by intense work, which inevitably took a heavy toll on his health. Wincenty Krasiński, worried about his son, sent the doctor Ludwik Sauvan to him to Rome. From then on, Sauvan took care of Zygmunt. In the spring of 1834, Krasinski’s

condition considerably improved. He used his revived energy for numerous meetings with other Polish nobles who were staying in Italy then. He met his relative, Adam Soltan, a participant of the November Uprising and a political emigrant. Despite the large age difference between them, Soltan became his confidant, especially in matters of the heart. He also made friends with Edward Jaroszyński and through this acquaintance he met Joanna Bobrowa – his long-time mistress and companion.

Zygmunt soon became fully absorbed in his love affair with Joanna Bobrowa. He abandoned writing and changed his travel plans. He wanted to spend as much time as possible with her, although at first, their contacts were difficult because Bobrowa was married. The lovers met whenever they could, and they had plenty of opportunities, especially when they travelled together, among other places, to Florence, Venice, Munich, Cologne or Kissingen. Unexpectedly, the lovers parted after a few months. It was not the end of the affair, although Krasiński admitted that he was getting tired of the relationship. Nevertheless, he and Joanna Bobrowa continued to meet until 1837. Their periods of separation were filled with correspondence by which Krasiński informed his beloved about his undertakings and shared his experiences. In one of his letters, he described his impressions after seeing the opera “Norma” by Bellini in the famous La Scala theatre in Milan: “My only moment of strong emotion – something I have not felt for a long time, because the days, even hours seem so empty – was yesterday in La Scala. Melibran was singing Norma, but her voice was nothing compared to her acting! Her face was changed by jealousy and despair, her hands were trembling in excitement and her fiery eyes [...] focussing on the sinister, calm, impressive majestic face of the man she used to love. [...] Ah! I am still shaken by the power of this woman’s art! I thought I was watching the real Norma. [...] Then the curtain fell, and the noisy applause of the ground floor reminded me of reality” [6]. The opera made a stunning impression on him, mainly Maria Melibran in the lead role. Zygmunt visited the theatre again two years later in 1836, most likely to admire her on stage again.

The poet actively participated in the cultural events of the 19th century Europe, including theatrical performances. It improved his mood, and most importantly, it helped him relax, especially after all kinds of strenuous health treatments. Hydrotherapy used to be very fashionable then, but the treatment he received in the spa of Graefenburg near Freiwald in Austrian Silesia turned out to be an extremely exhausting procedure. Nevertheless, Zygmunt had it administered many times, without realizing how negatively it would affect his health. Already after the first hydrotherapy session, the writer probably developed tuberculosis. As time went by, his condition grew only worse. He needed a long time to recover after each such treatment.

Despite his deteriorating health, Krasiński did not give up participating in social life. On the contrary, he still made new acquaintances, for example with Juliusz Słowacki with whom he quickly became friends. Their relations changed only in later years. Krasiński noticed Słowacki’s talent, he saw in the author “Balladyna” the antithesis of Mickiewicz. He saw himself as the third great national poet and spiritual guide of the nation, just after Mickiewicz and Słowacki.

However, his romantic vision of the prophetic poet stood no chance of fulfilment at that time, primarily due to his father, whom Zygmunt was unable to oppose. Wincenty Krasiński persuaded him to return to Poland and intended to prepare him for taking over the family’s estates in the future. He wanted to familiarize his son with the management of their property. He also found a suitable

fiancée for him, a daughter of a wealthy family, Elżbieta (Eliza) Branicka, whom Krasiński married several years later.

However, before he settled down, the poet had often caused his father a lot of stress. It began with another trip to Italy, specifically to Naples, where father and son were planning to spend Christmas at the estate of the Komar family. The trip turned out to be a disaster for Wincenty Krasiński, because Zygmunt met Delfina Potocka there, his second great love. Krasiński travelled around Europe with Potocka, just as he had done with Bobrowa. The lovers chose secluded, rarely visited places, mainly in Italy (Rome, Naples, the Alps, Lake Como) and France (Nice, Paris).

Wincenty Krasiński, however, did not give up his matrimonial plans for his son and managed to persuade him to marry Branicka. The wedding ceremony took place in Dresden in 1843. A few days after the wedding, the newlyweds set off on their honeymoon trip to Poland. They travelled by train, which was an exciting experience, especially for Krasiński's wife: „Our journey has been very enjoyable so far. We fly day and night at great speed. I sleep in my train carriage better than in my bed, rocked into sleep, like in the finest cradle” [7]. Zygmunt, in contrast to his wife, preferred more traditional means of transport. He found his horse carriage much more convenient. In his opinion, the railway's disadvantages outweighed its benefits, as he wrote in one of the letters to Potocka: “Travelling by rail is said to be so comfortable, but I abhor those tickets, those crowds on the platforms, sitting together with God knows whom! It is such a drag to collect your belongings, to hire a carriage, to drive to a distant inn. Each such trifle cuts my heart in two” [8].

After a few days, the spouses reached Opinogóra. It would seem that Krasiński's return to his favourite place of his youth should improve his well-being. It turned out to be the other way round – after five years abroad, he felt alien in his homeland. During the time he had spent abroad he had lost his sense of belonging to it. He did not find happiness in marriage either. Only his trip to August Cieszkowski to Wierzenica lifted his spirits. Another reason for his improved mood was his next trip abroad, which he had been planning for a long time. In June 1844, Krasiński obtained a passport and could finally see Delfina and his friend Jerzy Lubomirski. The three of them went to Paris. However, Krasiński did not have the fortune to enjoy Delfina's company very long, because his passport soon expired, and in September he had to return to Warsaw. Back in Poland, he committed himself to writing and publishing his works. He focused all his attention on propagating the ideas he was so passionate about. His belief in the rebirth of Poland by the power of God's love became an obsession. He could not come to terms with events such as the Galician Slaughter or the Spring of Nations. Krasiński treated social revolution as an action against the ruling class to which he belonged. He believed that its downfall would be a disaster of cosmic proportions and he attempted to prevent it. His efforts, however, came to nothing.

All these failures contributed to the rapid deterioration of his health, which was already severely undermined. His stays in German spas did not help. The last place the writer managed to reach was Paris. His terrestrial journey ended there, but according to romantic philosophy Krasiński began a new pilgrimage in the afterlife.

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3D GEOMETRY OPTIMIZATION OF THE FRAGMENT OF REMOVABLE PARTIAL DENTURE METAL FRAMEWORK WITH SINGLE INCISOR IN NUMERICAL ANALYSIS

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Abstract

This article focuses on geometry analysis and optimization of 3D models of the fragment of removable partial denture metal framework with single incisor. It is considered in the context of numerical analysis. To compare were created, two 3D models. The first model had a straight base plate. In second model geometry of base plate and metal framework were curved. Created geometries have been checked by numeric analysis in ANSYS program. Two kinds of analysis were performed. In first one load was added on the area of incisor edge, in second- on side surfaces of the whole tooth. The distribution of the most considerable deformations and stresses were checked, and they were very similar in all tests. More critical are stress distributions and their values, because fracture may occur in places of greatest stress. It can be concluded that the curve of the base plate has little influence on stress distribution and deformations. So curved base plate is more like in natural conditions, that means the in the mouth of the patient the stresses are slightly larger than in the initial simulations.

Keywords:

removable partial denture metal framework, finite element method, stress distribution, PMMA, 3D geometry

Introduction

Dental techniques offer many ways to restore lost dentition. One of this is a removable partial metal framework. This denture consists of a metal framework with clasps on abutment teeth, acrylic denture base plate (which is a reconstruction of alveolar process bone and gingiva) and acrylic artificial teeth. This kind of restoration is more durable than full acrylic one. Moreover, thanks to the metal framework- the whole denture takes up less space. However, in the case of single incisor (upper or lower), it causes problems too. Less space is equal to the smaller amount of acrylic resin for the base plate which means the worst surrounding tooth by PMMA. Finally, it leads to breaking off the tooth from base plate [1]. So, dental technician tries some ways to improve this connection. One on it grooves in the central part of the acrylic tooth to leak in the acrylic resin of base plate. In past research was checked the existence of groove with no groove by used numerical analysis and its influence on stress distribution and deformations [2] and the results show that made groove does not affect considerably on change of stress distribution and deformations. However, to achieve

more details results created geometry was modified and analyzed. The most important thing was the influence of the shape of the base plate on deformations and stress distribution.

Methods

Creation of 3D geometry

To compare were created two 3D models in SpaceClaim module of the ANSYS program (Ansys Inc., Canonsburg, USA). Both consist of the same single upper incisor (shape based on [3]). Other elements differed regarding curvature whole geometry. The first model was simplified one—that is why base plate and metal framework were straight like in case of the model I on Fig. 3.

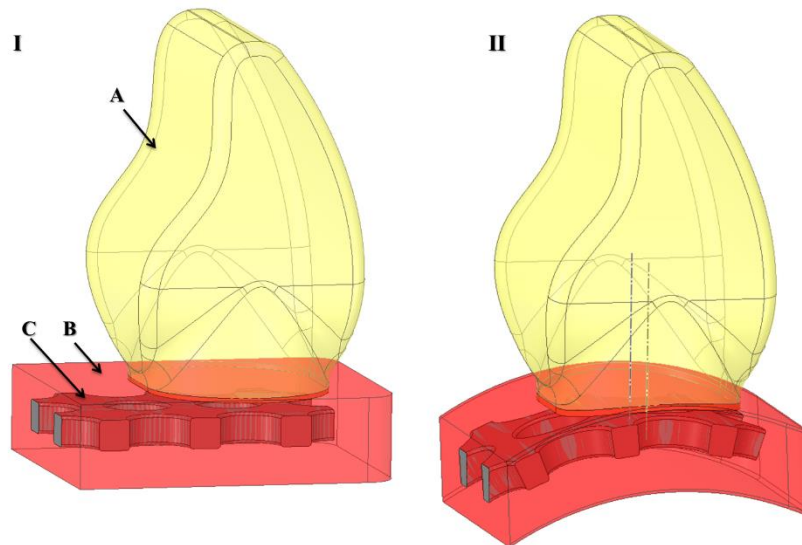


Fig. 3. Created 3D geometry: I) with the straight base plate, II) with the curved base plate.
Elements of both models: A) artificial tooth, B) denture base plate, C) metal framework
Source: own picture

Second (II) model was prepared to meet the case of real conditions. So geometry of base plate and metal framework were curved — curvature based on a scan of the patient's gypsum model. The first area of the alveolar process was separated. Then the curved plane was created based on the curve of this area. Finally, whole geometry of base plate and metal framework was prepared (model II on Fig. 3).

Dimensions of the metal framework and base plate based on literature [4]. The most critical part was an area of base plate between framework and tooth because this is a region where acrylic resin can be the smaller amount.

Numerical analysis

Created geometries have been checked by numeric analysis in ANSYS program for this purpose mesh was created based on solid bodies of geometry. All mesh elements were in quadratic order. On every body were used element sizing with 0,2 mm dimensions. Because these geometries were very complicated- final mesh had tetrahedrons shape. Additionally, on the area of contact tooth with the base plate was used refinement, to improve the accuracy of results. Finished mesh (Fig. 4) had almost 850 000 elements in excellent quality (deformation of elements was checked with elements quality option of the program).

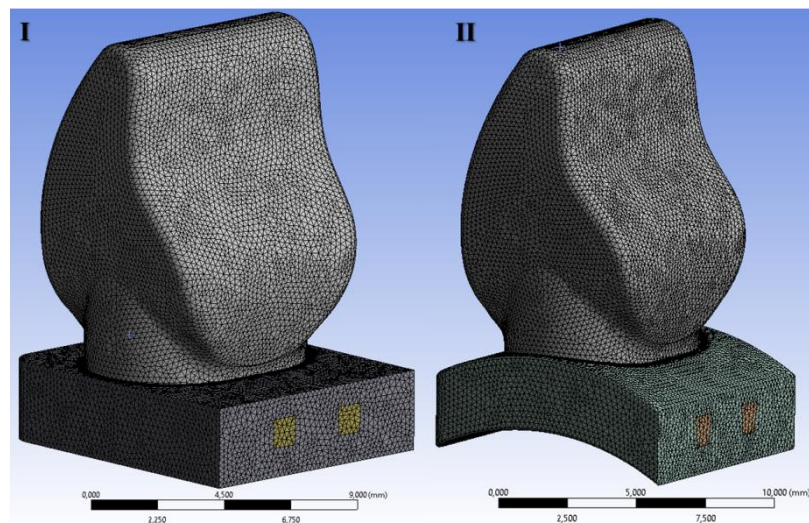


Fig. 4. Created mesh in case of geometry with: I) straight base plate, II) curved base plate
 Source: own picture

Numerical analysis was started from created connections between all bodies. So, like in natural conditions- between tooth and base plate was bonded connection and between base plate and framework- it was bonded too. Next were created boundary conditions like in Fig. 5:

- Fixed support was added in at the intersection of the prosthesis.
- On the area of the base plate, which in natural conditions is connected to alveolar process- was added remote displacement. It causes that selected part cannot move on Y-axis. This kind of support was the same in both simulations.
- The only load was different depending on the type of simulation. In first one load was added on the area of incisor edge at a 10° angle. In the case of the second type of simulations, the load was added on side surfaces of the tooth like on Fig. 5. That analysis was a simulation of the peel of a tooth from the base plate. Value of both loads was 120 N. That is a maximum force with which human could bite [5].

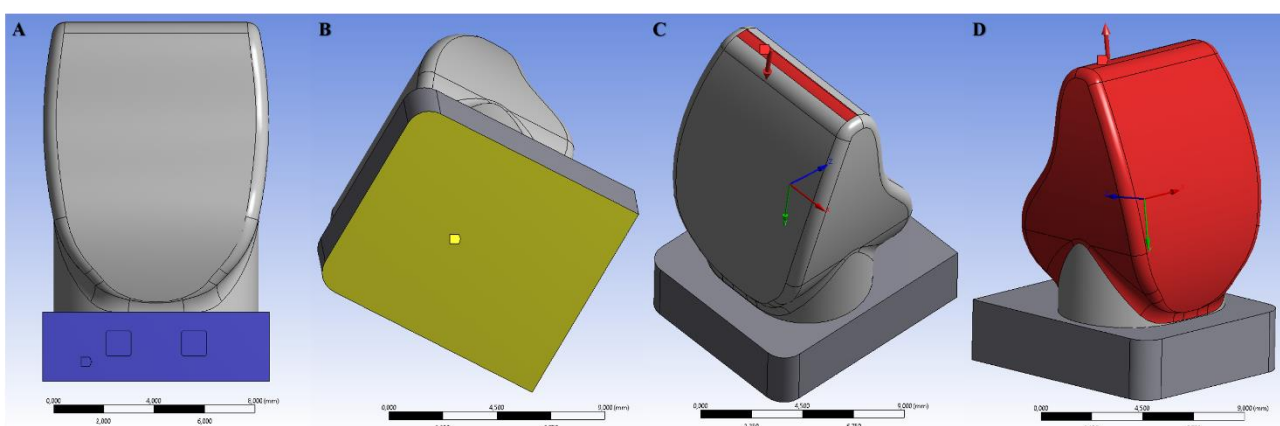


Fig. 5. Created boundary conditions: A) fixed support, B) remote displacement,
 C) force in case of first simulations, D) force in case of second simulations
 Source: own picture

In Tab. 4 are all materials with their properties used to all simulations. Tooth and base plate are made of PMMA slightly different in properties value. Metal framework usually is made of CO-Cr-Mo metal alloy produce specially for this kind of prosthetic restoration.

Tab. 4. Materials used in the analysis and their properties values based on a literature review moreover, examined by nanoindenter (marked as *)

PROPERTIES	UNIT	MATERIAL VALUE					
		PMMA (base plate)		PMMA (tooth)		Co-Cr-Mo	
		value	source	value	source	value	source
Density	g/cm ³	1,19	[6]	1,19	[6]	8,2	[7]
Young's Modulus	MPa	2 940,00	[6]	4 760,30	*	230 000,00	[7]
Poisson's Ratio	-	0,44	[6]	0,44	[8]	0,29	[9]
Yield Strength	MPa	51,70	[6]	51,70	[6]	720,00	[7]
Tensile Strength	MPa	58,50	[6]	58,50	[6]	960,00	[7]
Compressive Yield Strength	MPa	81,40	[6]	81,40	[6]	1 847,00	[10]

Results

The results were obtained as a graphic representation of total deformations and stress distribution with their values. Final results were used stress representation by von Mises's strength hypothesis. It was chosen, because most authors [11-15] analyzing the strength of PMMA connections with other materials used this kind of hypothesis.

On Fig. 6 and Fig. 7 are shown stress distributions in case of first and second simulations.

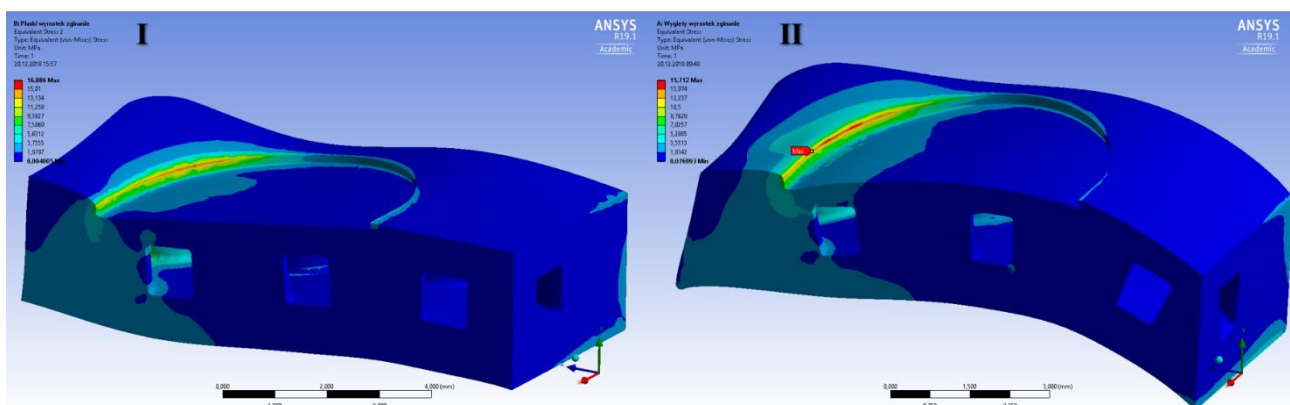


Fig. 6. Stress distribution in case of first simulations in denture base plate of geometry with:
 I) straight base plate, II) curved base plate.

Source: own picture

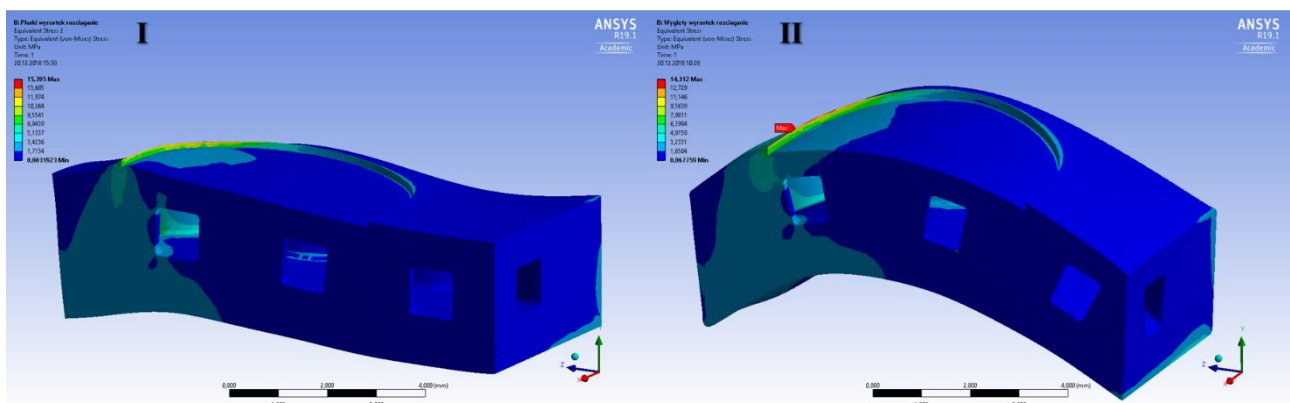


Fig. 7. Stress distribution in case of second simulations in denture base plate of geometry with:
 I) straight base plate, II) curved base plate

Source: own picture

On Fig. 8 and Fig. 9 are shown deformations in case of first and second simulations.

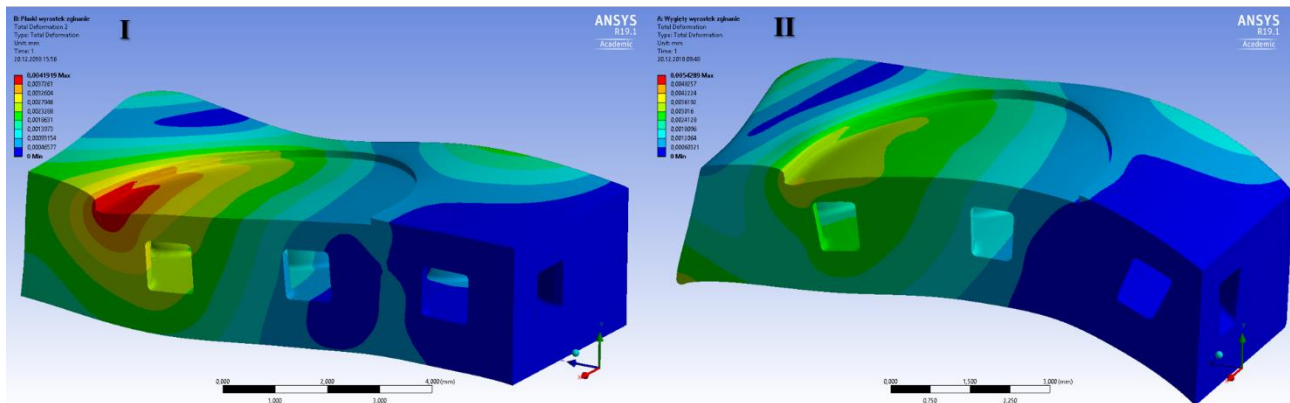


Fig. 8. Deformations in case of first simulations in denture base plate of geometry with:
I) straight base plate, II) curved base plate
Source: own picture

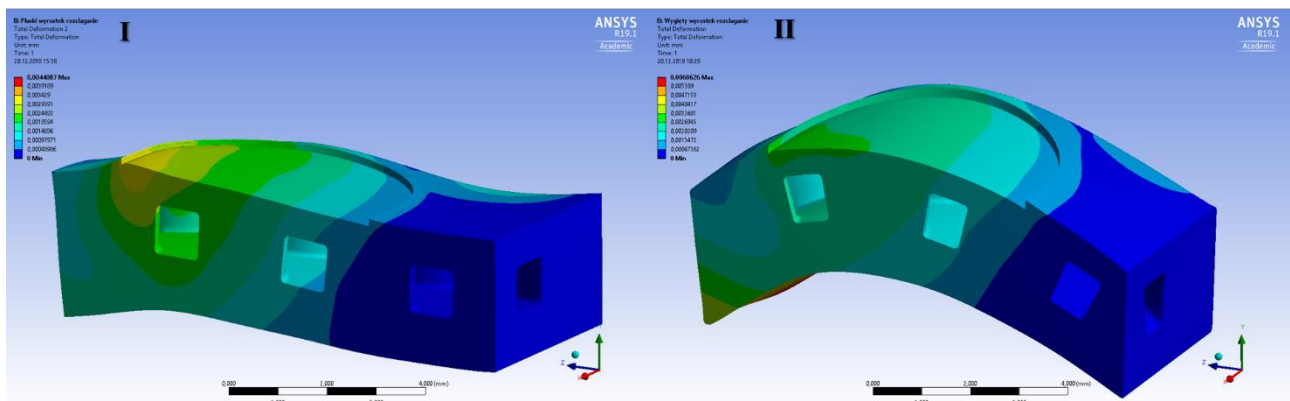


Fig. 9. Deformations in case of second simulations in denture base plate of geometry with:
I) straight base plate, II) curved base plate
Source: own picture

The distribution of the most considerable deformations and stresses was very similar in all tests. Summary values of gained highest results are in Tab. 5.

Tab. 5. Maximum values of deformations and stress distributions

SHAPE OF BASE PLATE	MAX VALUES OF DEFORMATIONS [mm]		MAX VALUES OF STRESS [MPa]	
	FIRST SIMULATION	SECOND SIMULATION	FIRST SIMULATION	SECOND SIMULATION
straight	0,004	0,004	16,9	15,4
curved	0,005	0,006	15,7	14,3

Obtained values of deformations and stresses slightly differed. Because of the curved shape of the base plate- deformations value were higher. However, stress values, in this case, were lower.

Conclusions

Based on past research [1, 2] and results obtained in this simulations it can be concluded that the curve of the base plate has little influence on stress distribution and deformations. More critical

are stress distributions and their values, because fracture may occur in places of greatest stress. So curved base plate is more like in natural conditions, that means in the patient mouth the stresses are slightly larger than in the initial simulations. It is therefore recommended for performing future tests on non-simplified models. Higher importance it could have in case of fatigue analysis, and this is the topic of the author's future research.

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