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ResearchArticle

Prediction of Heart Attack Using Fuzzy Logic Method and Determination of Factors Affecting Heart Attacks

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Abstract:

As a result of the researches, it has been revealed that heart attack is the number one cause of death in the world. This problem will continue to increase, especially today and in the future. In this study, a heart attack was predicted by considering the factors affecting heart attack. Due to the uncertain conditions in heart attack, the fuzzy logic method, which is frequently used in healthcare, was used and expert opinions were taken into account in the model created. 576 rules were defined using the Mamdani fuzzy inference method. The study was tested with 10 patient data and the results were compared with the actual values. In addition, multiple regression analysis was performed, variables that had a significant effect on heart attack were determined, and the relationship between dependent and independent variables was examined. It was shown in the study that dependent variables explained the independent variable by 41.9% thanks to the multiple regression analysis. The regression equation obtained in line with these results significantly predicted the heart attack and the effect levels of the independent variables were determined.

1. Introduction

When a sudden blockage occurs in the arteries feeding the heart for any reason, the heart muscle cannot get enough oxygen and causes damage to the heart tissue. Substances such as fat and cholesterol accumulate in the artery walls responsible for blood flow and form structures called plaques. These plaques multiply as time passes and cause cracks on them by narrowing the vessels. Clots occur in these cracks, occlude the vessels and cause a heart attack [1].Tobacco use, excessive alcohol consumption, high cholesterol and fat, age (men over 40, women over 50), diabetes, obesity, use of illegal drugs, high blood pressure, chronic high levels of stress, previous heart attack, arrhythmia are important risk factors [2,3,4]. The risk of heart attack increases after the age of 40 in men and 50 in women, and women are less likely to have a heart attack than men [1]. Among family members, people who have had a previous heart attack or have a history of heart disease, the elderly and men are more likely to have a heart attack than other risk factors [5]. The main symptom seen in a heart attack is heart pain in the chest. Apart from this area, pain is felt everywhere from the stomach to the jaw or teeth, from the shoulder blade to the right and left arm, fingers and wrists. Symptoms such as shortness of breath, excessive sweating, dizziness, nausea or vomiting, restlessness, and feeling of depression may be experienced [1,6,7]. The World Health Organization (WHO) states that heart disease is the # 1 cause of death worldwide. Approximately 17 million people die from these diseases each year, representing 31% of global deaths. 85% of these deaths are caused by heart attack and stroke [8]. WHO stated that 36% of deaths that will occur in 2020 will be caused by heart diseases [9]. In addition, WHO stated that heart diseases increase the risk of Covid-19. According to a recent study, it was revealed that 43% of those with Covid-19 in Spain have heart disease [10]. In the Turkey Statistical Institute (TSI) in total deaths, according

to the measurement data, it is observed that the increasing trend of heart disease. Heart diseases are in the first place among the total deaths with 40% in 1989, 45% in 1993, 40% in 2009, 39.6% in 2013 and 40.4% in 2014.In 2030, it is estimated that cardiovascular diseases will be 22.2 million [11]. Considering the mortality rates due to heart diseases, it is seen that our country ranks first among European countries [12]. Many studies have been conducted in the literature concerning many factors that cause heart disease. Fuzzy logic is one of these studies. The concept of fuzzy logic was introduced by Zadeh in 1965 [13]. Fuzzy logic, which is a control system, is in the form of range to point or range to interval [13]. Kumar and Kaur (2013) created a fuzzy model for heart disease risk prediction using the Mamdani inference method [14]. Lee and Wang (2011) conducted a study on diabetes using fuzzy expert system[15]. Rustempasic and Can (2013) tried to diagnose Parkinson's disease using the fuzzy C-mean clustering method and pattern recognition method [16]. Samuel, Omisore, and Ojokoh (2013) conducted a study diagnosing typhoid fever using fuzzy logic [17]. Biouki, Turksen, and FazelZarandi (2015) diagnosed Thyroid disease using fuzzy expert system [18]. Thakur, Raw, and Sharma (2016) diagnosed Thalassemia using the Mamdani fuzzy inference system [19]. Saikia and Dutta (2016) predicted dengue disease using fuzzy inference system [20]. Apart from these studies, many studies have been conducted in the literature as a result of the increase in mortality rates due to heart diseases. Different techniques were used in these studies. Torun (2007) designed a hierarchical fuzzy expert system to determine the patient's risk of coronary heart disease [21]. The 10-year risk of the patient was determined in the study. As a result of the study, the risk ratio was given to the user and the treatment method was recommended. Palaniappan and Awang (2008) developed a prototype heart disease prediction system using data mining techniques (decision trees, pure Bayesian and neural network) [22]. Patil and Kumaraswamy (2009) proposed a system that predicts heart attack using a multilayer perceptron neural network [23]. Adeli and Neshat (2010) designed a fuzzy system with 13 inputs and conducted a study to reveal heart disease, and as a result of this study, they reached 94% accuracy [24]. Bhatla and Kiran (2012) conducted a study to diagnose heart diseases using data mining and fuzzy modeling[25]. Devi and Anto (2014) conducted a study to diagnose coronary artery disease by designing a fuzzy expert system [26]. A smart health system has been proposed for heart disease prediction using deep learning and fusion approaches [27]. In this study, it was tried to predict heart attack by using fuzzy logic method. While establishing the model, seven input data and one output data were used. Entries; Exercise-induced St depression (oldpeak) according to age, gender, type of chest pain (Cp), cholesterol, fasting blood glucose (Fbs), exercise-induced pain (Exang) and rest. The desired output is heart attack prediction. Afterwards, the variables that had a significant effect on heart attack were determined by performing regression analysis and the results obtained were interpreted. In the second part of the study, fuzzy logic method is explained, application is made in third parts, and the conclusion part is included in the fourth part.

2. Material and Method

The concept of fuzzy logic was first introduced in 1965 by Prof. Dr Zadeh [13]. It emerged with the "FuzySets" article published by Lotfi A. Zadeh [13,21].Using the data related to the study to be conducted and at the same time benefiting from the professional experiences of the people, processing the obtained data with algorithms and using mathematical equations depending on the rules to be written is defined as "Fuzzy Logic" [28,29,30].
Classical set theory and fuzzy set theory are different from each other. While {0,1} notation is used in classical sets, the interval [0-1] is used in fuzzy sets. Because in classical set theory, an entity is either an element of that set or it is not. In fuzzy set theory, each entity receives a membership degree in the range [0-1].Membership degrees are indicated by membership function μ (x) [31]. According to this information, the membership degree of element x in fuzzy set A is,

$$\mu A(x): x \rightarrow [0,1] \text{ ie } 0 \leq \mu A \leq 1$$

shown in the form. The expression $\mu A = 0$ indicates that the x element does not belong to the fuzzy A set, and the expression $\mu A = 1$ indicates that the x element belongs to the fuzzy A set [32].

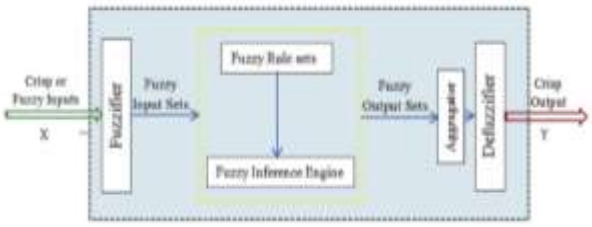

Figure 1. *General structure of the fuzzy logic model [33].*

The general structure of the fuzzy logic model is given in Figure 1. It consists of four components. These are: blur, rule base, inference engine, and clarification.

1. Blurring: Converts the input values to fuzzy values using the membership function. This process varies according to the membership function [21].
2. Rule Base: It is the relationship between inputs and outputs using various operators (fuzzy and implication operators) and interpreting the rules [34].
3. Inference Engine: In this section, rules based on rules are interpreted and fuzzy outputs are created [35].
4. Clarification: Incoming blurred information is clarified and converted into numbers [36].

First, entries are blurred using membership functions. Using fuzzy input and output values, fuzzy rules to be used in the solution of the problem are created and inference is performed with these rules. Finally, fuzzy information is clarified and turned into numbers [29]. Fuzzy logic has found wide application in many areas. The reason for this is the easy and useful solution-finding approach it provides in solving problems [37].It has been the subject of many fields such as medicine, manufacturing and engineering [38]. Another reason for its use in large areas is that it can model uncertain events, unclear data and functions by using expert opinions [39].Fuzzy logic is very important in the field of health, so it has many applications in medicine [40]. Problems are solved by using fuzzy sets for unclear conditions in medicine [41].

3. Results

This study was conducted using fuzzy logic in line with the data obtained from Kaggle. Fuzzy Logic Model was created using 7 input parameters and 1 output parameter, and it was estimated whether individuals would have a heart attack or not. Input parameters are St depression induced by exercise according to age, sex, type of chest pain, cholesterol, fasting blood glucose, exercise-induced pain, and listening. The output parameter is the heart attack prediction. All inputs are factors that will affect a heart attack. Input and output parameters are shown in Table 1. Triangle membership function (trimf) was used for age, gender, Chol, Fbs, Exang, Oldpeak and Heart attack prediction variables, and trapezoidal membership function (trapmf) was used for Cp variable. Since each variable is divided into classes within itself, the classes are expressed with linguistic variables when creating membership functions. Table 2 shows linguistic variables. Membership functions of the input parameters are shown from Figure 2 to Figure 8. In Figure 9, membership function of output parameter is given. In this study, Mamdani's Max-Min fuzzy inference method was used [42]. Centroid (Center of Gravity Method) method was used in the defuzzification stage.

Table 1. *Input and output parameters and their meanings*

Parameters	Meanings
Age	It is divided into 3 classes as young, middle-aged and elderly.
Gender	Men and women
Cp	It is divided into 4 classes: Typical pain, Atypical pain, No pain, and Asymptomatic pain.
Chol	It is divided into 3 classes as low, medium and high.
Fbs	It is divided into 2 classes as normal and high.
Exang	It means pain induced by exercise. It is divided into 2 classes: no pain and pain.
Oldpeak	It is ST depression induced by exercise compared to listening. It is divided into 2 classes as 2 mm below and 2 mm above.
Heart Attack Prediction	Output parameter. It is divided into two classes. Heart attack and heart attack proof

Table 2. *Classification of parameters*

Parameters	Linguistic variables
Age	40 years and under → Young 40–60 age → Middle age 60 years and older → Old
Cinsiyet	0=Woman 1=Man
Cp	0 = Typical pain, 1 = Atypical pain, 2 = No pain, 3 = Non-symptomatic pain
Chol	200 and below → Low 200 - 240 → Medium 240 and above → High
Fbs	125 and below → Normal 126 and above → High
Exang	0= No 1= Yes
Oldpeak	2 mm and under → 2 mm bottom 2 mm and older → 2 mm top
Heart attack prediction	0=No 1=Yes

First, the data were taken from Kaggle and the input and output parameters to be used in the study were determined. Limit values, linguistic variables and membership functions of these parameters have been created. In order to create the rule base, a relationship between input and output has been established and transferred to the Rule Editor section on the Fuzzy interface. The total number of rules created is 576. After the rule bases are created in the Rule Editor section, the rule index can be seen graphically thanks to the inference screen in the fuzzy interface (Figure 10).

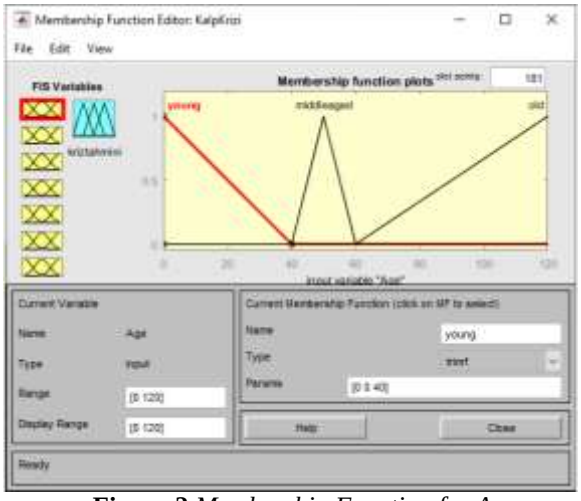

Figure 2.*Membership Function for Age*

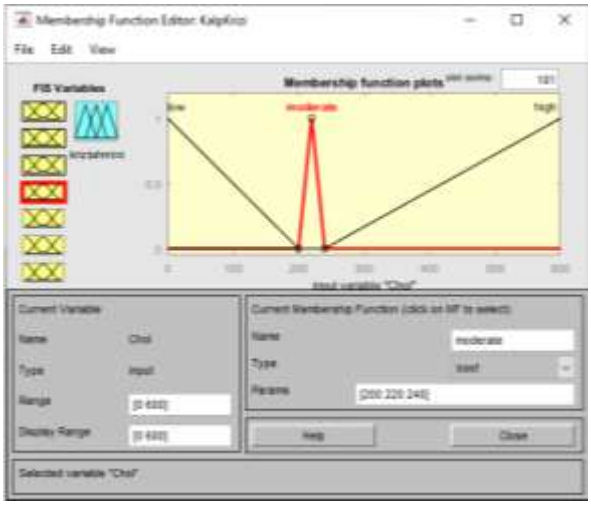

Figure 5. *Membership Function for chol*

Figure 3.*Membership Function for gender*

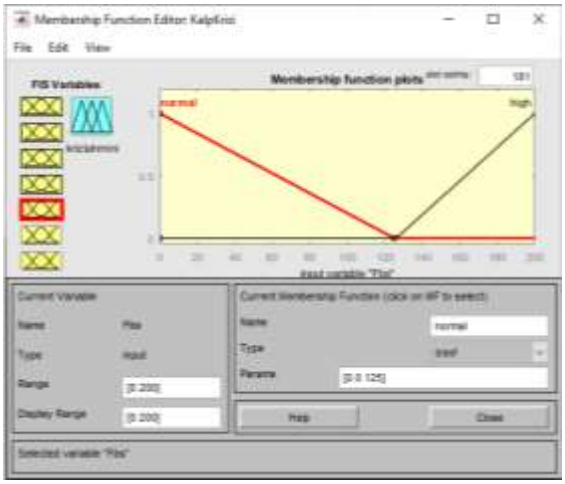

Figure 6. *Membership Function for Fbs*

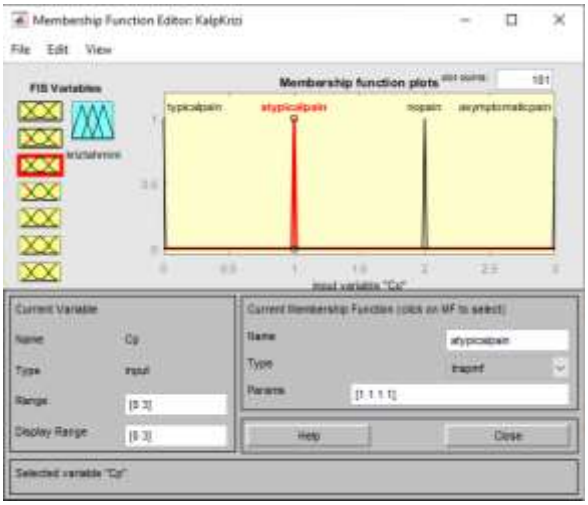

Figure 4. *Membership Function for Cp*

Figure 7. *Membership Function for Exang*

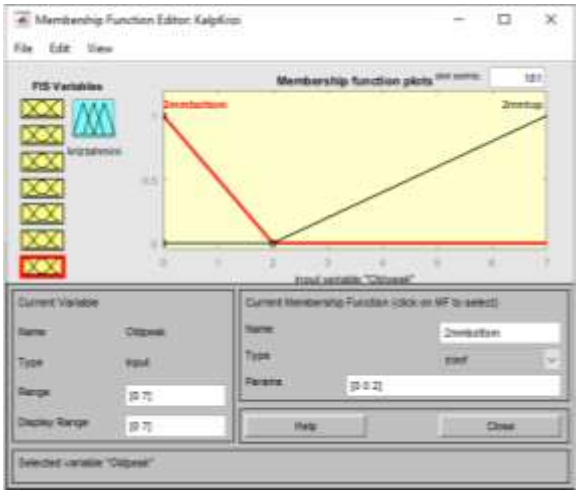

Figure 8. *Membership Function for old peak*

Figure 9.*Heart attack Fuzzy Logic Output*

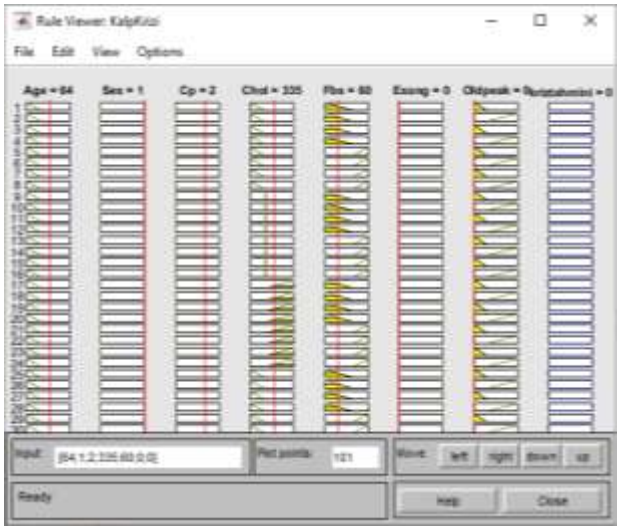

Figure 10. *Inference Screen*

Thanks to the data entered in the inference screen, whether the individual will have a heart attack or not can be seen in 0 or 1 format. 10 patient input data and heart attack prediction.

It is shown in Table 3.According to the results of the trial performed for 10 patients with the developed fuzzy logic model, all data were correctly estimated.

3.1. Regression Analysis

Table 3. *Input data and heart attack prediction for 10 patients*

No	Age	sex	Cp	Chol	Fbs	Exang	Oldpeak	Heart Attack real data	Heart Attack Prediction
1	63	1	3	233	135	0	2.3	1	1
2	57	0	1	236	110	0	0	0	0
3	37	1	2	250	72	0	3.5	1	1
4	52	1	2	199	127	0	0.5	1	1
5	44	1	0	120	56	1	2.8	0	0
6	61	1	0	203	85	0	0	0	0
7	71	0	2	265	140	0	0	1	1
8	43	1	0	177	120	1	2.5	0	0
9	64	1	2	335	60	0	0	0	0
10	45	0	0	236	80	1	0.2	1	1

The technique used to examine the relationship between dependent and independent variables is called Regression Analysis [43].

The value of the dependent variable is estimated by using the known values of the independent variables [44].

First, a heart attack prediction was made using fuzzy logic model. Then, multiple regression analysis was performed using dependent (output parameter) and independent variables (input parameters).In Table 4, variables entered in the model are shown in the Variables Entered column. It was stated that a heart attack was predicted using the data obtained from the variables entered.

Table 4. *"VariablesEntered / Removed" results*

VariablesEntered/Removed[a]			
Model	**Variables Entered**	**Variables Removed**	**Method**
1	oldpeak, fbs, chol, cp, sex, age, exang[b]	.	Enter

a. DependentVariable: kalpkrizi

b. Allrequestedvariablesentered.

Table 5 shows the multiple correlation value (R), how much the input values explain the variance of the heart attack prediction (R Square), the estimated standard error (Std. Error of the Estimate). It is seen that dependent variables determined according to Table 5 explain the independent variable at a rate of 41.9%. Table 6 Sig. Since its value is below 0.05, the regression equation obtained as a result of this analysis significantly predicts the heart attack. Table 7 shows the average value, standard deviation and sample number of each variable. Looking at the "Standardized Coefficients Beta"

Table 5. *Model Summary table*

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	,658[a]	,433	,419	,380

a. Preictors: (Constant), oldpeak , fbs, chol , cp , sex , Age , exan

Table 6 *Anova test results*

ANOVA[a]					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	32,505	7	4,644	32,123	,000[b]
Residual	42,644	295	0,145		
Total	75,149	302			

a. DependentVariable: kalpkrizi

b. Predictors: (Constant), oldpeak , fbs, chol , cp , sex , Age , exang

value in Table 8, the independent variables can be arranged in order of impact level. A one-unit increase in the Cp value takes the first place in the effect level because it causes an increase of 0.294 in the standard deviation of the heart attack prediction. Since a one-unit increase in Oldpeak value will cause a 0.277 decrease in the standard deviation of the heart attack estimate, it is in the last place in the effect level. By making this interpretation in other variables, the effect level order was determined as Cp, Fbs, Chol, Age, Exang, Sex, Oldpeak.

Table 7. *"Descriptive Statistics" results*

DescriptiveStatistics

	Mean	**Std. Deviation**	**N**
kalpkrizi	,54	,499	303
Age	54,37	9,082	303
sex	,68	,466	303
cp	,97	1,032	303
chol	246,26	51,831	303
fbs	,15	,356	303
exang	,33	,470	303
oldpeak	1,040	1,1611	303

Table 8. *"Coefficients" results*

Coefficients[a]												
Model	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**95,0% Confidence Inter val for B**		**Correlations**			**Collinearity Statistics**	
	B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**	**Zero-order**	**Partial**	**Part**	**Tolerance**	**VIF**
(Constant)	1,309	,171		7,658	,000	,972	1,645					
Age	-,008	,003	-,138	-2,974	,003	-,013	-,003	-,225	-,171	-,130	,892	1,122
sex	-,252	,049	-,236	-5,161	,000	-,349	-,156	-,281	-,288	-,226	,922	1,084
cp	,142	,023	,294	6,112	,000	,096	,188	,434	,335	,268	,829	1,206
chol	,000	,000	-,052	-1,129	,260	-,001	,000	-,085	-,066	-,049	,915	1,093
fbs	-,030	,062	-,021	-,478	,633	-,153	,093	-,028	-,028	-,021	,967	1,034
exang	-,202	,053	-,190	-3,812	,000	-,306	-,098	-,437	-,217	-,167	,775	1,291
oldpeak	-,119	,020	-,277	-5,920	,000	-,159	-,080	-,431	-,326	-,260	,876	1,142

a. DependentVariable: kalpkrizi

4. Conclusion

Heart attack is a very common health problem worldwide. According to researches, the number 1 cause of deaths is heart attack. Therefore, many studies have been done in the literature and are still being done. Different techniques were used in these studies. Artificial neural networks, data mining, fuzzy logic, deep learning are just a few of these techniques.

In this study, the fuzzy logic method, which is widely used in the diagnosis, treatment and risk estimation of many diseases in the field of health, was used.7 input parameters and 1 output parameter were used and a fuzzy model was created. At the end of the study, the data of 10 patients were shown in the model and whether they would have a heart attack or not was given as an output. Multiple regression analysis was conducted to determine the effect of other independent variables on the prediction of heart attack, which is the dependent variable, and to examine the relationship between them. According to the regression results, it is seen that the fuzzy logic equation significantly predicts the heart attack.

In the future, it is expected that studies will be carried out on different diseases using fuzzy logic method. In line with these studies, fuzzy logic will be of vital importance by increasing efficiency in health services and will become a powerful tool.

Author Statements:

- The authors declare that they have equal right on this paper.
- The authors declare that they have no known competing financial interests or personal

relationships that could have appeared to influence the work reported in this paper

- The authors declare that they have no-one to acknowledge.

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Research Article

Sol-gel Preparation of Silane-based Zirconia Hybrid Thin Film

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Coating
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Abstract:

The sol-gel process is an innovative advanced method, initially developed to synthesize glass and ceramics at low temperature. The sol-gel process can be used to synthesize materials with various of shapes, such as porous membranes, thin fibers, nano-size powders and thin films. In this study, epoxy and methacrylate-based silane coupling agents are used together with zirconium oxide to form a hybrid coating system on the glass surface. In the experimental study, an organic–inorganic molecular hybrid compound was prepared by the sol-gel method. Glasses were cleaned by traditional piranha solution (3:1 H_2SO_4: H_2O_2) to remove contaminants. Silanization was applied to increase the adhesion of hybrid coatings on glass substrates. Glass substrate was coated with this solution by a homemade dip-coater. (3-Glycidoxypropyltrimethoxysilane, GLYMO and 3-(trimethoxysilyl) propylmethacrylate, TMSPM) were chosen as a silane. Zirconia is an inorganic component of hybrid materials. Coated samples were characterized by Fourier Transform Infrared Spectrophotometer (FTIR), Scanning Electron Microscope with Energy Dispersive X-ray Spectroscopy (SEM-EDX), and Contact Angle Goniometer.

1. Introduction

Zirconia (ZrO_2) is an innovatively essential ceramic material. Technological importance of ZrO_2 is due to physical and mechanical properties. ZrO_2 has polymorphism properties, high dielectric constant and wide band gap.

$$\underset{\text{Monoclinic}}{(m\text{-}ZrO_2)} \xrightarrow[(1370\ ^\circ C)]{} \underset{\text{tetragonal}}{(t\text{-}ZrO_2)} \xrightarrow[(1900–2300\ ^\circ C)]{} \underset{\text{cubic phases}}{(c\text{-}ZrO_2)}$$

m-ZrO_2 is stable at temperatures below 1170 °C [1,2]. Amorph and crystalline ZrO_2 are synthesized by different methods such as sol-gel, CVD, PVD, sputtering, anodization etc. [3]. A mixture of organic and inorganic polymer materials is defined as hybrid materials. They have been receiving considerable attention in many technological applications [4]. This combination in the same material creates new properties in terms of mechanical, electrical, physical or optical properties. They contribute to the increase of scratch resistance, UV resistance, durability, hydrophobicity or hydrophilicity, easy to clean property and flexibility of the coating surfaces [5]. Nowadays, there are numerous thin film coating methods. The sol-gel method is one of the most widely applied methods, since it is easy, cheap, and handy. The sol-gel method is an appropriate method for obtaining both inorganic and hybrid inorganic-organic polymers [6].

2. Materials and Method

3-Glycidoxypropyl-trimethoxysilane (GLYMO, $C_9H_{20}O_5Si$ >=98%), 3-aminopropyl-Triethoxysilane (3-APTES, $H_2N(CH_2)_3Si(OC_2H_5)_3$,

>=98%), and 3-(trimethoxysilyl) propylmethacrylate, (TMSPM, $H_2C=C(CH_3)CO_2(CH_2)_3Si(OCH_3)_3$) 2-propanol (IPA, $(CH_3)_3COH$, >99%), Sulfuric acid (H_2SO_4, 95-97%), and hydrogen peroxide (H_2O_2, 30%) were purchased from Sigma-Aldrich and used directly, without further purification. Zirconium dioxide (Degussa P25, 21 nm) nano-particles were purchased Sigma-Aldrich. Chemical structure of silanes is shown in Fig. 1.

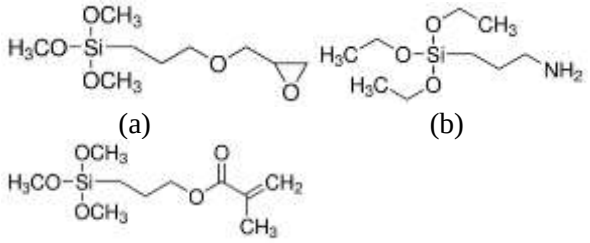

Figure 1. *Chemical structure of the a) 3-GLYMO, b) 3-APTES and c) TMSPM*

To clean glasses surfaces, they were dipped to piranha solution. The piranha solution is a mixture of H_2SO_4:H_2O_2 (5:1). Because it is a strong oxidant, it removes metals and organic contaminants from surfaces. Silanization solution was prepared by dissolving 0.5 g of 3-APTES in 50 mL isopropyl alcohol. GLYMO and TMSPM were mixed with deionized water and 2-propanol in two different beakers. Zirconium oxide nanoparticles were added and mixed the silane solutions for 1 hour. Then modified solution was coated on a glass sheet by dip coater at 80°C for four times.

3. Results and Discussion

3.1. FT-IR Analysis

FT-IR analysis was performed to identify the structure of silane based oxide coatings by using a Spectrophotometer (Shimadzu IR Prestige-21). As shown in Figure 2, the band at ~1050 cm^{-1} which is characteristic for –Si–O–C bond is observed. A characteristic band at 1460 cm^{-1}, which is for Zr-OH bonds vibrations [7]. Sharp bands, at 1510 cm^{-1} and 1560 $cm^{-1,}$ which are for –C=(O)–NH–.The two bands of OH groups appear at 3300 and 1650 cm^{-1} because of hydrolysis of the Si–O–Me groups [8 ,9].

3.2. SEM Analysis

The morphology and thickness of silane-based oxide coatings were determined from SEM (Leo 1430 VP) images of cross-section of coatings. As shown in Figure 3, SEM images look very similar, independently of the silane type.

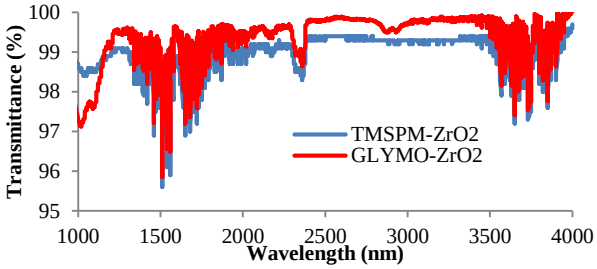

Figure 2. *FT-IR Analysis of silane-based zirconiumoxide coatings.*

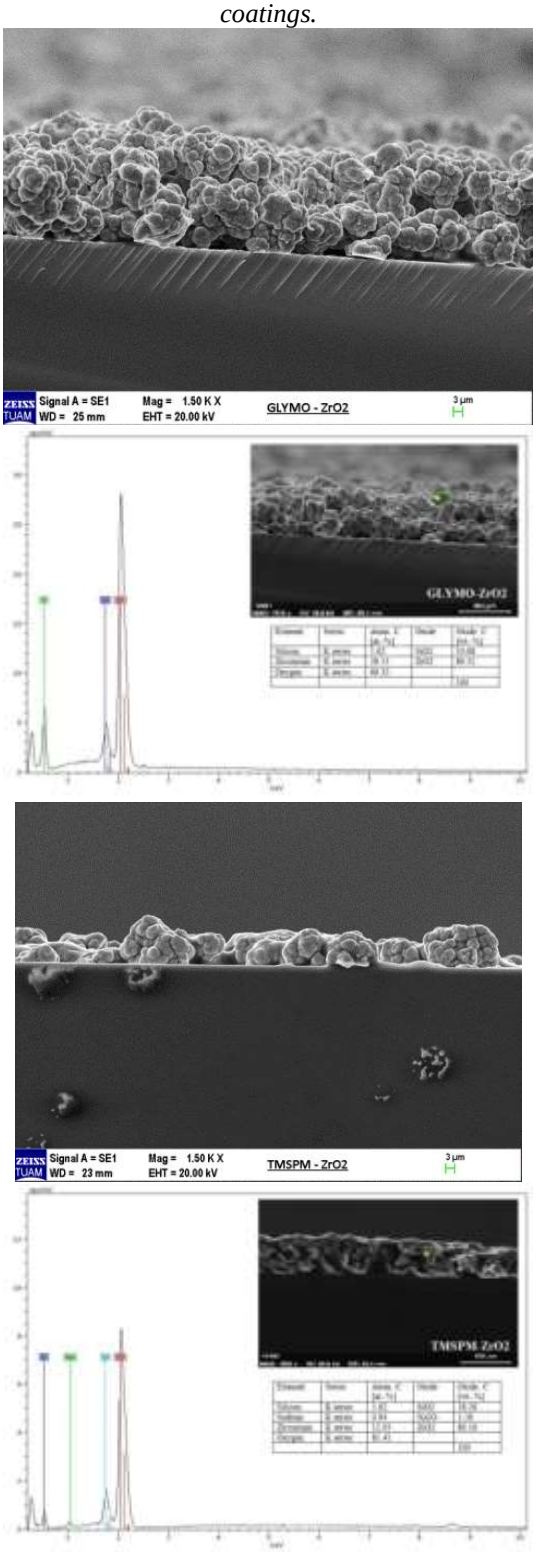

Figure 3. *SEM and EDX images of silane based oxide coatings.*

There are spherical crystallites on the surface [7]. SEM-EDX Analysis prove zirconium and oxygen element on the surface.

3.3. Contact Angles Measurements

Contact angle (CA) was utilized to determine the wettability of the silane-based zirconium oxide coatings. CA was determined by KSV Attention Theta Lite TL 101. As shown in Figure 4, CA results are 92° and 103° for GLYMO-ZrO_2 and TMSPM-ZrO_2, respectively. They have a hydrophobic character [3]. This indicates a stronger effect of the organic groups (CH_3, CH_2) on the CA values than the surface roughness of coatings [7, 10].

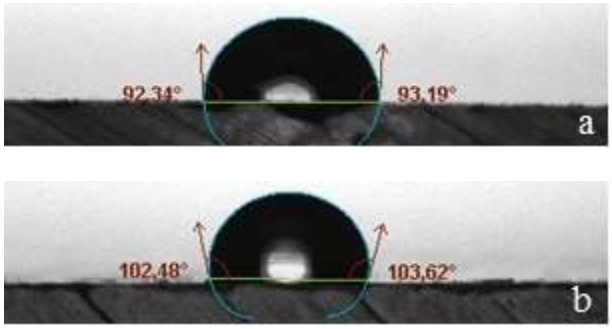

Figure 4. *Contact angles measurements of silane-based oxide coatings a) GLYMO-ZrO_2 and b) TMSPM-ZrO_2.*

3.4. Band Gap

The optical band gap of silane-based oxide coatings was calculated by Tauc's method. Experimentally, it was determined graphic of $(\alpha h\nu)^2$ versus the photon energy ($h\nu$). It shows that the plotting gives a straight slope in at a certain point [11,12]. The optical band gaps are given in table 1. Optical band gaps are lower than the values reported in the literaure (4.87-5.10 eV)[2].

Table 1. *The optic band gap of silane based oxide coatings.*

Silane type	**Band Gap eV**
GLYMO-ZrO_2	3.68
TMSPM-ZrO_2	3.62

4. Conclusion

Silane-based ZrO_2 thin films were successfully prepared at low temperature by the sol-gel process. Thin films thickness were between 10 and 15 µm. FT-IR results show that silane coupling agents were hydrolysed and attached to the surface. Surfaces of coating were smooth and homogenous. Contact angles of silane-based ZrO_2 coatings were proved hydrophobic structure. Optical band gaps of thin film were obtained as 3.68 and 3.62 eV for GLYMO-ZrO_2 and TMSPM-ZrO_2, respectively.

Author Statements:

- The authors declare that they have equal right on this paper.
- The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- The authors declare that they have no-one to acknowledge.

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ResearchArticle

Evaluation of the Relationship Between Service Quality and Patient Satisfaction in Hospitals: Case of Acibadem Hospital

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Service Quality,
Health Care,
Customer Satisfaction

Abstract:

The service offering of the sector worldwide and in Turkey remain significant contribution to national income. When we look at the sectors that provide health services in particular, the contribution made in economic growth due to the increase in the life expectancy all over the world and technological advances increased the importance of quality in health services. The place of quality in the field of health has quite different qualities compared to other sectors. There is human life in the health services sector. In this context, the quality of the service provided is the most important factor affecting customer satisfaction. In this study, the effects of the quality of service provided in health services on customer satisfaction were investigated. The sample of this study consists of 300 people selected by simple random sampling method among the patients receiving service at Acıbadem Hospital. As a result of the research, it was noted that there is a significant and positive relationship between patient satisfaction and perceived quality. In addition, it was determined that perceived quality varies according to marital status, age and income level. Also, it has been determined that patient satisfaction varies according to age, income level and the unit whose service is evaluated.

1. Introduction

Although marketing is widely used in the service sector, this is considered new for the healthcare sector. However, more and more rich and developing activities are encountered. Therefore, the issue of service and service marketing attracts attention, and the rapid growth and progress seen in the field of service around the world has also made organizations interested in this field. The first goal of marketing in health care organizations; to provide more qualified services to consumers in order to meet consumer expectations in a timely and accurate manner and to achieve the objectives of the organization. However, the ability of marketing to achieve this goal is becoming more difficult in the health sector as well as in other areas. The factors affecting patient satisfaction in the delivery of health services become more and more complex over time. The development of technology, competition of organizations with each other, increasing the level of social well-being, easy access to information about health, and the differentiation of consumers' desires and needs over time have forced some innovations in health care. Health care organizations should listen to the expectations of customers and society in order to survive in the market, make a profit and gain a competitive advantage. It is possible to increase the satisfaction of health service recipients by evaluating the quality of health care. The aim of this research is to establish the relationship between patient satisfaction and perceived quality. Another purpose of the study is to reveal whether patient satisfaction and perceived quality differ significantly according to socio-demographic variables.

1.1 Quality of Service in Health

It is seen that the concept of service is used quite widely in many areas. However, various

definitions that refer to the concept of service appear. The Service is basically intangible, that is, the activity or benefit that an organization or person offers to others. As a result, it doesn't result in ownership of anything [1]. Service is a system that solves or facilitates often intangible problems arising from customers' lives. The service is a whole of activities and benefits made in this context [2]. In another definition, the service; benefits that consumers buy without having anything to do with property [3]. The service consists of satisfactions in the routine lives of individuals that they cannot give up in any way. On the other hand, there has been a phenomenon of service since the existence of man. Services are elements that provide spiritual satisfaction beyond providing material satisfaction to individuals. It is clear that the transferred service definitions are close in meaning. In general, the service, regardless of the sale of goods or services, are actions that saturate desires and requirements when launched and can be characterized independently [4]. In this era, companies that produce services attach great importance to the issue of quality like other companies. With the quality of the service provided, companies aim to achieve growth in market share by increasing their competitive levels. Quality provides a positive image on the customer base. Considering that it is difficult to reach new customers and retain existing customers, ensuring customer satisfaction and loyalty is realized by providing quality service [5]. The concept of quality generally evokes the quality of what is offered in goods and services. However, in determining the quality, factors such as the quality of the person, the leader, the administration, the system, the hardware should also be taken into account. The quality of anything, good or bad, defines quality. But for better or worse, it differs according to the needs and expectations of individuals. Therefore, when the concept of quality is approached in terms of management, it is seen that a goods or service offered is capable of responding to the requirements and expectations of consumers [6]. The quality of service is how much the service meets consumer expectations. The degree to which the activities presented to the end buyer meet the expectations is the most important criterion that determines the level of service quality. If the perceived quality and the expected quality remain at a very low level compared to the expected quality, then the customer will not get enough satisfaction and his satisfaction will decrease [7].

In determining the quality of service in companies, the service perceived by consumers and the thoughts that arise as a result are of great importance. In a company, the main factor in improving the quality of service is the quality of service and the measurement of the reactions of the buyers according to this performance. It is also seen that there is a high risk of failure in programs aimed at improving the quality of service. Companies that provide services often enter the quality improvement process by offering a variety of incentives to retain customers they can't be satisfied with [8]. Looking at the findings of the research carried out by James [9], it is seen that the quality improvement efforts in American hospitals to date are concentrated in the areas of management and support services in general. However, there has not been much initiative related to total quality management in medical services. James found that physicians should also strive for quality. For this, it is essential to know how to ensure quality first. In the first step of dealing with other areas of hospital services, doctors need to eliminate their concerns about quality. However, it is also useful to make a certain payment for the time that the doctor will devote to studies that are not directly related to clinical services. James underlined that doctors need to fully embrace these processes in order to maintain order in the diagnosis and treatment processes. All these are measures that should be applied in terms of quality in ensuring customer satisfaction within hospital services. Businesses that provide health care are seen as a service area among service enterprises. As of today, there is continuous improvement in health care delivery both in the world and in Turkey and new understandings are being proposed. As a result of all these developments and innovations, the importance of health services has started to be clearly understood. It is seen that health care providers are separated from other service enterprises in terms of being life-threatening due to the fact that their main basis is human and therefore public health. The main purpose of health service delivery is to meet the needs of the person and indirectly the society and the desired health services in a unique way to the person and in the desired time; to ensure that it is benefited at the least cost. At this point, it is also understood how important the quality of service is in the organizations that provide health care. Ever-changing technology, knowledge, cost increases, the rise in patient complaints and the desire for good care make healthcare much more complex. At the same time, it is not enough today that only services are widespread, maintained and accessible. It has also become important how satisfied people are with these widespread, continuous and accessible services [10]. High-quality service is "the service that is expected to maximize a comprehensive measure of the patient's well-being once the balance of expected values and losses is calculated at all stages within the service process," said Avedis

Donabedian, a leading figure in shaping the quality approach in healthcare [11]. The issues expressed as characteristics of quality in health services are as follows [11];

Efficacy, when used under optimal conditions, is the ability of health care science and technology to make improvements in the field of health. "If it is not possible to determine the most favorable conditions, he instead used the term "under certain conditions".

Effectiveness, is the level of real access to improvements that are already accessible in health. This requires comparison between the performance in reality and the targeted performance in the field of health care in a scientific and technological sense, ideally or under certain conditions.

Efficiency, is the ability to reduce the cost of service without reducing accessible improvements in healthcare.

Optimality, is a balancing act with the improvements in health and the cost of these improvements. This also means that there is a "best" or "optimal" point between the costs and benefits of health care. Below the point mentioned, more benefits can be obtained at a lower cost than the benefit, and on top of that, additional benefits are obtained at a very cost compared to the benefit.

Acceptability, is explained in the form of conformity to the desires and expectations of individuals and their families. There are five elements of acceptability. These are the ones that are going to accessibility, the relationship between the patient and the healthcare provider, the comforting aspects of the service offered, the preferences of patients regarding the effects, risks and costs of the service, and everything that patients define as accurate and fair.

Legitimacy, is expressed in the form of compliance with social preferences described as moral values, principles, norms, laws and regulations. In summary, it is social acceptability.

Equity, is compliance with the principle that determines what is right or just in the division of the benefits of health services provided among members of society. Fairness is part of what makes service adoptable and socially legal for individuals. The fairness feature is so important that it is treated as a separate feature in terms of quality.

The quality of health care should not be considered unilaterally. Quality in health services requires the protection of the rights of the receiving party as well as the meeting of the needs of the service servers. Uninterrupted training and professional development of health care providers should be taken into account during the service delivery process. If this training and development is not provided and not configured, it is impossible to talk about patient satisfaction and public health at this point if it is not possible to talk about the cooperation of service servers and health administrators when it comes to the lack of infrastructure and tools that are essential at the point of service delivery. In the same way, solving problems, mutual respect and trust, receiving and evaluating feedback is also essential. In the absence of all these counts, the system cannot repay such exceptional efforts. Therefore, to underline once again, deficiencies make it impossible to talk about quality, patient satisfaction, public health and vitality in health services. It seems that a lot of work falls on health managers and decision makers in terms of duties and responsibilities when it comes to quality and satisfaction [12].

1.2 Customer Satisfaction

Customer satisfaction is, by general definition, the positive attitude developed by customers as a result of the evaluation of their experience following their use of the product or service. The basis of customer satisfaction is that the performance of the company can respond to customer expectations and even exceed its expectations [13]. Customer satisfaction/ dissatisfaction should not be considered as part of the product or service. This concept is the perception that the customer has uploaded about the product and service in an individual sense. Therefore, since the customers are different, their satisfaction will also differ when they encounter the same service [14]. A customer's perception of product/service is influenced by their individual experiences, social and economic situation, cultural environment, values, education level, beliefs, mental state and attitudes generated by using the data obtained through various communication channels. Customers' perceptions of the product or service affect purchasing behavior. These perceptions also directly and indirectly affect customer satisfaction [15]. Many studies on customer satisfaction have shown that the factors given below seriously affect patient satisfaction. In the field of health services, it is possible to list the factors affecting customer (patient) satisfaction as follows [16]. Employee Patient Interaction: Hospitals that provide health care work as a team. Quality service is the responsibility of all those who work within the hospital. If a lack or irregularity occurs in part of the

service offered or in one of the team providing the service, the perception of these problems by customers, i.e. patients, affects the remaining areas. In this case, the image of the hospital is most negatively affected. No matter how advanced the technology develops, the quality of service will be poor when the human resources available do not have satisfactory characteristics in terms of quality.

Doctor's Behavior: When evaluating the quality of the service in the medical services provided to patients, behaviors such as listening, taking time to be sensitive, kindness and respect are taken into consideration rather than the expert knowledge of the physician. The behavior of the physician affects patient satisfaction as well as the effectiveness of the service offered. In case of a positive relationship between patient and doctor interaction, patients do not take a break from their treatment by following the doctor's recommendations.

Nurse-Patient Interaction: In the provision of health services, the main function of nurses is to help the healthy or sick person. The assistance to be provided covers activities aimed at maintaining the healthy life of the healthy individual and capturing the knowledge, expectations and strength necessary for the patient to regain his health.

Information: Informing the patient and his/her family by the physician causes them to be able to meet their disease situations in a more understanding way. It is the condition that the patient is most interested in and he wonders how long he will remain this way, he wants to know what type of treatment processes will be applied. Informing patients about their health also affects patient satisfaction.

Nutrition Services: Another point that influences patient satisfaction is nutrition services according to the researches. Patients are affected not only by the quality of the food, but also by the staff who give the food, the presentation and appearance of the food. If there is no problem in the presentation of the food given to the patient, they tend to evaluate this food as quality.

Physical and Environmental Conditions: The physical conditions of hospitals inside and outside are one of the issues that people care about very much. It also affects satisfaction. Inadequate room conditions, an untreated hospital are among the issues that patients complain about the most. It is also the most important element of customer dissatisfaction. The physical environment of the place of service is of great importance for consumers to give the tips they were looking for before purchasing the service.

Bureaucracy: One of the most important issues affecting patient satisfaction is bureaucracy-based barriers in the hospital. This situation causes a waste of time and long-term waits during the procedures. For many hospitals, hospitalizations and discharges of patients are a problem due to the long wait of the patients and their relatives. It is observed that patients experience unhappiness and dissatisfaction due to wasting time.

Trust: The short time to adapt to an environment in which the patient feels alienated is closely related to the patient feeling safe. Trusting the medical care and treatment, hospital team and environment from the hospital is an important issue in the satisfaction of patients.

It is possible to think about the concepts of patient satisfaction and customer satisfaction in parallel with each other. Customer satisfaction is conceptualized as "patient satisfaction" by researchers in the field of health care [17] patient satisfaction is also the result of many variables. However, what the researchers focus on most in defining the concept is the differences between the patient's expectations before receiving the service and their perception of the service after receiving it. The concept of patient satisfaction is considered as a basic criterion in patient care quality. According to Yılmaz (2001), demographic factors such as age, gender and education level are effective in patient satisfaction [18]. However, the dimensions of this effect have produced different results in different studies. Patient satisfaction; has a profitability-enhancing effect. However, positive communication is very important for healthcare businesses as they have positive outcomes such as patient loyalty. Patient satisfaction for healthcare providers; it provides many more positive results such as ensuring patient loyalty by retaining the general population, positive communication from mouth to mouth and high profitability, and increasing the patient's tendency to follow the recommendations of the physician. In this case, the satisfaction of the patient with the service provided reduces costs and increases the sense of trust as it also reveals a commitment. All this leads to an increase in the number of patients in the hospital. As seen in many studies, customer (patient) satisfaction in health institutions contributes significantly to the occurence of loyal customers. Increasing the patient's confidence in where they receive health care and their faith in treatment leads to an increase in the number of customers (patients) by giving

positive advice to potential customers. All these results make customer (patient) satisfaction an important issue for healthcare businesses [19]. It makes a comparison between the expectations of the patients receiving health care and the ones they encounter. The receiving party, that is, the patient, reaches a level of satisfaction in relation to the perception of the health service offered. When this level and the diagnostic and treatment services offered by the institution are combined, the perception of quality arises. This situation increases the preference and advisability of the institution by other people and may lead to the opposite preference and non-recommendation [20]. Patients are the recipients of the service. Since health is one of the most important issues in the lives of individuals, patients are more careful due to their conditions than services provided in other sectors related to the service provided. Patients also want to be more serious about their choices and pay for what they pay. Here, too, the way the health care provider perceives the service is very important. If the patient is satisfied with the treatment service he receives, he will try to fulfill what is asked to be done during the treatment period in order to recover. Positive behaviors are exhibited to patients who are satisfied with the service provided, ensuring that the patient carefully follows the recommendations of the doctor and other remaining health workers. Satisfied patients exhibit much better behaviors in their treatment processes. They follow the medications given or the recommendations related to the treatment. The basic rights of patients are to receive good and high quality service. When patients apply to a health institution for health problems, they do not know what to face. Therefore, they act anxiously. Since they are not psychologically good, the attitudes and behaviors of the employees in the place of service may also affect patients positively or negatively.

The aim of this research is to establish the relationship between patient satisfaction and perceived quality. Another purpose of the study is to reveal whether patient satisfaction and perceived quality differ significantly according to socio-demographic variables.

2. Material and Method

Within the scope of this research, two problem sentences were developed. The first problem sentence is "Is there a relationship between perceived quality and patient satisfaction?" The second problem sentence was created as "Does perceived quality and patient satisfaction differ significantly according to socio-demographic variables?". This research is limited to patients receiving services from Acıbadem Hospital. In addition, it is limited to the questionnaire used to collect data.

In this research, in which the relational screening model is preferred, the relationship between patient satisfaction and perceived quality was revealed. In other words, the association between patient satisfaction, which is dependent variable, and perceived quality, which is an argument, has led to the preference of a relational screening model in the research. There are a total of 28 questions in the survey. While the personal information contained in these questions was prepared by the researcher, the Patient Satisfaction Scale was taken from the studies of Araz (2019) [21] and the Perceived Quality Scale was taken from the studies of Yeşilyurt (2018)[22].

The universe of this research is made up of patients receiving services at Acıbadem Hospital. The research sample consists of 300 people to be selected by simple random sampling method among the patients. In the selection of the sample determined in the study, the sample diameter was selected as 95% reliability and 5% sensitivity. The surveys were delivered to the participants in a face-to-face manner. In the answering of the questionnaires, questions that would reveal personal information such as first and last names from the patients were not included. Thus, patients were provided with a sincere answer to the questions within the questionnaire.

Data from the survey application is resolved in SPSS 25.0. Accordingly, correlation analysis was performed in the determination of a relationship between patient satisfaction and perceived quality. In addition, the Mann-Whitney U test in binary variables in determining whether there is a significant difference between some demographic characteristics of the participants and perceived quality and patient satisfaction; Kruskal-Wallis H test was applied in more than two variables.

3. Results

The results of the reliability and normality analysis of the scales used in the research are presented in Table 1. According to the results of the analysis, it was revealed that the expressions that reveal patient satisfaction are very reliable and the expressions that reveal the perceived quality are highly reliable. In addition, the Kolmogorov-Smirnov and Shapiro-Wilk values of both scales. It was understood that they did not show a normal

distribution due to being larger than 05 and therefore non-parametric tests were applied in the research. Descriptive statistics on the demographic characteristics of the participants are presented in Table 2. When looking at the gender of the participants, 55.7% were women, 72.3% were married and 37.7% were 36-45 years old; It turned out that 53% had a bachelor's degree and 46% had an income of 3001-4000 TL. All respondents to the survey received services from internal medicine, urology, ENT, dermatology, orthopedics and children's outpatient clinics in an equal level (50 people each). 80.3% of the participants stated that the procedures took an average of 1-3 hours when they went to the hospital to get health care. Descriptive statistics on the scales used in the research are presented in Table 3. As shown in Table 3, I am generally undecided on patient satisfaction statements, i.e. moderate participation; I agree with the statements regarding the perceived quality, that is, it has turned out that there is a positive turnout. The results of correlation analysis between perceived quality and patient satisfaction are presented in Table 4. Accordingly, it has been revealed that there is a positive and moderate relationship between perceived quality and patient satisfaction. This result indicates a linear relationship between perceived quality and patient satisfaction. In other words, as the perceived quality increases, patient satisfaction will increase in the same direction. The results of the difference tests to determine whether perceived quality and patient satisfaction differ by gender are presented in Table 5. According to the results, perceived quality and patient satisfaction do not differ by gender ($p>0.05$).

The results of the difference tests to determine whether the perceived quality and patient satisfaction differ according to marital status are presented in Table 6. According to the results, patient satisfaction does not differ according to marital status ($p>0.05$). In addition, it was found that there was a significant difference between the perceived quality according to the marital status variable ($p<0.05$). It turns out that the perceived quality levels of married people are higher than singles.

The results of the difference tests to determine whether the perceived quality and patient satisfaction differ by age are presented in Table 7. As a result of the Kruskal-Wallis H tests, it was revealed that both variables differed significantly by age ($p<0.05$). As a result of Hochberg's GT2 test, which was carried out to determine which groups the difference between patient satisfaction and age was between; It turned out that there was a difference between the satisfaction of those aged 26-35 and those under 25 and those aged 46-55. As a result of the multiple comparison tests between the perceived quality and age of the participants, it was found that there was a difference between the quality perceived by those aged 56 and over and the quality perceived by those aged 26-35, 36-45 and 46-55 years.

The results of the difference tests to determine whether the perceived quality and patient satisfaction differ according to the level of education are presented in Table 8. As a result of the Kruskal-Wallis H tests, it was determined that neither variable differed significantly according to the level of education ($p>0.05$).

The results of the difference tests to determine whether the perceived quality and patient satisfaction differ according to the income level are presented in Table 9. As a result of the Kruskal-Wallis H tests, it was determined that both variables differed significantly according to income level ($p<0.05$). Hochberg's GT2 test, which was conducted to determine which groups have the difference between perceived quality and income level, revealed a significant difference between the quality perceived by those with incomes between 2001-3000 TL and the quality perceived by those with incomes of TL 3001-4000 and TL 4001 and above. In addition, it has been revealed that there is a significant difference between the quality perceived by those with incomes of TL 4001 and above and the quality perceived by those with incomes between 3001-4000 TL.

The results of the difference tests to determine whether the perceived quality and patient satisfaction differ according to the unit whose service is evaluated are presented in Table 10. Within the framework of the analysis results, it was determined that patient satisfaction differed significantly ($p<0.05$) compared to the unit whose service was evaluated, but the perceived quality did not differ significantly ($p>0.05$). According to the unit whose service was evaluated, patient satisfaction was found to be a significant difference between the satisfaction of those who received services from the children's outpatient clinic and the satisfaction of those serving from the department of internal affairs, urology and dermatology as a result of the Tukey multiple comparison test.

The results of the difference tests to determine whether the perceived quality and patient satisfaction differ according to the duration of the service provided are presented in Table 11. According to the results, both variables differed significantly according to the duration of the service

provided ($p<0.05$). Here, it was found that the satisfaction and perceived quality of the patients who went to the hospital to get health care between 1-3 hours were higher than those who lasted less than 1 hour.

Table 1 *Reliability and Normality Analysis Results*

Scale	Cronbach's Alpha Multiples	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistics	df	p	Statistics	df	p
Patient Satisfaction	.70	,158	300	,000	,952	300	,000
Perceived Quality	.88	,145	300	,000	,938	300	,000

Table 2 *Demographics of Participants*

Variable	Group	N	%
Gender	Woman	167	55,7
	Male	133	44,3
Marital Status	Married	217	72,3
	Single	83	27,7
Age	25 years and under	17	5,7
	26-35 age	108	36,0
	36-45 age	113	37,7
	46-55 age	43	14,3
	56 years and older	19	6,3
Education Level	Secondary	33	11,0
	Associate Degree	68	22,7
	University	159	53,0
	Master	40	13,3
Salary Level	2001-3000 TL	39	13,0
	3001-4000 TL	138	46,0
	4001 TL and Up	123	41,0
Unit Evaluated Service	Internal Medicine	50	16,7
	Urology	50	16,7
	Ear-Nose-Throat	50	16,7
	Dermatology	50	16,7
	Orthopedics	50	16,7
	Pediatrics	50	16,7
Duration of Service Provided	Less than 1 hour	59	19,7
	1-3 hours	241	80,3

Table 3 *Average and Standard Deviation Results of Scales*

Scale	N	Average	Standard Deviation
Patient Satisfaction	300	3,19	,328
Perceived Quality	300	3,63	,384

.***Table 4*** *Correlation Analysis Results*

			Patient Satisfaction	Perceived Quality
Spearman's rho	Patient Satisfaction	r	1,000	,609**
		p	.	,000
	Perceived Quality	r	,609**	1,000
		p	,000	.
**. Correlation is significant at 0.01.				

Table 5 *Gender Difference Test Results*

Variable	Gender	N	Sequential Average	Sequential Totals	Mann-Whitney U	p
Patient Satisfaction	Woman	167	147,98	24713,00	10685,000	,57
	Male	133	153,66	20437,00		
Perceived Quality	Woman	167	150,45	25125,00	11097,00	10,0
	Male	133	150,56	20025,00		

Table 6 *Difference Test Results by Marital Status*

Variable	Gender	N	Sequential Average	Sequential Totals	Mann-Whitney U	p
Patient Satisfaction	Married	217	153,71	33355,50	8308,500	,30
	Single	83	142,10	11794,50		
Perceived Quality	Married	217	157,80	34243,50	7420,500	,02
	Single	83	131,40	10906,50		

Table 7 *Age Difference Test Results*

Kruskal-Wallis H Test						Hochberg's GT2 test
Variable	Age	N	Sequential Average	Kruskal-Wallis H	p	
Patient Satisfaction	(1) 25 under	17	200,82	20,232	,00	2 < 1 * 2 < 4 *
	(2) 26-35 age	108	131,64			
	(3) 36-45 age	113	143,51			
	(4) 46-55 age	43	184,17			
	(5) 56 over	19	178,03			
Perceived Quality	(1) 25 under	17	175,41	15,350	,00	5 > 2 ** 5 > 3* 5 > 4**
	(2) 26-35 age	108	138,48			
	(3) 36-45 age	113	156,23			
	(4) 46-55 age	43	129,76			
	(5) 56 over	19	209,39			

* p<0,05; ** p<0,01

Table 8 *Difference Test Results by Education Level*

Kruskal-Wallis H Test						Hochberg's GT2 test
Variable	Education Level	N	Sequential Average	Kruskal-Wallis H	p	
Patient Satisfaction	(1) Secondary Education	33	163,82	5,981	,11	
	(2) Associate Degree	68	134,24			
	(3) University	159	158,66			
	(4) Master	40	134,73			
Perceived Quality	(1) Secondary Education	33	155,23	2,835	,42	
	(2) Associate Degree	68	150,00			
	(3) University	159	154,95			
	(4) Master	40	129,76			

* p<0,05; ** p<0,01

Table 9 *Difference Test Results by Income Level*

Kruskal-Wallis H Test	

Variable	Salary Level	N	Sequential Average	Kruskal-Wallis H	p	Hochberg's GT2 test
Patient Satisfaction	(1) 2001-3000 TL	39	208,56	21,482	,00	1 > 2** 1 > 3** 2 > 3**
	(2) 3001-4000 TL	138	136,50			
	(3) 4001 TL and over	123	147,79			
Perceived Quality	(1) 2001-3000 TL	39	213,26	26,698	,00	1 > 2** 1 > 3**
	(2) 3001-4000 TL	138	149,83			
	(3) 4001 TL and over	123	131,35			

* p<0,05; ** p<0,01

Table 10 *Difference Test Results by Unit Evaluated*

Kruskal-Wallis H Testi						Tukey Test
Variable	Unit Evaluated Service	N	Sequential Average	Kruskal-Wallis H	p	
Patient Satisfaction	(1) Internal Medicine	50	136,55	18,137	,00	6 < 1 ** 6 < 2 6 < 3 **
	(2) Urology	50	133,29			
	(3) Ear-Nose-Throat	50	116,92			
	(4) Dermatology	50	131,78			
	(5) Orthopedics	50	108,96			
	(6) Pediatrics	50	111,21			
Perceived Quality	(1) Internal Medicine	50	141,02	8,556	,13	
	(2) Urology	50	114,03			
	(3) Ear-Nose-Throat	50	121,96			
	(4) Dermatology	50	137,70			
	(5) Orthopedics	50	112,79			
	(6) Pediatrics	50	167,65			

* p<0,05; ** p<0,01

Table 11 *Difference Test Results by Duration of The Service Provided*

Variable	Time	N	Sequential Average	Sequential Totals	Mann-Whitney U	p
Patient Satisfaction	Less than 1 hour	59	129,08	7615,50	5845,500	,03
	1-3 hours	241	155,74	37534,50		
Perceived Quality	Less than 1 hour	59	98,46	5809,00	4039,000	,00
	1-3 hours	241	163,24	39341,00		

4. Conclusions

This study was carried out in order to determine the relationship between the satisfaction of the patients receiving services from Acıbadem hospital and the quality levels they perceived. As a result of the analysis, it was recorded that there is a meaningful and positive relationship between patient satisfaction and perceived quality. In Araz's (2019) study, it was observed that the perceived quality of service has a positive relationship with patient satisfaction [21].

In the study, it was found that there was no significant difference between perceived quality and patient satisfaction by gender. In the study, in which Tükel and his colleagues (2004) examined the satisfaction levels of patients who were treated and discharged in bed, differentiation was found between the satisfaction levels of the participants according to their gender [23]. In the study conducted by Uyar (2014), it was found that there was a significant difference between the perception of service quality by the gender of the participants

[24]. In this study, it was found that women's perception of quality of service was higher than that of men.

Another finding obtained in the study found that there was no significant difference between patient satisfaction and marital status, while there was a significant difference between perceived quality. In this section, it turned out that the perceived quality levels of married people were higher than singles. In the study conducted by Şişe and Altinel (2012), it was determined that patient satisfaction differed according to marital status and that single patients had a lower level of satisfaction than married or widowed patients [25]. In the study conducted by Öz and Uyar (2014), it was found that the perceived quality of service according to the marital status variable did not differ significantly [24].

Another finding of the study revealed a significant difference between age and patient satisfaction and perceived quality. This result is similar to the work done by Araz (2019) [21].

In another finding, it was found that there was no significant difference between patient satisfaction and perceived quality according to the level of education. This result contrasts with the work of Araz (2019) [21]. As a matter of fact, in his study, Araz stated that there is a significant difference between the level of education and the perceived quality of education and that the level of perception of the quality of service in this difference is in the participants who have graduated from high school. In Mohammad's (2007) study, there was no significant difference of 0.05 between perceived quality of service and level of education [26].

In the study, it was revealed that patient satisfaction and perceived quality differed significantly in the context of income level variable. While the study of Hekimoğlu and his colleagues (2015) [27] found that patient satisfaction differed according to income level, no significant difference was detected in the study conducted by Dölek and his colleagues (2005) [28]. Uyar's (2014) study of health enterprises found that there was no significant difference between participants' income levels and perceived quality of service [24].

Finally, patient satisfaction differs significantly according to the unit whose service is evaluated, but the perceived quality does not differ significantly; according to the duration of the service provided, it turned out to differ significantly. In order to talk about efficacy and efficiency in health care, the health of people and society in a broad sense is the most important indicator to ensure the continuity of this good behavior. The most important indicator of the development levels of the countries is that the health services provided to the people living in that society are included in a certain measure. It is also important whether the resources used in this field are used effectively. When Turkey is discussed in this regard, it is seen that the issue of quality in the presentation of health services has been taken into account in a period of the last ten years. In general, it is obvious that the quality of health care provided must meet a certain standard.

Rapid change and development in the field of health has also caused the technology and treatment methods used to change. At this point, health expenses have increased. Therefore, the competition of health care organizations has become apparent. The intensification of competition conditions has raised the issue of customer satisfaction. In the literature review, it is seen that those who are satisfied with the health service they receive in general and those who are not share these feelings and thoughts with others. As of today, the measurement of patient (customer) satisfaction is aimed not only at seeing satisfaction with the service provided to patients, but also to evaluate the performance of health institutions. Health service providers have had to pay attention to quality in service and customer satisfaction indirectly in order to survive in the sector and to be long-lasting in intensifying competitive conditions. The modern marketing approach focuses on the customer. The customer in the health sector is sick. At this point, the new understanding in the health sector is to gain new customers after the retention of existing customers in the service offered first. As a result, the relationship between customer satisfaction and customer loyalty and the factors affecting them have become critical for healthcare management. In the provision of health care, only the quality health service provided by the doctor or the correct approach to the patient is not enough. The presentation of health services from the caregiver to the admissions officer should be seen as a team effort. A negative behavior that will occur in the process from the first entry to the exit of the patient will have a negative effect on satisfaction. Although the service does not have a material quality, it is defined as a product that has the ability to meet the needs of its users. In other words, it is an economic activity that provides service, space, shape and psychological benefit [29]. In addition to being abstract, the service has a number of features

such as inability to stock, intancurable, transferable to someone else, and simultaneous production and consumption [30]. Quality, on the other hand, can be defined as a feature of the service or product and the benefit it provides other than the characteristics of the goods or services received for the purpose of meeting the request and need [11]. Based on the description of the service and quality concepts, the quality of service is related to the degree to which the customer is satisfied with the service provided [31]. The quality of service can also be defined as the best delivery of the service provided in line with the needs of the customer. The service that the customer perceives creates the quality of the service [32]. Customer potential increases relative to the quality of the service provided. Therefore, it is important to demonstrate the perceived quality of service. It has been shown that customer satisfaction increases in the same direction with the increase in perceived service quality in the researches [33]. As a result of the results obtained in the research and the examination of the field paper, some recommendations were developed. Based on the fact that the research takes place only in the case of Acıbadem Hospital, research can be done on different sample masses at the point of generality. The variables covered within the scope of the research were evaluated by quantitative research method, and qualitative methods such as interviews or focus group interviews can be used in subsequent researches. In the research, the relationship between patient satisfaction and perceived quality was revealed. Future research can determine whether this level of satisfaction and perceived quality has any effect on employees' perception of performance.

Author Statements:

- The authors declare that they have equal right on this paper.
- The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- The authors declare that they have no-one to acknowledge.

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Research Article

Sol-gel Preparation of Silane-based Titania Hybrid Composite Thin Film

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Abstract:

In this study, epoxy and methacrylate-based silane coupling agents are used together with titanium oxide to form a hybrid coating system on the glass surface. In the experimental study, an organic–inorganic molecular hybrid compound was prepared by sol-gel method. First glasses were cleaned by traditional piranha solution (3:1 H_2SO_4: H_2O_2) to remove contaminants. In order to improve the adhesion of hybrid coatings on glass substrates silanization treatment was applied. Silanization solution was prepared by dissolving 1 g 3-aminopropyl-Triethoxysilane (3-APTES) in 100 mL 2-propanol. Glass substrates were coated with this solution using a dip-coater. Silanes (3-Glycidoxypropyltrimethoxysilane, GLYMO and 3-(trimethoxysilyl) propylmethacrylate, TMSPM or MEMO) were mixed deionized water and 2-propanol. Titanium oxide was added and mixed the silane solutions for 1 hour. The resultant solution was coated on a glass sheet by dip coater with heater. After evaporation of solvents, coated samples were characterized by Fourier Transform Infrared Spectrophotometer (FTIR), Scanning Electron Microscope with Energy Dispersive X-ray Spectroscopy (SEM-EDX) and Contact Angle Goniometer.

1. Introduction

Functional hybrid composite coatings have many desirable properties for a wide range of technological and industrial applications [1,2]. Hybrid organic-inorganic composite coatings can be prepared by the sol-gel method and offer many excellent technical advantages [3]. The sol-gel process is a wet-chemical technique also known advanced coating method [4]. In hybrid coatings, silane compounds are used as an organic component [5]. TiO_2 thin films are important materials in nanotechnology [6].

2. Materials and Method

3-Glycidoxypropyl-trimethoxysilane (GLYMO, GPTMS, $C_9H_{20}O_5Si$ >=98%), 3-aminopropyl-Triethoxysilane (3-APTES, APTS, $H_2N(CH_2)_3Si(OC_2H_5)_3$, >=98%), and 3-(trimethoxysilyl) propylmethacrylate, (TMSPM, $H_2C=C(CH_3)CO_2(CH_2)_3Si(OCH_3)_3$) isopropyl alcohol (IPA, $(CH_3)_3COH$, >99%), Sulfuric acid (H_2SO_4, 95-97%), and hydrogen peroxide (H_2O_2, 30%) were purchased from Sigma-Aldrich and used directly, without further purification. Titaniumdioxide (21 nm, Sigma-Aldrich) nano-particles were used as inorganic compound in hybrid composite. Chemical structure of silanes is shown in figure. 1.

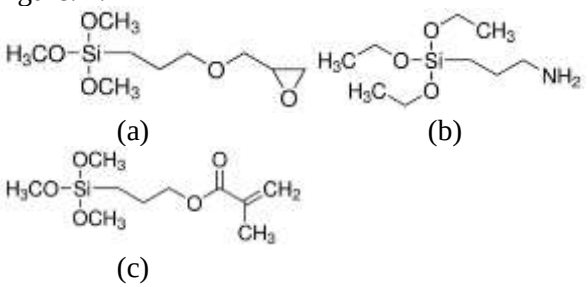

Figure 1. *Chemical structure of the a) 3-GLYMO, b) 3-APTES and c) TMSPM*

Glass substrates were cleaned with piranha solution. The Piranha solution is a mixture of H_2SO_4:H_2O_2 (5:1). To enhance adhesion between coating and substrate, silanization was applied to glass surface. Silanization is the covering of a surface with the silane coupling agent. This solution was prepared by dissolving 3-APTES in isopropyl alcohol. Silane compounds (GLYMO and TMSPM) were separately mixed with deionized water and isopropyl alcohol in two different beakers. Titanium dioxide nanoparticles were added and mixed the silane solutions for 1 hour. The modified solution was then coated on a glass substrate by dip coater at 80 °C for four times.

3. Results and Discussion

3.1. FT-IR Analysis

FT-IR analysis was performed to identify structure of GLYMO and TMSPM based TiO_2 coatings by using Spectrophotometer (Shimadzu IR Prestige-21). Figure 2 show the difference in the FTIR spectra of GLYMO and TMSPM based TiO_2 coated glass substrate from 400 to 4000 cm-1. As shown in Figure 2, the peaks in between 500 cm^{-1} and 1000 cm^{-1} are assigned to the Ti-O vibration bond [7]. Asymmetric and symmetric CH_3 stretching vibrations at 2860 and 2900 cm^{-1} were observed. The two bands of OH groups appear at 3650 and 1650 cm^{-1} because of hydrolysis of the Si–O–Me groups. The band at 1510 cm-1 which is for –C=(O)–NH–. Also, a peak at 1050 cm^{-1} appears, which can be assigned to the formation of Si–O–Si bonds [8,9].

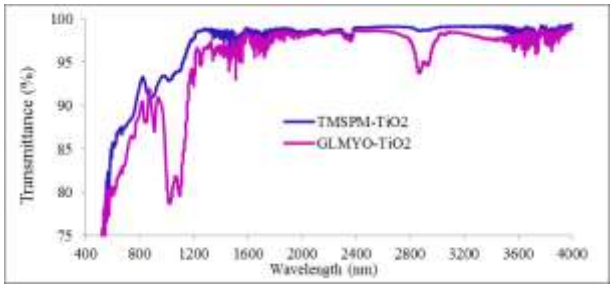

Figure 2. *FT-IR Analysis of silane-based oxide coatings.*

3.2. SEM Analysis

Scanning electron microscopy (SEM, Leo 1430 VP) was applied to examine the morphology of the samples. As shown in Figure 3, SEM images look very rough, independently of the silane type [10]. SEM-EDX Analysis prove titanium and oxygen element on surface.

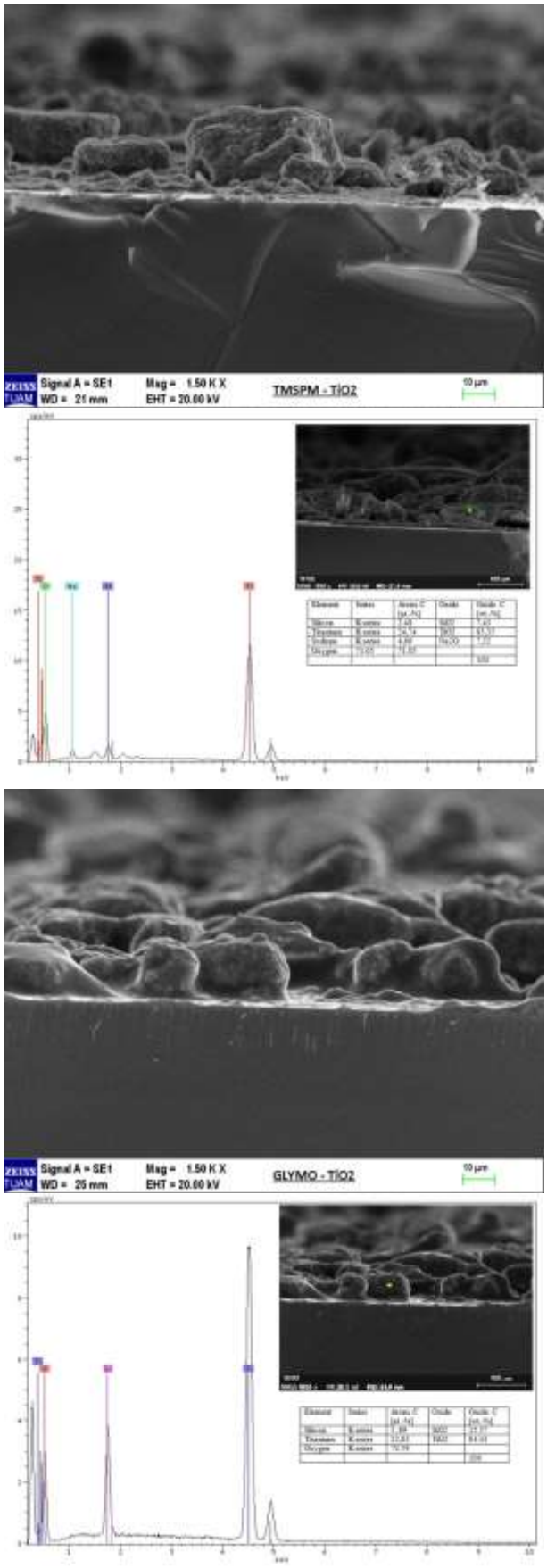

Figure 3. *SEM and EDX images of silane based oxide coatings.*

3.3. Contact Angles Measurements

Contact angle (CA) was utilized to determine the wettability of surfaces. CA of the silane-based titanium oxide coatings was determined by KSV Attension Theta Lite TL 101. As shown in Figure 4, CA results are 61° and 70° for GLYMO-TiO_2 and TMSPM-TiO_2, respectively. They have a hydrophilic character [11]. This indicates stronger effect of the hydroxyl groups on the CA values than the surface roughness of coatings [10, 12].

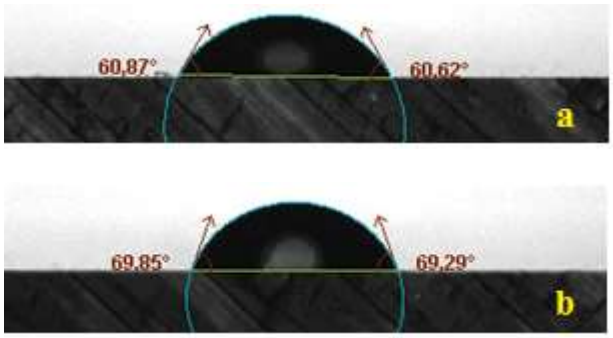

Figure 4. *Contact angles measurements of silane based oxide coatings a) GLYMO-TiO2 and b) TMSPM-TiO2.*

3.4. Band Gap

The energy band gap (Eg) of the silane-based TiO_2 films can be estimated by plotting $(\alpha h\nu)^2$ versus $(h\nu)$. It was calculated by Tauc method. Figure 5 shows that the plotting gives a straight slope at a certain point [13, 14]. The optical band gap is found 3.58 and 3.46 eV for GLYMO-TiO_2 and TMSPM-TiO_2, respectively, near the value of 3.85 eV, found by H. Oh et al. [15].

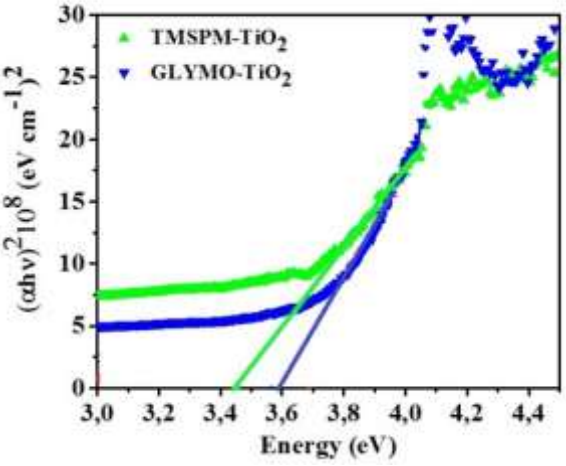

Figure 5. *Optic band gap of silane based oxide coatings.*

4. Conclusion

Silane-based TiO_2 thin films were successfully prepared at low temperature by sol-gel process. Thin films thickness were between 100 and 150 µm. FT-IR results show that silane coupling agents were hydrolysed and attached to the surface. Surfaces of the coating were smooth and homogenous. Contact angles of silane-based TiO_2 coatings were proved hydrophilic structure. Optical band gaps of thin-film were obtained as 3.58 and 3.46 eV for GLYMO-TiO_2, and TMSPM-TiO_2 respectively.

Author Statements:

- The authors declare that they have equal right on this paper.
- The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- The authors declare that they have no-one to acknowledge.

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Research Article

Investigation of the Relationship Between the Core Temperature of Hazelnuts and Ambient Conditions in the Drying Process

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Drying rate
Drying temperature

Abstract:

Hazelnut, which is one of the major export products in Turkey, can be generally evaluated and preserved in dried form. There are difficulties encountered in keeping its internal temperature and humidity constant at desired values because it is commonly exposed to solar energy and dried in outdoor environment. Especially due to rainy and variable weather conditions, it is possible to decay and decompose the inner hazelnut without full drying. Because of improper drying, hazelnuts are known to lose their nutritional value. In this study, the attitude of hazelnut was observed in different ambient conditions and the drying temperatures in hazelnut drying processes performed under laboratory conditions. For this purpose, insulated drying booths for experimental setup were created and air circulation was provided for forced convection by fans. Approximately equal sized hazelnuts were placed in the cabin. The main properties of hazelnuts before and after conditioning were recorded for each experiment. The internal temperature, surface temperature and mass loss of the hazelnut were evaluated together. Drying attitudes were recorded for different types of hazelnuts (round, pointed and long). The optimum ambient conditions and drying temperatures were determined during hazelnut drying process. Drying times at 25-50 ^{0}C temperature were determined for hazelnuts with 60% relative humidity under ambient air conditions at 3 m/s rate. It has been understood that keeping the drying speed and temperature high or low causes uncontrolled and insufficient drying. It has been observed that different drying conditions can be applied depending on hazelnut storage properties.

1. Introduction

Turkey, the leader of world hazelnut production, accounts for 68,8% of world hazelnut production. Although consumption of hazelnut is very limited, dry hazelnut consumption corresponds to a large part of hazelnut market. The dry hazelnut quality varies depending on the conditions of the hazelnut, depending on the growing conditions as well as the drying conditions. For this reason, work continues to determine the best hazelnut drying conditions. Hazelnut, together with other nuts, is consumed as a common snack food. They are also used in the main sweet and savory dishes that represent a valuable component of a healthy Mediterranean diet [1,2,3]. According to many clinical trials, regular intake of nuts is associated with a reduced risk of various diseases such as cardiovascular disease, specific cancer types and neurode generative disorders such as an improved memory, learning and cognitive ability [4, 5]. Some studies [6, 7] that examine the drying of hazelnut, which is a biological porous structure, indicate that the diffusion coefficient changes during drying depending on the temperature and nourishment.

2. Material and Method

2.1. The Experimental Setup

Experiments were carried out in a laboratory scale convective air dryer duct as shown in Figure 1. There are one electric motor, fan, flow trimmer and

heater in the experiment setup. The channel is 12 cm square in cross section and 135 cm in length. The perimeter of the duct is insulated to prevent heat losses to the surround. The mass flow rate of the drying air was controlled by a fan at different engine speeds to determine the u value ranging from 0,2 m / s to 0,6 m / s at the channel entrance. The air heated at the inlet of the channel passes through the test zone, allowing the sample of the nut in the axial center to be dried by convection. A thermometer and a U-manometer channel are connected to measure the temperature and pressure drops in the channel. In addition, a data logger was used throughout the experiments to record the temperature changes in the sample and to record the mass losses.

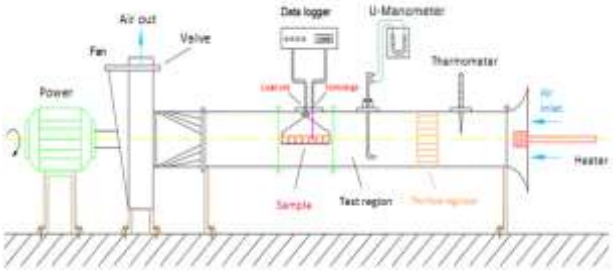

Figure 1. *Schematic view of the experimental setup*

2.2. Sphericity Ratio for Hazelnut

The statistical study done on 100 hazelnut samples selected from the test samples determined the sphericity ratio of the hazelnut. According to the geometry in Figure 1, the global ratio of the nut to the nut was determined [8].

Figure 2. *Hazelnut dimensions considered for shape value*

The average diameter of the hazelnut, da, can be determined with the height H, the width W, and the Length K as

$$d_a = \frac{(H + W + L)}{3} \qquad (1)$$

The actual volume of the hazelnut was determined by the amount of mercury overflowing when immersed in the bolt.

$$\varphi = \frac{A_0}{A_v} \frac{\pi \left(6V_v/\pi\right)^{\frac{2}{3}}}{A_v} \qquad (2)$$

Where A_0 is the equivalent surface area, A_v is the surface area of the hazelnut, and V_v is the volume of hazelnut. In this way, the calculated globality rate was determined as 91% on average.

2.3. Moisture Determination and Balance Moisture

The moisture content in the hazelnut was determined before and at the end of the experiments. After grinding with the shells of the samples taken from the hazelnut parties, the humidity content was determined by using the Ohaus MB-45 model moisture analyzer for determining the amount of dry matter. The equilibrium moisture values of the dried hazelnut are determined in closed glass jars containing saturated solutions of various chemical substances, keeping the environment at different relative humidity seen Table 1. The jars are made in two sections. Chemical solutions are placed on the bottom of the jars. Sieves were placed in the middle of the jars and samples of hazelnuts placed in petri dishes were placed on top of the sieves. The jar covers are tightly closed and placed in a constant temperature environment.

Table 1. *Certain substances that hold the environment in which saturated solutions in water are present at different relative humidity [9].*

Salt Name	Chemical Formula	Relative humidity (%)	Quantity (gr)	The amount of water (lt)
Potassium acetate	CHCOO	22	200	65
Magnesium	$MgCl_2$	32	200	25
Potassium	K_2CO_3	41	200	30
Magnesium nitrate	$Mg(N_3)_2$	53	200	80
Sodium bromide	NaBr	57	200	50
Sodium nitrate	$NaNO_3$	66	200	50
Stronsyum	SrCl	70	200	60
Sodium chloride	NaCl	5	200	60
Ammonium	$(NH)_2$(S	90	200	60
Potassium	KCl	67	200	90
Barium chloride	$BACl_2$	90	250	70
Lidyum chloride	LiCl	11	200	70

2.4. Heat Transfer Modeling

With the assumption that the structure of the nut is a multi-layered sphere, studies first focus on numerical solutions of heat transfer in a one-

dimensional transient regime in layered spheres. The numerical solution of the heat transfer in a single-layered culvert is given in [9]. In the study, heat transfer in three-layered cullet with numerical method was obtained for various parameters. The same material values are given for the layers and are calculated as a single layer sphere and the results are consistent with the values given in [11,12]. In the experiments, the cooling curves were drawn using dried chestnuts. Wherein the moisture inside nut has the value of the equilibrium moisture. . In the mathematical model considered, single hazelnut grain is modeled with a layered sphere approach consisting of eutectic + air + crust. The number of Ra (Ra = Gr * Pr) was calculated in the air layer for chubby hazelnut. Since Ra> 1708, it is assumed that heat conduction is only conduction since there is no air movement in this layer.

$$\frac{\partial^2 T}{\partial r^2}+\frac{2}{r}\frac{\partial T}{\partial r}=\frac{1}{a}\frac{\partial T}{\partial t} \qquad 3)$$

Hence,

$$\frac{\partial T}{\partial t}=a\left(\frac{\partial^2 T}{\partial r^2}+\frac{2}{r}\frac{\partial T}{\partial r}\right) \qquad (4)$$

Where $a\ (=k/\rho c_p)$ is the diffusion coefficient.
Boundary conditions must be taken into consideration in order to determine the temperature distribution in the hazelnut from *r=0 to r=R1*. Related correlation is written as follows:

I. From Fourier's law at r = 0,

$$\frac{\partial T}{\partial r}=0 \qquad (5)$$

II. From Fourier's law at r =R_3,

$$-k_3\frac{\partial T}{\partial r}\Big|_{r=R_{3-3}}=-k_2\frac{\partial T}{\partial r}\Big|_{r=R_{3-2}} \qquad (6)$$

III. From Fourier's law at r=R_2,

$$-k_2\frac{\partial T}{\partial r}\Big|_{r=R_{2-2}}=-k_1\frac{\partial T}{\partial r}\Big|_{r=R_{2-1}} \qquad (7)$$

IV. From Fourier's law at r=R_1,

$$\dot{q}=h(T_y-T_\infty)=-k_1\frac{\partial T}{\partial r}\Big|_{r=R_1} \qquad (8)$$

In these equations, $\dot{q}$ is the heat flux. T_y and T_∞ shows the surface temperature and the ambient air temperature respectively. $R_{(3-3)}$, $R_{(3-2)}$ and $R_{(2-1)}$ represent the radius on the right side of the third layer, the radius of the second layer side and the radius on the side of the first layer respectively.
These expressions can be obtained in dimensionless form using the following relations.

$$\theta=\frac{T-T_\infty}{T_0-T_\infty}\,,r^*=\frac{r}{R_1},\tau=\frac{a_1 t}{R_1^2},\ a_i^*=\frac{a_i}{a_1} \qquad (9)$$

Where a_i represents the heat dissipation coefficients in the layers.
Thus, the equation 4 can be written as

$$\frac{\partial T}{\partial t}=a_i^*\left(\frac{\partial^2 T}{\partial r^{*2}}+\frac{2}{r^*}\frac{\partial T}{\partial r^*}\right) \qquad (20)$$

If the following definitions are made for border conditions,

$$\frac{\partial T}{\partial r^*}=0\,,-k_{2-3}^*=\frac{k_2}{k_3}\ \ ve\ \ k_{1-2}^*=\frac{k_1}{k_2} \qquad (13)$$

The following dimensionless expressions can be obtained.

$$\begin{aligned}-k_{2-3}^*\frac{\partial\theta}{\partial r^*}\Big|_{r=R_{3-2}}&=\frac{\partial\theta}{\partial r^*}\Big|_{r=R_{3-3}}\\ -k_{1-2}^*\frac{\partial\theta}{\partial r^*}\Big|_{r=R_{2-1}}&=\frac{\partial\theta}{\partial r^*}\Big|_{r=R_{2-2}}\end{aligned} \qquad (42)$$

Using the *r** and θ terms in the equations, a dimensionless expression can be developed based on the number of Biot as follow;

$$h\theta=-\frac{k_1}{R_1}\frac{\partial\theta}{\partial r^*} \qquad (53)$$

Bi number for the sphere is written as

$$Bi=-\frac{hR_1}{k_1} \qquad (64)$$

Hence,

$$\frac{\partial\theta}{\partial r^*}=Bi\theta \qquad (75)$$

Numerical solutions of differential equations are different for parabolic and elliptic differential equations. Since the heat transfer is in the transient regime and the temperature in the sphere changes only radially, the differential equation expressed in Equation 10 is a two-dimensional parabolic differential equation. The implicit solution method and the Crank-Nicolson method are used after the differential equation is made the finite difference equation by using the finite difference method. The

resulting finite difference equation generally takes the following form in the solution domain:

$$A_j\theta_{j-1} + B_j\theta_j - C_j\theta_{j+1} = D_j \qquad (86)$$

Where A_j, B_j, C_j ve D_j are some coefficients for the corresponding expressions. The solutions of these equations are done by the Gauss-Elimination TDMA method. In order to remove the discontinuity at the center of the sphere, r = 0, some derivative equations can be derived from the contact surfaces of the layers using the derivative condition. The results obtained for the various parameters are given in graphical form using the implicit solution method [11, 12].

2.5. Calculation method applied in determination of mass transfer

For each experiment, real hazel weights were obtained from relative hazel weight of hazelnut parties. Full dry hazel weights were determined using an oven. The values obtained from the experiments are plotted with time with respect to the hazel party weights with the help of the following relation.

$$f(t) = \frac{M_t - M_e}{M_0 - M_e} \qquad (97)$$

Where M_t, is the weight of the hazelnut [13, 14].

3. Results and Discussion

The average dimensions of the hazelnut samples and the experimental conditions are given below in the process of determining the heat transfer parameters.

Re=45500, $R_{hazelnut}$=0,00868 m, T_{medium}=18 ^0C, $W_{hazelnut}$=%6,6, C=0,007721 1/s, J_i=1,4116723

For the selected plump hazelnut samples, the heat transfer coefficient as *h=87.91 W/m^{2}K* and the heat transfer coefficient as *k=0.187 W/mK* were determined for *Bi=4* according to the experimental data. Figure 3 shows the temperature distribution graph obtained as a result of the experiments for changing the central temperature in the hazelnut. According to the studies on this subject can be continued hazelnut varieties and sizes.
During drying, the central temperature changes in the thin exhibition hazel party, the values according to the exhibition entrance and exit temperatures, and the changes in the drying air depending on the drying air speed and humidity, are shown in Figures 4-8.

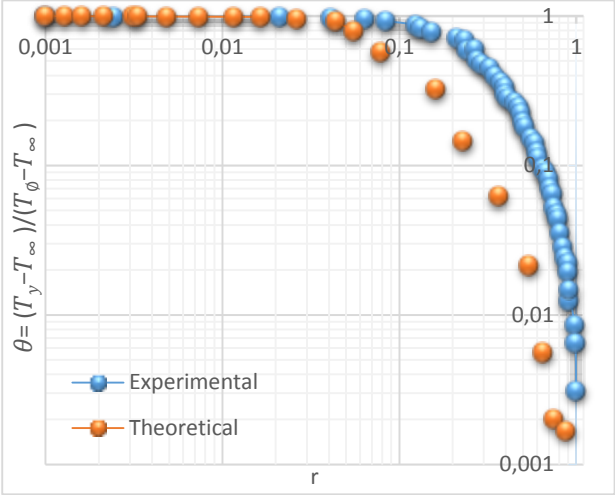

***Figure 3**. Temperature distribution in hazelnut.*

The graph obtained for equilibrium moisture measurements of hazelnut samples is given in Figure 9.

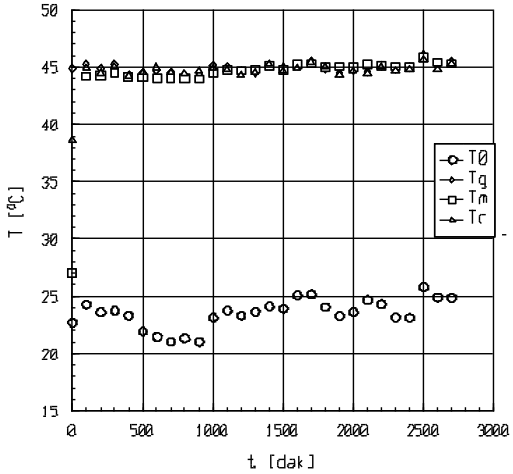

Figure 4. Change of experimental drying air and hazelnut center temperature (T_g=45°C, u=0.3m/s, Ø=0.65)

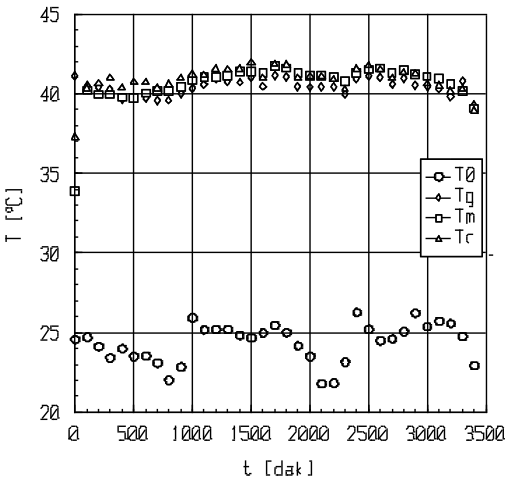

***Figure 5.** Change of experimental drying air and hazelnut center temperature (T_g=40°C,u=0.3m/s, Ø=0.65)*

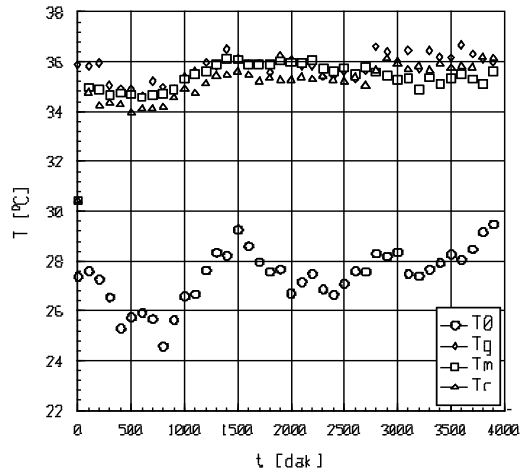

Figure 6. *Change of experimental drying air and hazelnut center temperature (T_g=35°C, u=0.3m/s, Ø=0.65).*

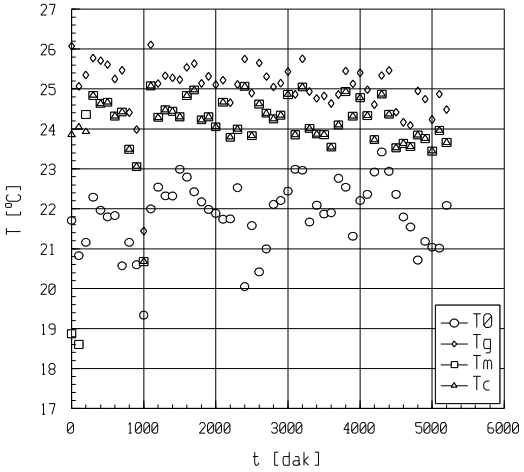

Figure 7. *Change of experimental drying air and hazelnut center temperature (T_g= 25°C, u=0.3m/s, Ø=0.65)*

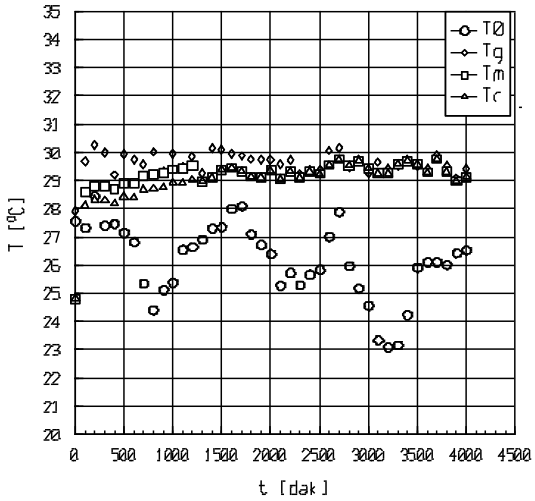

Figure 8. *Change of experimental drying air and hazelnut center temperature (T_g=30°C, u=0.3m/s, Ø=0.65)*

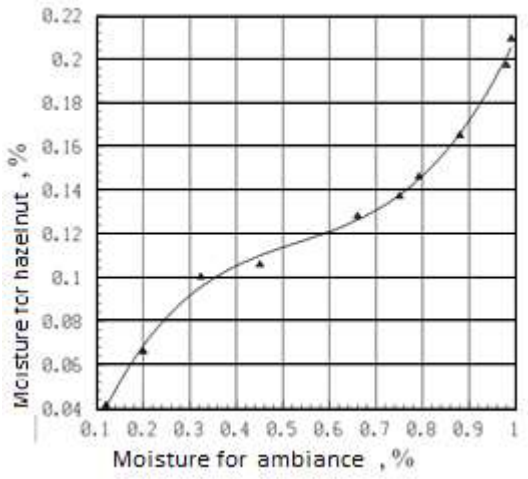

Figure 9. *The equilibrium moisture curve for plump hazelnut (T= 20°C).*

At various temperatures of the drying air, the change in the time of the nuts in the hazelnut part (M_{av}-t) is given in Figure 10 for a 65% relative humidity and a 0,3 m/s rate. It has been observed that the results obtained with the experiments performed in this study are in close agreement with the mathematical model used for temperature distribution in hazelnut (layered sphere). The compatibility of experimental and theoretical work is shown in Figure 3.

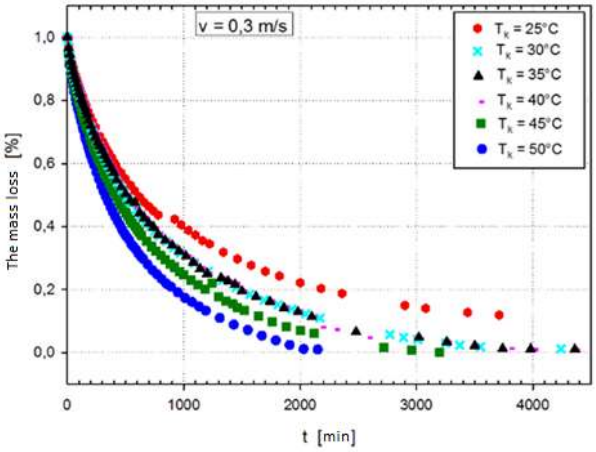

Figure 10*. M_{av}-t changes in hazelnut (ι=0.60, u=0,3 m/s)*

In the study, drying of hazelnut at *60%* relative humidity, *0.3* m/s speed and *25, 30, 35, 40, 45* and *50°C* air temperatures were discussed. At the time of drying, the temperature of the drying air at the outlet and the center temperatures showed a fall in the first time depending on the temperature of the inlet product and the latent heat of vaporization, but later this difference only appeared due to evaporation latent heat. This is seen in Figures 4, 5, 6. 7 and 8. The increase in air temperature reduces the drying period and increases drying speed,

weight loss and percentage of nematode plotted against time (Figure 10). During the same drying period in columns where the drying air velocity is great, over hardening in the hazelnut kernel and gaps in the center of the inner hazelnut have occurred. Dried hazelnuts should be around *6%.* This seems to have occurred at about *20%* ambient air humidity. The ambient air will also increase the balance of the waste ash. It is seen that the nut is changing very rapidly in the equilibrium humidity when it exceeds *65%* of the humidity of ambient air.

3. Conclusions

The results obtained in experiments with air humidity of *65%* relative humidity, air velocity of *0,3 m/s* and air temperatures of 25, 30, 35, 40, 45 °C were interpreted in fine view.

As the temperature of the drying air is high, the drying time is reduced and the drying speed is increased, while the initial times of weight reduction are rapidly decreasing, the reduction rate is slowing down to the balance amount of moisture in those conditions. It has been shown that the mathematical model introduced for the determination of heat transfer parameters in nuts can be used to determine the thermodynamic properties of hazelnuts. The mathematical model established with the experimental data obtained in the drying of the pomegranate nuts very well. It has been shown that the drying characteristics of hazelnut can be determined when the temperature of the drying air, the product balance nemesis and the moisture content of the product are known. Our recommendations are to determine the thermodynamic properties of hazelnut based on all hazelnut species. Investigation of the effects of drying conditions on hazelnut storage properties in artificial drying.

Author Statements:

- The authors declare that they have equal right on this paper.
- The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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Case Report

Effects of Chelation Therapy on QT Dispersion in Lead Exposed Industry Workers in Turkey

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Abstract:

Occupational lead poisoning is a common and serious occupational health problem, with workers mainly exposed to lead through inhalation and ingestion. A wide range of studies conducted on lead intoxication and its ECG effects, revealed that QT interval is one of the most important parameters. QT dispersion is a marker of heterogeneity and is frequently encountered in patients with a disparity in ventricular recovery and is implicated as a direct marker of cardiovascular mortality. Battery, metal mine and car service workers who had been working in the same workplace for at least two years and admitted to Ankara Occupational Diseases Hospital for annual examination and hospitalized with toxic blood lead levels, were enrolled in the study. Patients were given chelation therapy with Ca-EDTA, and ECGs were taken before hospitalization and one week after the chelation therapy. A total of 155 male Caucasian workers (mean age = 32 ± 12 years) were evaluated. The mean blood lead level was 55.3 ± 5.1 µg/dL (min = 45.3 µg/dL max = 70.9 µg/dL). None of the participants had an arrhythmic event or death. QT dispersion before chelation and post-therapy was 38.86±13.24 msec and 35.80±12.32 msec, respectively (p=0.000001). Chelation therapy by Ca-EDTA in lead poisoning could reduce ventricular arrhythmias by homogenizing ventricular repolarization times.

1. Introduction

Cardiovascular disease is the leading cause of mortality and a primary contributor to the burden of disease worldwide [1]. Traditional risk factors such as hyperlipidaemia, hypertension, smoking, and diabetes as well as potentially preventable exposures to environmental toxicants, including lead and other metals, are factors that may explain population variations in cardiovascular disease rates [2, 3].

Lead and lead alloys have a wide range of industrial applications including leaded gasoline, industrial processes such as lead smelting, coal combustion, lead-based paints, lead containing pipes, or lead-based solder in water supply systems, battery recycling, grids and bearings [4]. Once absorbed, it is widely distributed and can be found in many tissues [5]. Occupational lead poisoning is

a common and serious occupational health problem and it leads to promoted oxidative stress and inflammation, disturbed NO signalling pathways, altered major vasoregulatory systems, damaged endothelial lining, promoted smooth muscle cell proliferation, and transformation and inhibition of fibrinolysis. Workers are exposed to lead mainly via inhalation and ingestion [6]. In Turkey, there is a legislative standard for air lead concentrations in the workplace, but there is no official standard or medical guideline for a biological exposure index. In daily practice, similar with Occupational Safety and Health Administration-USA (OSHA-USA), blood lead levels > 40 µg/dl is accepted as a threshold for critical medical care and chelation, if clinically necessary. In Turkey, the incidence of lead exposure is high due to weak preventive measures and a lack of occupational health standards.

Recent analyses suggest that health effects may become apparent at concentrations <5 µg/dl, although no evidence exists for a threshold, even at concentrations of 1 µg/dl [7]. Acute toxicity is related to occupational exposure and is quite a common issue. In general, chronic toxicity occurs when using well water or by exposure to lead-polluted air in industrial regions [8]. However, in Turkey, occupational exposure may be encountered as a result of chronic exposure, due to the above-mentioned factors. There is no conclusion regarding the exact nature of lead influence on ECG. Since the 1970's, it has been observed that lead increases myocardial sensitivity to noradrenalin and its arrhythmogenic effects and causes bradycardia via blocking beta adrenoreceptor activity [9, 10]. In various electrocardiographic studies, repolarization disorders and rhythm disturbances were observed in groups of workers who were exposed to lead, when compared to the controls [11]. Among the 775 men who participated in the Normative Aging Study, bone lead levels were found to be positively associated with heart rate, corrected QT and QRS intervals, particularly in the younger men [12]. Also, a risk of intraventricular or atrioventricular block in men with elevated bone lead levels was increased, whereas blood lead level was not associated with any of the electrocardiographic disturbances [12]. In a wide range of studies conducted on lead intoxication and its ECG effects, it was revealed that the QT interval is one of the most important parameters. As QT interval represents ventricular depolarization and repolarization, measurement of QT may help determine the period of mean ventricular action potential. QT dispersion is a marker of heterogeneity and frequently encountered in patients with a disparity in ventricular recovery. Dispersion of QT is implicated in the genesis of ventricular arrhythmias and as a direct predictor of cardiovascular mortality [13, 14].

Authors of these studies suggest that the cumulative exposure to low lead levels causes electrocardiographic conduction disturbances [15]. In light of previous studies and efforts, our aim was to determine whether there is an association between blood lead levels and chelation therapy on QT dispersion.

2. Materials and Methods

2.1 Patients

Battery, metal mine and car service workers who were admitted to Ankara Occupational Diseases Hospital for an annual examination and were hospitalized with toxic blood lead levels, were enrolled in this study. Study participants' ages were 20 - 44 years and had been working in the same workplace for at least two years.

After explaining the aim of the study, informed consents were obtained. Well-trained occupational physicians conducted patient interviews with all the participants. Then, a questionnaire containing questions regarding the patients demographic characteristics (gender, age and marital status), job-related information including history of the work causing the lead exposure and work experience, as well as respiratory disease history, intake of medicine, smoking history, leisure time, physical activity, and diet, was completed by the patients.

Body mass index (BMI) was calculated as the ratio of body weight to height squared and expressed as kg/m2. One trained physician measured the blood pressure from both arms of the study participants, while the patient was in a sitting position. After the subjects had rested for 20 mins, three measurements were taken with 5 minutes (mins) intervals, by using a standard mercury sphygmomanometer. Systolic and diastolic blood pressures were recorded as the pressures at the first and fifth Korotkoff sounds, respectively. The average of three readings was used in the data analysis [16]. Workers with a previous history of diabetes, heart or kidney diseases, malignancies, and those who were on antiarrhythmic and QT prolonging drugs were excluded.

2.2 Blood Sample Collection

Samples for blood lead levels, complete blood count and blood chemistry were analysed. The blood specimens were heated in a hot water bath at

37°C for 25 mins and homogenized by shaking for one min. Three millilitres of each of the blood samples was transferred into a Pyrex test tube. A 3:1 mixture of trichloroacetic acid (TCA 5%) and perchloric acid solution (2 M) was added into each test tube and tubes were centrifuged for 25 minutes at 3,000 rpm. The supernatant from each sample was decanted into a labelled sample bottle and the precipitate was further digested with 3.0 mL 2 M perchloric acid and centrifuged for 15 mins. The supernatant from each centrifuged sample was decanted and mixed with its corresponding supernatant from the first lysis. Finally, the lysates were stored at – 4°C until dispatched for analysis [17]. The concentration of lead in the blood samples was determined on a Flame Atomic Absorption Spectrometer (NovAA 300) at 283.3 nm after optimizing the various instrument parameters. Triplicate samples were analysed in each determination and averages of the triplicate measurements were taken for each sample. Instrument drift was checked by running the standards after analysing 10 samples. Quantification of lead in blood was carried out by using a standard lead solution with known lead concentration. Percentage recoveries determined from blood samples spiked with 10 µg of lead per 4.0 mL of blood sample were 94.6% on average. However, no correction for recoveries was performed in our data [17].

2.3 ECG Recordings

Standard resting 12-lead electrocardiograms were taken at supine position while at rest for at least for 10 mins on a SCHILLER AT102 ECG device (SCHILLER INC). QT interval was measured manually by the researchers from the beginning of the QRS complex to the end of the T wave and a corrected QT was calculated by the Bazzet's formula: QTc= QT / [RR]½. QT dispersion was calculated as the difference between the longest and the shortest QT interval on the 12 lead surfaces ECG.

2.4 Statistical Analyses

The collected data was analysed by using SPSS18 program (SPSS Inc., Chicago, IL, USA). The relationship between the blood lead levels and the statistical differences in the change on QT dispersion indices before and after therapy for lead poisoning, were analysed using a Paired

3. Results

A total of 155 male Caucasian workers with a mean age of 32 ± 12 years were evaluated. The mean blood lead level was 55.3 ± 5.1 µg/dL, ranging from 45.3 to 70.9 µg/dL. The mean working years were 3.7 ± 1.1 years. Patients were given chelation therapy with Ca-EDTA and ECGs were taken before hospitalization and 1 week after chelation. Demographic characteristics of the participants are shown in Table 1. Alcohol consumption rate was 6.45 %, while the smoking rate was 66.46 % among workers. Medical history of 11 participants included the hypertension diagnosis. None of the study participants were on medical therapy that prolongs QT interval on surface ECG and none of the participants experienced arrhythmic event or death during hospitalization.

Table 2 indicates the QT dispersion before and after chelation therapy for lead poisoning. Two QT dispersion measurements were taken from participants, one was at the time of the hospital admission and the second was before hospital discharge. QT dispersion before chelation therapy was measured as 38.86 ± 13.241 msec and there was a statistically significant difference between post-therapy measurements that were 35.80 ± 12.32 msec (p = 0.000001).

Table 1. *Demographic values and disease history of the participants.*

Gender	Male 155 (100%)
Age (years)	32.83 years
Marital status (married)	97 (62.58 %)
Smoking	
Non-smoker	35 (22.58 %)
Ex-smoker	17 (10.96 %)
Smoker	103 (66.46 %)
Blood pressure	
Systolic (mean)	124.7 mmHg
Diastolic (mean)	76.5 mmHg
BMI	22.7 kg/m²
History of dyslipidaemia	18 (11.6 %)
History of hypertension	11 (7.09 %)
Alcohol consumption	10 (6.45 %)

Table 2: *Effect of chelation therapy on QT dispersion times*

	Before chelation	**After chelation**	**p**
QT dispersion times	38.86±13.24 msec	35.80±12.32 msec	0.000001

4. Discussions

Lead may cause cardiovascular effects by altering the renin-angiotensin system, activating the sympathetic system, changing the homeostasis of

electrolytes, and inducing free radical production that lead to direct endothelial dysfunction [10, 18-20].

QT prolonging, arrhythmogenic, cardiotoxic, accelerated atherosclerosis and hypertensive effects of lead are well-known and are widely studied subjects of both toxicology and cardiology. Fifteen studies reported the association of lead with other electrocardiographic parameters but only three of them investigated the potential effects of lead on QT interval [12]. In 1990 in Poland, Sroczynski et al. conducted a study of 711 industrial workers exposed to lead and concluded that as the blood lead levels increased the prevalence of ventricular repolarization changes also increased [21]. Another study designed by Gatagonova et al. recruited lead workers in Russia and found that the incidence of P wave, QT and QRS interval changes increased by increasing lead levels [22].

All studies, except the Normative Aging Study, were conducted on the occupational populations in Europe. These types of outcome including rhythm disorders, ischemic changes and cycle duration, varied widely across studies, and the findings were inconsistent. Normative Aging Study conducted by Chenget al. [12] in a subgroup of people in which higher concentrations of lead in the blood were detected, researchers pointed out the prolonged QRS interval and disturbances in intracellular conductivity in people over 65 years, and the increased risk of atrioventricular block in people over 65 years. Notably, the American National Health and Nutrition Examination Surveys (NHANES) have consistently demonstrated increased mortality associated with lead exposure [23]. Based on the information obtained from NHANES III, the mortality from all-cause, cardiovascular disease and cancer was increased by 59 %, 55 % and 69 %, respectively, in people with blood lead levels (BLL) over 10 mg/dL compared to the people with BLL of <5 mg/dL [23]. Alarmingly, even populations with BLL between 5 and 9 mg/dl had a higher mortality than populations with a BLL lower than 5 mg/dL [23].

There are very few surveys related to lead exposure in Turkey. In a survey of traffic policemen in Bursa, the average lead blood level was 9.4 µg/dL [24], while among the battery workers in Gaziantep the average level was 36.83 µg/dL [25], and in apprentices working in Bursa conducted by Pala et al., the average level was 4.99 µg/dL [7]. In other Turkish surveys regarding the BLL of apprentices, the average blood lead levels were 7.6 µg/dl in Isparta [26], and 27.8 µg/dl in Sanliurfa [27]. On the other hand, blood lead levels were higher in our study when compared to the above-mentioned studies and were 55.3 ± 5.1 µg/ dL, ranging from 45.3 to 70.9 µg/ dL.

5. Conclusions

None of the above-mentioned studies evaluated the effects of chelation therapy on the ECG parameters in patients with lead poisoning. Our findings revealed that the chelation therapy with Ca-EDTA decreases the QT dispersion times and forms a homogeneous repolarization of the ventricle. Several large prospective studies published assessed the predictive value of QT dispersion for cardiac and all-cause mortality in the general population.

As dispersion of QT is implicated in the genesis of ventricular arrhythmias, chelation therapy by Ca-EDTA in lead poisoning could reduce ventricular arrhythmias by homogenizing ventricular repolarization times, by reducing QT dispersion times. On the other hand, further large-scale studies on the effects of chelation therapy on cardiovascular mortality can provide more useful information.

Author Statements:

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Case Report

Electrocardiographic Changes in Occupational Exposure to Arsenic

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Abstract:

Arsenic (As) and its poisonous effects, toxic nature and carcinogenic effects are well-documented. As an environmental toxicant, As widely appears in nature in both its organic and inorganic form. As an occupational toxicant, As is shown to be linked to an increased risk in many cardiovascular diseases including hypertension, ischemic heart disease, peripheral arterial disease (also known as Blackfoot disease), and carotid atherosclerosis. QT prolongation is a frequently seen effect of as poisoning and a dispersion of QT is implicated in the genesis of ventricular arrhythmias as well as a direct predictor of cardiovascular mortality. A total of 207 metal-mine workers, who were admitted to the Ankara Occupational Diseases Hospital for a routine annual follow up, were enrolled in the study. A control group was composed of 207 healthy individuals who were screened for arrhythmias, hypertension and obstructive coronary artery disease. Patients being treated with a medication that could affect the QT interval and patients with the conditions, were excluded from the study. Statistical differences were analysed by performing independent sample t-tests. Our study showed a significant difference in the QT max between healthy individuals and the subjects with high occupational As exposure (P=0.039). QT dispersion and an As level in the hair samples, also showed a significant difference between the study groups (p=0.002 and p=0.001 respectively). Possible occupational exposure to As may cause cardiac arrhythmias and sudden cardiac death. Further studies are needed to document the increased cardiac risk in populations with environmental and occupational exposure.

1. Introduction

Arsenic (As), known as the king of the poisons and the poisons of the king, is believed to have been initially obtained by Albert Magnus in 1250 A.D. Since that time, its poisonous effects, toxic nature and cancerogenic effects are well-documented. As an environmental toxicant, As widely appears in nature in both its organic and inorganic form. Exposure to arsenic occurs in many ways, but mostly by arsenic polluted drinking water, occupational, and by medicinal sources as in pro-myelocytic leukaemia therapy. The maximum level of arsenic in drinking water must be under the level of 10 µg/L as set by the US environmental protection agency [1, 2]. Chronic exposure to As via drinking water or by inhalation as an

occupational toxicant, is shown to be linked to an increased risk in many cardiovascular diseases, including hypertension, ischemic heart disease, peripheral arterial disease (also known as Blackfoot disease), and carotid atherosclerosis [3-5] in a dose-response relationship [6]. Non-cardiac diseases such as hypo and hyperpigmentation of the skin, bladder cancer and lung cancer in heavy smokers, can be seen in people with high levels of exposure [7-9]. As a carcinogenic agent, As is classified as a group 1 and a group A by the international agency for research for cancer and the U.S. EPA [10, 11]. Carotid artery disease, coronary atherosclerosis and peripheral arterial disease may be caused by the direct cardiovascular toxic effects of the arsenic induced by its oxidative injury to the endothelial cells, proliferative effect on smooth muscle cells, macrophages and endothelial cells [12], or by an indirect mechanism that may have an underlying effect on the cardiovascular risk factors such as, hypertension, diabetes and hypercholesterolemia.

Various effects of toxic arsenic levels on a surface ECG have been observed in cases of occupational exposure and through the therapy for acute pro-myelocytic leukaemia with arsenic. QT prolongation is a frequently seen effect of arsenic poisoning and dispersion of QT is implicated in the genesis of ventricular arrhythmias and as a direct predictor of cardiovascular mortality [2, 13, 14]. A QT interval on the surface ECG is determined by the width of the ventricular action potential throughout the whole myocardium and is a presentation of repolarization time in the ventricles [15]. In the general population, the duration of the QT interval varies between 430 to 480 msec and can show differences according to age, gender, heart rate, medications, and the underlying heart disease [16]. The effect of Arsenic on the potassium channel is well studied [17-19] as ventricular repolarization is mostly dependent on potassium efflux. Arsenic prolongs the QT interval by potassium currents IKr and IKs [20, 21]. In this study, our aim was to determine the effect of arsenic on the QT interval and the QT dispersion in workers exposed to high levels of occupational arsenic.

2. Materials and methods

2.1. Patients and Methods

Occupational arsenic exposure could take place in industrial areas such as the glass industry, wood preservation, semiconductor production lines, in agricultural workers where arsenic is used as a desiccant and defoliant, and in the production of semi ferrous metals like gold and copper. A total of 207 metal-mine workers, who were admitted to the Ankara Occupational Diseases Hospital for a routine annual follow-up, were enrolled in the study. A control group was composed of 207 healthy individuals who were screened for arrhythmias, hypertension and obstructive coronary artery disease. Patients were treated with a medication that could affect the QT interval and those patients with the conditions were excluded from the study. A blood sample of every participant was collected for biochemical analysis and a complete blood count and a surface 12-lead ECG was obtained. All participants provided a written informed consent at the time of the enrolment. The study was approved by the Ankara Occupational Diseases Hospital ethics committee. The control group was formed from age, sex and risk factor matched volunteers. Weekly work hours of each participant, the type of industry they were working in, the duration of arsenic exposure, medical history and arsenic levels from their previous medical follow-ups were collected.

2.2. Hair Sampling

As a part of the annual follow-up, hair samples were taken from each worker, stored in a cooling bag without any chemical addition and transported to the centre for analysis. Arsenic levels were analysed in the Ankara Hifzissiha laboratories. Hair samples were washed with 0.1 % triton-X solution and dried at room temperature for 24 hours. Specimens of 0.1 gr were weighed and transferred to Teflon tubes. 5 mL of concentrated nitric acid solution was added into the tubes. Digestion procedure for hair samples was carried out using a CEM Mars Xpress microwave system (1600W oven at 200 °C for 15 minutes). Every sample was transferred from the microwave test tubes to polypropylene flasks and filled with distilled water up to 10 ml. In this study, Varian AA 240 Z Graphite Atomic Absorption Spectrometry (GFAAS) equipped with Zeeman background correction system was utilized for as determination. All the samples were kept at +4 °C in a refrigerator. Ultra-pure nitric acid and deionized water were used throughout all the analyses. All chemicals used were of analytical reagent grade. A standard solution was prepared from the dilution of 1,000 ppm (mg/L) As stock standard solutions. Concentrated HNO3 was obtained from Merck. Deionized water from Innovation Pure Water System (Human Corporation) was used throughout the study. An Arsenic Hollow Cathode Lamp was used for As detection. Absorbance was measured as the peak height at 193.7 nm with a spectral band pass of 0.5

nm. Five replicate measurements were performed using GFAAS for standard and sample solutions. The result of the hair analysis was given as ppb (µg/L) for As. The method presented in this study is sensitive and suitable for the detection of As in human hair at the low ppb level. The calibration curve was characterized by a high correlation coefficient (r = 0.9989). Furthermore, the GFAAS method was certified with the standard reference material CRM 397 (human hair), for the validation of the analytical method.

2.3. Electrocardiographic Recording and Measurements

A 12-lead resting ECG recording of each participant was obtained using Schiller AT-102 in the supine position, at rest, for at least 15 minutes, at a recording rate of 50 mm/sec. Measurements and interpretation of the QTc and the QTcd were performed by two electrophysiologists who were blind to the patients characteristics. In the case of an interobserver discrepancy (greater than 10%) of the measurements, a mean value of the two measurements was used. The QT interval was measured manually by the researchers from the beginning of the QRS complex to the end of the T wave and the corrected QT was measured using Bazzet's formula: QTc= QT / [RR]½. The QT dispersion was calculated as the difference between the longest and the shortest QT interval, on the 12 lead surfaces ECG.

2.3. Statistical Analysis

Statistical analysis was performed using SPSS software (SPSS statistics 19, IBM). Minimum and maximum values, as well as mean ± standard deviation of continuous variables, were reported. Taking into consideration the sample size, an independent sample t-test was performed on samples to analyse differences between the groups. Pearson correlation coefficients were compared for As levels and the QT intervals. The confidence interval levels were chosen as 95% ($p<0.05$) and 99% ($p<0.01$).

3. Results

Table 1 demonstrates the significant differences in the QT max between healthy individuals and the subjects with high occupational As exposure (p = 0.039). The QT dispersion and As level in the hair samples also showed a significant difference between the study groups (p=0.002 and p=0.001, respectively).

Table 1. *Significant difference in the QT max between healthy individuals. (*p < 0.05 and **p < 0.01*)

Groups		**QTc max**	**QTc min**	**QTdisp**	**As (µg/g)**
Control	Mean ± S.D.	0.382 ±0.024	0.365 ±0.024	0.015 ±0.013	0.21 ±0.20
	Min	0.321	0.308	0	0.01
	Max	0.454	0.428	0.053	0.94
As-exposed workers	Mean ± S.D.	0.387 ±0.026	0.362 ±0.023	0.024 ±0.041	2.10 ±3.07
	Min	0.327	0.314	0	0.083
	Max	0.465	0.430	0.413	25.711
Total	Mean ± S.D.	0.385 ±0.026	0.364 ±0.024	0.0194 ±0.031	1.06 ±2.31
	Min	0.321	0.308	0	0.08
	Max	0.465	0.430	0.413	25.71
P		0.039*	0.342	0.002**	0.001**

The correlation between As levels in the hair samples and the QTc and the QTdis. A highly significant correlation was found between the QTcmax and the QTdis. ($r=0.788$; $p<0.01$ and $r=0.214$; $p<0.01$, respectively) A similar relationship between the QTc and the QTdisp parameters was determined ($r=0.211$; $p<0.01$). When the study population was grouped according to their occupational professions, fine grinding and drilling workers were found to have higher As levels (2.74 ± 3.46 ppm and 0.52 ± 0:45 ppm respectively, $p <0.001$), than the patients working in other industries.

4. Discussions

Occupational exposures to inorganic arsenic are associated with an increased mortality from cardiovascular disease [22, 23]. The most common means of arsenic exposure is in the arseniasis-endemic areas and through the ingestion of high-arsenic drinking water [24]. Morbidity and mortality from ischemic heart disease and cerebral infarction may be considered as late clinical manifestations of a long-term arsenic exposure, either by occupational or by drinking arsenic polluted water [1, 25, 26].

Arsenic exposure is accepted as an etiologic factor in type 2 diabetes and atherosclerosis. Means of exposure with drinking water is widely known, however, although exposure via aerosol is rare, it is also encountered. The QT interval represents ventricular depolarization and repolarization therefore it helps determine the period of mean ventricular action potential. In clinical practice, the corrected QT (QTc) allows the clinician to evaluate the QT interval regardless of the heart rate. The QTcdisp is a marker of heterogeneity and is frequently encountered in patients with a disparity in ventricular recovery. A long-term oral As2O3 exposure significantly increased the mean heart rate

and QTc interval and reduced the SDNN. However, the QT-interval, QT and QTc dispersions were not changed in a study conducted in a promyelocytic leukaemia population, in which patients were treated with oral As by Siu et al [27]. Furthermore, for indicators of pro-arrhythmic risks [16, 28], significant QTc prolongations of more than 30 milliseconds were observed at only a single time point (2 hours after oral As2O3), QTc prolongation never exceeded 50 milliseconds, and a QTc interval of more than 500 milliseconds was observed in only 3 patients within 4 hours of oral As2O3 administration [27]. Importantly, these observations were translated into absent ventricular pro-arrhythmia in all patients [27]. These results were superior to intravenous As2O3 administration, where 26 % of patients had QT intervals more than or equal to 500 milliseconds, with the QTc interval prolonged by 30 to 60 milliseconds in 36.6% of the patients during the treatment, and by more than 60 milliseconds in 35.4% of patients, resulting in torsades de pointes in 1% of cases.

In our study, As exposure was found to be related with ECG changes such as the QT dispersion. Possible occupational exposure to As may cause cardiac arrhythmias and sudden cardiac death. Further studies are needed to document the increased cardiac risk in populations with environmental and occupational exposure.

Author Statements:

- The authors declare that they have equal right on this paper.
- The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- The authors acknowledge that this paper presented as oral presentation in ICCESEN-2020

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Erratum

Erratum to "Experimental Study on Fracture Conductivity in Hydraulic Fracturing" [IJCESEN 6-1(2020)19-22 doi: 10.22399/ijcesen.570108]

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This paper represent correction of some information previously published paper (IJCESEN 6-1(2020)19-22 doi: 10.22399/ijcesen.570108). The details are given below.

Details of Errata:

1. Part 2.1:" Two diameters of proppants are 20/40-mesh, which are commonly used in China. The bulk density and apparent density of ceramic proppants are 1.58 g/cm^3 and 2.84 g/cm^3, respectively". should be "The bulk density of ceramic proppants is 1.6 g/cm^3."

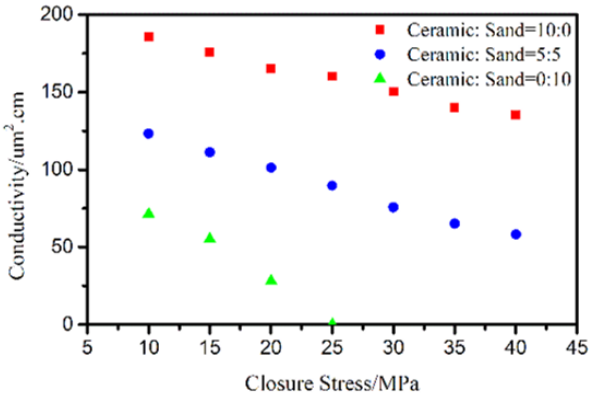
2. Part 2.4: The closure stress increased from 10 MPa to 40 MPa with an increment of 5MPa each time. The test time is 50 h for each stress point, which is according to the API standard 2 wt. % KCL is the test fluid." should be: "The test time is 30 h for each stress point, which is according to the API standard. Brine is the test fluid."

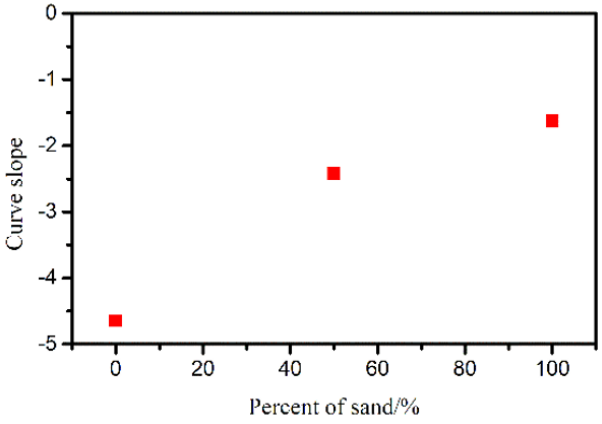
3. Part 3.2: "The conductivity of 100 % sand decreases to zero under a closure stress of 25 MPa, on the contrary, the conductivity of ceramic is still high above 150 μm^2·cm." should be delated.

4. Part 3.3: "The roundness and sphericity of the ceramic are both 0.8, which are bigger than the sand with the 0.7. The crushing rate of ceramic under a stress of 52 MPa is 5 %, while the crushing rate of sand under a stress of 28 MPa is 9 %." should be delated.

5. Equation (3) should be S=0.03P-4.41.

6. Figure 2 and figure 3 should be corrected as follows.





The authors would apologize for any inconvenience caused.