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Research Article

The Relationship of IL 17a, Vit-D Levels and some Biochemical Markers with Psoriasis and the Effect of Oral Vitamin D Supplementation on Clinical Amelioration of the Disease

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Abstract:

The aim of the study was to measure vitamin D levels before and after giving specific doses of it. Patients with psoriasis have an imbalance in vitamin D levels, as vitamin D levels have been correlated with the level of disease progression. Psoriasis incidence rates after administration of vitamin D at a dose of 1 month every day 2000 IU, then the second and third month every week 10,000 IU for period a 3-month indicate that the size of the affected area did not expand or stopped expanding. Also in our study, interleukin-17 levels and lipid profile showed some changes, indicating that high levels of vitamin D may reduce inflammation or inflammatory diseases by contributing to immune system activation. There were notable changes in average lipids and the effect was likely caused by changes in vitamin D levels, which play an important role in lipid metabolism. There was also a decrease in calcium levels.

1. Introduction

In general, Psoriasis is very much an inflammatory skin disease caused by the immune system. Excessive proliferation or expansion with incomplete or partial differentiation of epidermal keratinocytes in affected subjects and reduced keratinocyte apoptosis characteristic of psoriasis lesions, associated in both dermis and epidermis with inflammatory cell infiltrate. The most common method for determining the severity and degree of psoriasis is to utilize the Psoriasis Area and Severity Index. Vitamin D and its receptor are involved in keratinocyte growth and proliferation, dermal immune system homeostasis, and apoptosis. Many immune response cell types not only express receptors of Vitamin D, but it also has all these enzymatic machines for 1,25- dihydroxy vitamin D synthesis; these cells-related synthesis sites are of major importance to regulate and control various immune responses [1, 2]. Psoriasis presents clinically in a variety of ways. Clinical type is not a predictor of illness severity or course; nonetheless, clinical type is a critical determinant in determining the treatment regimen [3].

The genesis of psoriasis is complicated, with a complex interaction between the immune system and two essential elements determining the disease's start and progression: environmental conditions and genetic tendency. While one-third of persons with psoriasis have a first-degree ancestor who also has the condition, the way the disease presents is influenced by environmental variables. Numerous factors, including physical trauma, psychological stress, medications, food, and infections, may contribute to the disease's onset [4]. These substances can cause keratinocytes (KCs) to produce cytokines include and consist of interleukin-17A (IL-17A), and also tumor necrosis factor-alpha (TNF-), which then cause local skin macrophages and dendritic cells to become activated (DCs) [5, 6]. The generation of type I interferons is a sign of pDC activation, which is essential for the creation of the psoriatic plaque (IFN- and IFN-). Type I IFN signaling is involved in Th1 and Th17 development and function, as well as the generation of IFN- and interleukin IL-17A, respectively, and promotes myeloid dendritic cell (mDC) phenotypic development [7, 8].

In this study, 110 subjects with varying degrees of disease activity (55 Vitamin D deficiency in men and 55 Vitamin D deficiency in women with psoriasis) who are matched for gender. Vit.D, IL17A and some biochemical markers will be measured in psoriasis patients. The study was conducted in Baghdad Governorate / Medical City Hospitals / Bab Al-Moadham.The tests indicated below, on the other hand, shall be performed in accordance with the manufacturer's modus operandi (kit user handbook). Serum Vit.D Test, Serum Interleukin 17A, Serum HDL, Serum TC, Serum Tg, Serum Ca, Serum LDL, Serum RF, and hsC-RP are some of the assays available.

2. Materials and Methods

2.1 Equipment's and Apparatuses

The following is a list of the equipment and apparatus that were used throughout the research. Centrifuge, Micropipettes, Tips (blue, yellow), Automatic Elisa Reader, Gel tube , Plain Tubes, The Cobas e 411 analyzer, Incubator, Centrifuge tube, Water path , Auto Vortex. The kits that used in study; Vitamin D, IL 17, Total cholesterol, Triglyceride, HDL, hs-CRP, Calcium, VLDL, LDL.

2.2.1 Measurement of interleukin 17A

This work made use of the sandwich enzyme-linked immune-sorbent assay (ELISA) technology. Anti-IL-17A antibody was used to pre-coat 96-well plates. As detecting antibodies, anti-IL-17A antibodies conjugated to biotin were utilized. After cleaning the wells with wash buffer, the standards in the kit, test samples (patients sample), and biotin labelled detection antibody were added. Unbound conjugates were removed using wash buffer after the addition of HRPS streptavidin. HRP enzymatic activity was observed using TMB substrates. HRP accelerated the reaction of TMB, resulting in a blue product that's become yellow when exposed to an acidic solution provider. The yellow density has a direct relationship with the amount of IL-17A caught in the plate. Examine the Outside Diameter (O.D.). The concentration of IL-17A may then be measured using and take place in a microplate reader and absorbance at 450 nm.

2.2.2 Measurement of 25 hydroxyvitamin D

This assay is designed to measure total 25OHVD in human serum and plasma in a quantitative manner. This test, is intended to aid in the determination of vitamin D deficiency. The Cobas e 411 immunoassay analyzer is compatible with the electro chemiluminescence binding assay.

2.3 Statistical Analysis

(SPSS) version 25 and the XLSTAT add-on for Microsoft Excel 2010 software were used for all analyses. The t-test for students was performed to compare the mean of the various groups. Pearson's correlation test and we were used to evaluate how the different biomarkers were related to each other. All tests were two-sided, and the results are reported as means + standard deviations, medians, or 95 percent confidence ranges for odd ratios Statistical significance was defined as a P-value of less than 0.05.

3. Results

Main aim is to study the frequency and duration of psoriasis and the prevalence of infection for the entire group of patients who joined the study, as shown in Table 1 and Figure 1. The majority of the patients in the research had been sick for more than seven years. Also, the frequency and percentage of the age distribution (study group) for the whole group of psoriasis patients, which shows after conducting the statistical analysis that the peak incidence of psoriasis was between the ages of 28-42 years, and this means that the ratio is 36.43 % (48 of 110 patients; 17.27 % - 26.36 %) as shown in Table 1.

Table 1 *The table shows, after statistical analysis, the peak incidence of psoriasis*

Duration of Psoriasis (Year)	**Frequency**	**Percent**
< 7	9	8.18 %
7 - < 14	15	13.63 %
14 - < 21	17	15.45 %
21 - < 28	21	19.09 %
28 - < 35	19	17.27 %
35 - < 42	29	26.36 %
Total	110	100.00 %

The frequency and percentage of use of vitamin D in our study was mentioned in order to know vitamin D effected. In our study, the mean values (±SD) of chemical parameters measured for a whole group of patients before conducting the study and after this step we giving VD supplementation, then we again measured biochemical tests.

3.1 The Parameters of Study before the Supplement with Vitamin D

The mean values (±SD) of chemical parameters measured for a whole group of patients before giving

vitamin D supplementation, then we again measured biochemical tests.

3.1.1 The results in men and women before for of age, Vit. D and IL-17A

We obtained the mean value in men and women for of age (33.547 ± 8.748, 40.784 ± 7.946 year, respectively), serum concentrations vitamin D (12.843 ±3.281, 9.647 ±4.758 ng/ml, respectivily), IL-17A (162.533 ±19.859, 155.858 ±17.731 pg/ml, respectively) as shown in Table 2 and Figure 2 which indicated the effect of vitamin D levels, total lipids and triglycerides in psoriasis.

Table 2 *The mean age, Vit.D and IL-17 in men and women before giving vit-D*

Parameter	Men group Mean±SD = 55	Wemon group Mean±SD = 55
Age (Year)	33.547 ± 8.748	40.784 ± 7.946
25OHVD (ng/ml)	12.843 ±3.281	9.647 ±4.758
IL-17A (pg/ml)	162.533 ±19.859	155.858 ±17.731

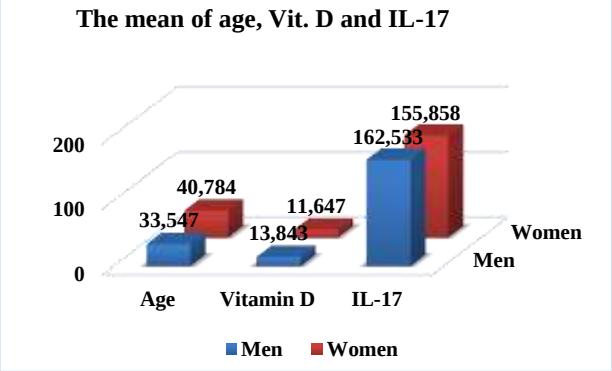

Figure 1 *The mean age, vitamin D and IL-17A with psoriasis*

3.1.2 Lipid profile (after) in patients with psoriasis

Also, the mean values (±SD) of chemical parameters measured for a whole group of patients before giving vitamin D supplementation, then we again measured biochemical tests. We obtained the mean value of men and female for serum concentrations of total cholestrol (252.758 ± 13.867 and 144.637 ± 19.285 respectivily), triglyceride (189.647 ± 16.975 and 108.731 ± 10.638 mg/dL respectivily), HDL (54.736 ± 18.758 and 62.845 ± 11.930 mg/dL respectivily), LDL (114.648 ± 24.869 and 128.849 ± 25.302) and VLDL (24.741 ± 3.648 and 29.957 ± 7.834 respectivily), as shown in Table 2 which indicated to dicrease lipid profile in patients with psoriasis and effect of vitamin D levels on total cholestrol and triglycerides in psoriasis

Table 3 *The mean of lipid profile in men and women before giving vit-D*

Parameter	Men group Mean±SD = 55	Wemon group Mean±SD = 55
Total cholesterol	252.758 ± 13.867	144.637 ± 19.285
Triglyceride	189.647 ± 16.975	108.731 ± 10.638
HDL	54.736 ± 18.758	62.845 ± 11.930
LDL	114.648 ± 24.869	128.849 ± 25.302
VLDL	24.741 ± 3.648	29.957 ± 7.834

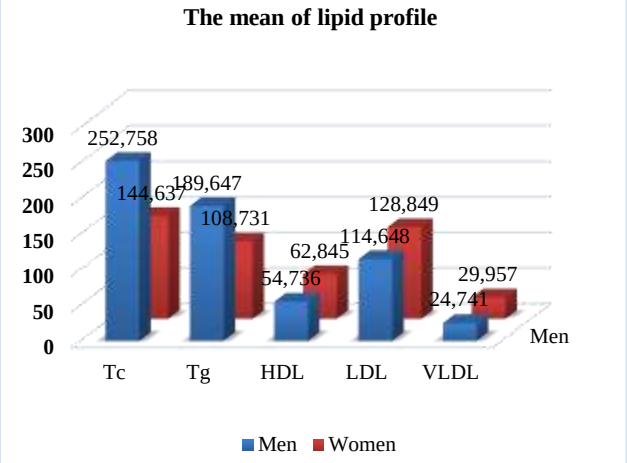

Figure 2 *The mean lipid profile with psoriasis*

3.1.3 The calcium, hs-CRP and RPP (after) in patients with psoriasis

We obtained the mean value for serum concentrations of calcium (10.318 ± 2.496 and 8.759 ± 1.109 mg/dL respectivily), hs-CRP (6.854 ± 0.856 and 11.843 ± 1.059 mg/dL respectivily), RPP (2.703 ± 0.275 and 3.041 ± 0.917 mg/dl respectivily), as shown in Table 3. Which indicated to staiblty of calcium in men and women, while increase hs-CRP in patients women with psoriasis and within normal in men. The rate of progression of psoriasis (RPP) was more in women than men.

3.2 The Parameters after the Supplement with Vit-D

To meet our study's objective, after giving vitamin D for three months to men (the first month every day 2000 IU, then second and third month every week 10000 IU period 3 month) the mean values (±SD) of chemical parameters of the group of psoriasis patients were measured.

Table 4 *The mean of calcium and C-RP in men and women before giving vit-D*

Parameter	Men group Mean±SD = 55	Wemon group Mean±SD = 55
Calcium (mg/dl)	10.318 ±2.496	8.759 ±1.109
hs-CRP (µg/ml)	6.854 ± 0.856	11.843 ± 1.059
The rate of progression of psoriasis (RPP)	2.703 ± 0.275	3.041 ± 0.917

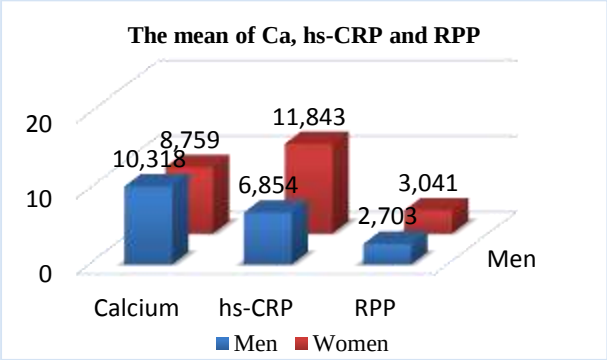

Figure 3 *The mean Ca, hs-CRP and RPP with psoriasis*

3.2.1 The age, Vit. D and IL-17A (after) in patients with psoriasis

We obtained the mean value for age (17.681 ±5.562 and 19.845 ± 5.689 mg/dL respectivily), serum concentrations vitamin D (34.69 ± 10.47 and 41.23 ± 9.06 respectivily) and IL-17A (186.74 ± 23.739 and 177.803 ± 19.264 respectivily) as shown in Table 4. Which indicated to little increase in age of men and women, while clearly increase vitamin D and IL-17A in patients men and women with psoriasis. This indicateted to stoping spread psoriasis by improvement of vitamin D levels and IL-17 in psoriasis patients.

Table 5 *The mean of age, Vit.D and IL-17 in men and women after giving vit-D*

Parameter	Men group Mean±SD = 55	Wemon group Mean±SD = 55
Age (Year)	17.681 ±5.562	19.845 ± 5.689
25OHVD (ng/ml)	34.69 ± 10.47	41.23 ± 9.06
IL-17A (pg/mL)	186.74 ±23.739	177.803 ±19.264

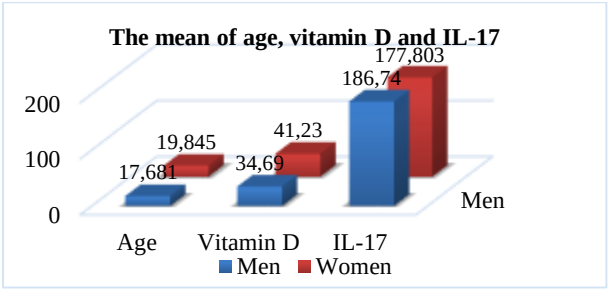

Figure 4 *The mean age, vitamin D and IL-17A (after) with psoriasis*

3.2.2 The lipid profile (after) in patients with psoriasis

The mean value in men women for serum concentrations of total cholestrol (158.638 ± 21.689 and 165.951 ± 16.063 respectivily), triglyceride (113.301 ± 11.264 and 96.974 ± 12.863 mg/dL respectivily), HDL (63.748 ± 12.690 and 55.070 ± 14.073 mg/dl respectivily), LDL (104.073 ± 18.073 and 107.253 ± 18.073 respectivily) and VLDL (26.542 ± 5.783 and 23.950 ± 5.073 respectivily), as shown in Table 5. Which indicated to change in lipid profile toward decrease. The change occur due to increased lipids metabolism through improvement vitamin D levels and therefore arrows with stopping *spread psoriasis patients.*

Table 6 *The mean of lipid profile in men and women after giving vit-D*

Parameter	Men group Mean±SD = 55	Wemon group Mean±SD = 55
Total cholesterol	158.638 ± 21.689	165.951 ± 16.063
Triglycerde	113.301 ± 11.264	96.974 ± 12.863
HDL	63.748 ± 12.690	55.070 ± 14.073
LDL	104.073 ± 18.073	107.253 ± 18.073
VLDL	26.542 ± 5.783	23.950 ± 5.073

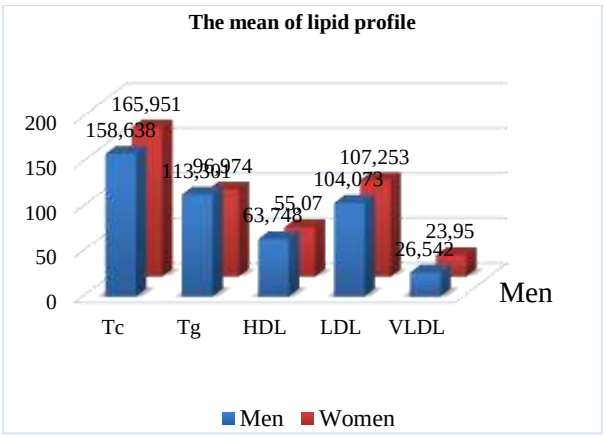

Figure 5 *The mean lipid profile (after) with psoriasis*

3.2.3 The calcium, hs-CRP and RPP (after) in patients with psoriasis

We obtained the mean value for serum concentrations calcium (9.748 ± 1.364 and 9.472 ± 1.999 mg/dL), hs-CRP (7.063 ± 0.964 and 8.903 ± 2.038 mg/dL) and RPP (4.047 ± 1.063 and 3.997 ± 2.096 respectivily), as shown in Figure 6 and Figure 7 which indicated to staiblty of calcium in men and women, while normality of hs-CRP in patients men and women with psoriasis. The rate of progression of psoriasis (RPP) was normal in women than men.

4. Discussions and Conclusions

Vitamin D levels, have been linked to the rate of disease development in psoriasis patients. The rates of developing psoriasis after giving vitamin D at a dose of 50000 weekly indicated that the size of the affected area did not expand or stopped expanding. Also in our study, the levels of interleukin-17 and SRB showed some changes, which indicates that high levels of vitamin D may reduce inflammation or inflammatory diseases by contributing to the activation of the immune system.

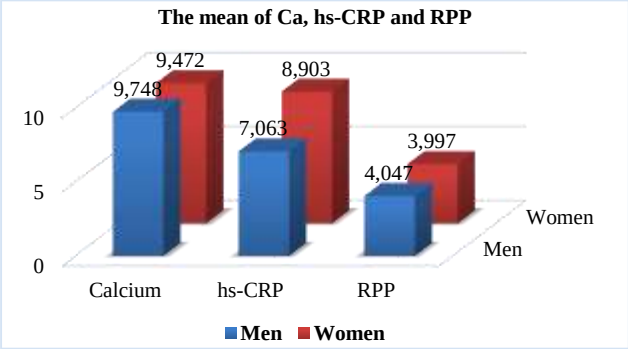

Figure 6 *The mean Ca, hs-CRP and RPP (after) with psoriasis*

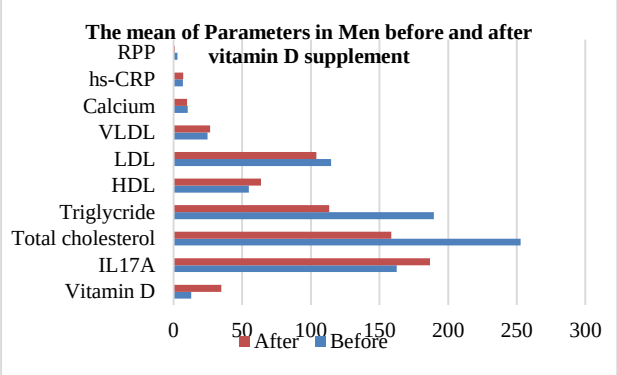

Figure 7 *The difference between the study means in men before and after vitamin D administration*

Lipid levels have an impact. Changes in vitamin D levels, which play a key role in lipid metabolism, are likely to be the cause of the effect. The amount of calcium in the body also increased.

Vitamin D is helpful for plaque-type psoriasis when / used applied directly to the human skin. As a psoriasis disease adjuvant, oral vitamin-D supplementation could be beneficial. The current state of knowledge about the use of oral vitamin D for psoriasis treatment is critical [9]. The immune system causes psoriasis, which is an inflammatory skin disease. In psoriasis lesions, hyperproliferation of epidermal keratinocytes is both the dermis and the epidermis show signs of inflammatory cellular infiltration. Vitamin D is produced naturally on the skin by exposure to sunlight. Vitamin D, has recently been linked to the pathogenesis of a variety of skin illnesses, including psoriasis. On multiple cases, low vitamin D levels have been associated to psoriasis. Vitamin D (Vit.D) has emerged as an essential and basic local therapeutic option in the treatment/ therapeutic of psoriasis due to its role in keratin cells reproduction and maturation. To date, successful psoriasis therapy based on the adequate dietary vit-D intake or oral vit-D the supplementation has remained an unmet clinical that requirement to human, evidence and certain of its therapeutic benefits is still being contested [10]. Our results showed that psoriatic patients had poorer vitamin D levels than healthy controls, adding to the expanding body of evidence relating vitamin D levels to the duration of psoriasis. Our study's observational nature, as well as the small number of patients who received biological immunosuppressive medication, are both disadvantages. More observational and randomized-controlled trials are needed to back up our findings [11]. According to studies, the cytokine, (IL-17A), interleukin-17A is involved in the pathogenesis of a number of immunoinflammatory diseases, including psoriasis, psoriatic arthritis, and rheumatoid arthritis. Although, T helper type 17 cells create the majority of IL-17A, it is also produced and synthesized by a special group of other cell types in the human body, including CD8+ T cells and T cells. of blood clots. In target cells involving bioprocesses including keratinocytes and fibroblasts, IL-17A increases the expression of multiple genes associated with inflammation, thereby increasing the production of cytokines and their derivatives, antimicrobial peptides, chemokines and other mediators that contribute to and participate in Clinical disease characteristics. Inhibitors of IL-17A in the human body resulted in rapid downregulation of the psoriasis gene signature and high clinical response rates in patients with moderate to severe plaque psoriasis. Important in the etiology of psoriasis. Alternatively, IL-17A inhibitors enhanced clinical response rates in psoriatic arthritis and rheumatoid arthritis to a lesser extent than placebo, indicating that IL-17A is either required in a subgroup of subjects or plays a minor role. In rheumatoid arthritis. More information on the involvement of IL-17A in various illnesses is expected to come from ongoing phase 3 clinical studies [12]. Plaque psoriasis' exact pathophysiology is unknown, however, it is most likely caused by environmental and genetic factors that promote dysregulated innate and adaptive immunity in the skin. Interleukin (IL)-17A is a cytokine that aids in the defense of the host against external bacteria and fungus. A growing body to evidence suggests that IL-17A, has a role in the development of psoriasis. While Th17 cells produce the most IL-17A, neutrophils, mast cells, and Tc17 cells also produce it. In psoriatic lesions, each of these cell types can be present [13]. Psoriasis is a common skin disease that his affects from 2% to 3% of the population. The prevalence of the condition in the general population or humans is affected by biochemical factors, as well as genetic, viral, environmental, infectious and immune factors, endocrine and psychological factors, as well as addiction to some types of drugs and alcohol. Psoriasis has been recognized and defined as a systemic disease of the skin with a variety of abnormalities and consequences affecting the skin

and multiple organs in the last years of the last century. People with psoriasis often have dyslipidemia as a comorbidity, meaning changes in their levels. In the early or first third of the last century, researchers were studying lipids on the surface of psoriatic skin, stratum corneum lipids, lipid metabolism in humans, epidermal phospholipids, serum lipids (total lipids), cutaneous low-density lipoproteins, oxidative stress, and the associations between Clinical symptoms, inflammation criteria, and lipids. Disease parameters. According to research, psoriasis is an immunometabolic disease [14]. We recommend taking groups that include patients without psoriasis also in conducting the same studies in the future to identify changes, identify problems and reach the best results.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
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Research Article

Experimental Analysis of Copper Pipe and Steel Pipe in Shell and Tube Heat Exchanger

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Abstract:

In this thesis, the experimental analysis of two different systems was carried out by using copper tube and steel tube in shell and tube heat exchangers. The experimental systems were designed and manufactured to have the same physical properties in two types of heat exchangers. Manufacturing costs were noted to enable comparison.
In the system where the experiments were carried out, only the heat exchanger bodies were replaced and the analyses were carried out and the other systems were kept constant. In order to perform an efficient analysis of the efficiency, the inlet temperature of the heater water was kept constant and it was not exposed to any recirculation or heat loss. Although it was observed that the efficiency of the copper tube heat exchanger increased significantly when the inlet water temperature was high during the experiments, there was no significant difference in efficiency between the two heat exchangers at low temperatures.
As a result of these analyses, it has been concluded that if the heat transfer is to be carried out for low temperatures, considering the cost, the carbon steel tube heat exchanger can be used despite of the high thermal conductivity of copper.

1. Introduction

Heat exchangers are used to transfer thermal energy between two or more fluids or solid particles and a fluid at different temperature and thermal contact. The basic principle of a heat exchanger is that it transmits heat without transferring the fluid carrying the heat. There is no external thermal energy and work interaction in heat exchangers. Heat transfer mainly occurs due to conduction and convection [1-2]. In order to increase the efficiency according to the variety of the application, and at the same time, the width of the area to be used is effectively used by considering the possibilities of mechanical piping, taking into account the temperature change and the effect on the environment [3-5].
In previous studies, analyses were made from various aspects in order to increase the efficiency of heat exchangers, and in these studies, numerical analyses were made on the thermal hydraulic performance of three sets of shell and tube heat exchangers (STHEs) with different materials or different geometric tube layout patterns [6-15]. 30º, STHE_T), rotated triangle (60º, STHE_RT) and joined (STHE_C) patterns were performed. The results from solving the main continuity, momentum and energy equations showed that most of the heat transfer and pressure drop occurs during shell-liquid cross flow through the tube bundles. (Petinrin, M.O, Dare, A.A., 2015). The choice of size and material according to the needs in the design system are the main items in saving. In this study we have done, we have observed experimentally whether copper (111 W / m K @ 20 ^{0}C), which is a more thermal conductor, is always a correct alternative to a steel – EN10208 (42.2 W / m K @ 0 ^{0}C) material. The goal of this work is comparison of efficiency copper and steel pipe exchanger regarding to different temperatures and to guide for initial investment.

2. Classification of Heat Exchangers

Heat exchangers are devices that provide heat transfer between fluids at different temperatures,

which we frequently encounter in today's industry, and where we can control the degree of these heat transfers, which we use effectively in areas such as chemistry, energy, food, and which are needed at points such as ventilation and air conditioning, heat storage.

2.1 Classification According to Construction Properties

The design and construction of this type of heat exchanger are generally categorized according to their construction characteristics.

2.1.1 Shell-Tube Heat Exchanger

In case-tube heat exchangers, which consist of a cylindrical body and parallel pipes placed in this body, one of the fluids flows through the pipes and the other flows through the body. Pipes or pipe bundle, body, heads on two heads, front and rear mirrors on which the pipes are fixed, and baffle plates or support rods that can support the pipes that direct the flow in the body are the elements of this heat exchanger type [16-18].
The standards of the construction of these heat exchangers have been determined by the tube heat exchanger manufacturers association, TEMA (Tubular Exchanger Manufacturers Association). The ability to meet the elongation that may occur due to pressure and temperature difference should be considered in the arrangements of fixed tube bundle heat exchangers. The recommended standard nominal pressures for the fluids used in the bodies and pipes of this type of heat exchanger are generally 2, 5, 6, 10, 16, 25 and 40 bar [19].

Figure 1. *Shell-Tube Heat Exchanger*

3. Results and Discussions

For the analysis of the experiments to be carried out to compare the effect of the thermal conductivity of the pipes on the results and the entry costs in the establishment of the system in the shell and tube heat exchangers, a system/setup shown in the figure 2.

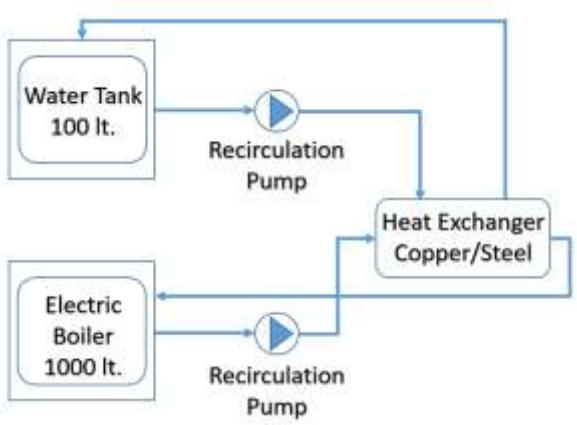

Figure 2. *Process Flow Diagram*

Here, in order to keep the temperature of the water entering the heat exchanger constant, we have supplied the inlet water with 1000 lt electric boilers in order to prevent any temperature change in 10 minutes. A circulation pump is used in order to circulate the hot water coming from the electric boilers in the heat exchangers. There is only one tank used for the same period of time for the storage and analysis of the water to be heated, and exactly 100 litres has been selected in this tank. Again, 1 circulation pump was used to circulate the water to be heated. During the experiments, a thermometer was added to the hot water inlet and outlet temperatures of the heat exchanger, and a thermometer was added to the inlet and outlet of the water to be heated, and the temperature controls were observed with digital displays. Except for the copper tube heat exchanger and steel tube heat exchanger used in the experiments, no mechanism has changed and the conditions have been observed equally. The heat exchangers are fixed with flanges on both sides with 4 bolts and nuts, only these parts are removed during the change and then their connections are provided. Heat exchanger specification is given in table 1.

Table 1. *Heat Exchanger Specification*

	Copper Heat Exchanger	Steel Heat Exchanger
Pipe Diameter (m)	0,0213	0,0213
Body Length (m)	0,51	0,51
Pipe Quantity (pcs)	9	9
Surface Area (m2)	0,0016	0,0016

4. Conclusions

Comparison of the results of the experiments at 50°C, 70°C and 90°C is summarized in the table 2.

The final temperature of the heated water specified here is the temperature of the water transferred from the heat exchanger to the tank.

Table 2. *Comparison of Experimental Analysis Results*

Heater Water Inlet Temp.	Copper Tube Heat Exchanger Final Temperature of Heated Water (10 min)	Steel Tube Heat Exchanger Final Temperature of Heated Water (10 min)
50°C	30,1°C	29,7°C
70°C	42,5°C	40,4°C
90°C	53,8°C	51,6°C

Considering the results, we see the temperatures of 30.1°C and 29.7°C when the final temperatures are taken into account in our experiment at 50°C, and we noted that the difference is 0.4°C.

In our experiment at 70°C, temperatures of 42.5°C and 40.4°C were determined, and the efficiency between these two heat exchangers was observed as 2.1°C, slightly different from 50°C.

In our experiment at 90°C, the difference between the temperatures of 53.8°C and 51.6°C was 2.2°C, although there was no significant difference from our previous experiment at 70°C, but it was not noticeable compared to that at 50°C. We concluded that there was a noticeable change.

After these comments, we came to the conclusion that there are no serious differences in the setups where the inlet temperature of the heating water is low, but that the difference is even wider in the environments where the temperature of the heating water increases.

When we compare the entrance cost and the test results as a whole, the temperature of the heating water is low and the temperature of the water desired to be heated is very high, there is almost no temperature difference, and the entrance cost is high in the copper tube heat exchanger. It has been concluded that choosing the tube heat exchanger is not correct.

At higher temperatures, the yield that can be obtained should be analysed much better and then a selection should be made, and it should be paid attention to how long it takes to get the return of the yield to be obtained.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** 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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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Research Article

Heterologous Expression and Molecular Cloning from Williamsia Marianensis

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Williamson
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Abstract:

The majority of therapy methods include downsides and limits. As a result, many researchers are focused on developing effective remedies. Therapeutic peptides, like proteins and antibodies, are a potential class of medications that have a number of advantages over traditional pharmaceuticals. Williamson marianensis-produced cholesterol oxididase has been demonstrated to have medicinal value. Using PCR and primers specific to an expression vector (pET28b), we were able to clone the cholestrol oxidase gene and express it in *E. coli* (BL-21/DE3) Rosetta following identification with IPTG. Genscript Corporation in the United States sequenced gyncholestrol oxidase (500 bp) to create a cox sequence, which was then submitted for synthesis. pET 28a(+) cox william showed a twofold restriction digestion pattern. The pattern was made up of two strands: one was a carrier plasmid (4200 bp) and the other was a 2800 base pair strand that contained the cholesterol oxidase gene. The cholesterol oxidase gene was successfully cloned and expressed as a consequence. Williamson marianensis-derived cholesterol oxidase will be exploited in future medicinal results.

1. Introduction

Human infections might be caused by the genus Williamsia [1], which belongs to the actinomycete family [2]. In the genus Williamsia, the DNA G+C content was 64–65 percent [3]. Williamsia infections and illnesses in people have been recorded, the illness was caused by exposure to the environment; however, no indication of an environmental source for Williamsia infections was found [4]. Marisch and his team were the first to describe W. muralis as the cause of lung infection in an elderly lady [5].

R. equi, a Gram-positive coccobacillus that dwells inside the host's macrophages and uses this enzyme as pathogenicity [6], was a potential pharmacological target for treating bacterial infections. Plasmids were also useful genetic tools for manipulating and analyzing microorganisms by introducing, modifying, or removing target genes [7].

There is no particular medium defined for the isolation of Williamsia from human clinical samples for identification by various culture media. Columbia agar supplemented with 5% sheep blood agar and brain heart infusion (BHI) agar [8], M3 agar supplemented with cycloheximide and nystatin [9], glucose/yeast extract agar (GYEA) plates [10], and raffinose [11].

Sequence-based identification was the most accurate approach and evaluation of taxonomic features for Williamsia identification. At the genus and species levels, 16S rRNA gene sequencing was an effective standard approach for accurately identifying new bacteria and emerging diseases [12]. Cholesterol oxidase is a bifunctional alcohol dehydrogenase/ oxidase flavoprotein that catalyzes the dehydrogenation of C(3)-OH in a cholestane environment to give the carbonyl product.

The interfacial catalysis association mechanism requires that the substrate binding site be directed toward and in contact with the lipid bilayer. The face that must be orientated towards the membrane holding the substrate was determined by X-ray crystal structures of the soluble enzyme in the absence of lipid [13]. These research focused on the Streptomyces and Rhodococcus equi enzymes because they were accessible to expression, mutagenesis, and higher solution crystallography. Their structures and mechanisms are almost similar [14].

The goal of this work was to identify and express the gene encoding cholesterol oxidase from Williamsia marianensis in E. coli, as well as to examine the sequence encoded cholesterol oxidase in silico.

1.1 Methodology

The activity of cholesterol oxidase was measured spectrophotometrically, as described before [15]. The hydrogen peroxide released by cholesterol oxidase's enzymatic digestion of cholesterol as a substrate might be detected by oxidative coupling of phenol 4-aminoantipyrine, catalyzed by horseradish peroxidase, in this approach. The latter reaction would produce quinoneimine red dye, which could be spectrophotometrically detected at 500 nm (Figure 1).

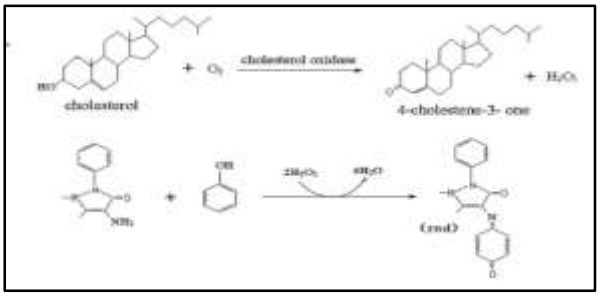

Figure 1. *Mechanism of cholesterol oxidase action on cholesterol as a substrate [16]*

The reaction mixture included 3 mM cholesterol in 1 mL 1 percent Triton X-100, 100 mL enzyme solution, 300 mM potassium phosphate buffer pH 7.0, 1.2 mM 4-aminoantipyrine, 21 mM phenol, and 20 U horseradish peroxidase, with a final volume of 3 mL. During the incubation time, the enzyme reaction was carried out at 37 °C for 10 minutes with moderate agitation. Boiling at 100°C for 3 minutes halted the reaction. Allow the reaction tubes to cool to ambient temperature. The generated color was then spectrophotometrically quantified at 500 milliseconds. The quantity of enzyme that released one micromole of H_2O_2 per minute at 37°C under the indicated test conditions was defined as one unit of enzymatic activity (U).

These primers were supplied in lyophilized form by (IDT/DNA Company), and the stock solution was prepared by dissolving the lyophilized primers in nuclease free water until a final concentration of 100 picomol/l, and the working solution was prepared by adding 10 l of stock solution to 90 L of nuclease free water to obtain a working primer solution of 10 picomol/l (stored at freezer -20 C).

Competent cells of the above-mentioned *E. coli* strain were produced using $CaCl_2$ as previously reported [17]. In a 250 mL Erlenmeyer flask, 100 mL LB was inoculated with 1 mL of overnight E. coli seed culture. The infected soup was incubated for 2-3 hours at 37°C with 200 rpm agitation until it reached an optical density of 0.4 at 600 nm. After that, the germs were put on ice for 30 minutes to cease growing. The cells were extracted by centrifugation at 4,500 rpm for 20 minutes at 4 degrees Celsius. The bacterial pellet was suspended in 20 mL of cool 0.1 M $CaCl_2$ and maintained on ice for 30 minutes after decanting the supernatant. Cells were harvested by centrifugation at 4,500 rpm for 20 minutes at 4°C. The bacterial pellet was suspended in 2 mL of chilled 0.1 M $CaCl_2$, and this bacterial suspension is chemically competent E. coli cells at this point.

Chemically competent E. coli cells were combined with 2-3L (50 ng) of the vector in an eppendorf tube (100L) (plasmid). For 40 minutes, the mixture was maintained on ice. The cells were then subjected to a heat shock in a water bath at 42°C for 45 seconds before immersing the eppendorf tube in ice for 5 minutes. The eppendorf tube was then filled with 900 mL of LB broth and incubated at 37°C for 1.5 hours with 180 rpm agitation. This 1 mL culture was disseminated on the surface of LB agar plates with the appropriate selectable marker kanamycin at a final concentration of 34 g/mL at the conclusion of the incubation period. The inoculated agar plates were then incubated for 24 hours at 37°C.

2. Results and Discussions

The map of the recombinant construct pET-28a (+)/Cox william, which was synthesized by GenScript Co. and created using SnapGene software, as shown in Figure 2. The recombinant plasmid is 7045 bp long after the cholesterol oxidase gene has been inserted. The whole length is 7045 bp, as displayed. In terms of nucleotide and protein molecular weights, the predicted recombinant protein cholesterol oxidase should be 1821bp and 69.3 kDa, respectively. The cholesterol oxidase gene was 1821bp in length. The 6-His tag would provide the recombinant cholesterol oxidase protein an additional 18 amino acids. Furthermore, the XhoI recognition site would add two additional amino acids.

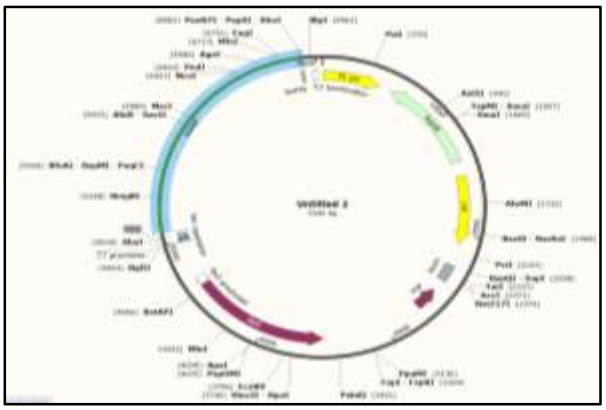

Figure 2. *The map of the recombinant construct pET-28a (+)/Cox_william*

As a consequence, 23 more amino acids would be added to the recombinant cholesterol oxidase protein, resulting in the creation of a 630 amino acid recombinant cholesterol oxidase protein. The final recombinant protein would have had 629 amino acids when the stop codon was removed. The recombinant protein's anticipated molecular weight is 69.3 kDa. The recombinant Williamsia marianensis strain of the Cox william gene was expressed in *E. coli* BL21 (DE3) Rosetta Strain; host strain detects an able level of gene expression was achieved after induction with (one mM of IPTG), for 18 hours at 30°C; then after cell lysis, the protein extract (soluble fraction) of the recombinant protein was purified with IMAC Chromatography. Figure 3 shows the twofold restriction digestion pattern of pET-28a (+)/Cox William. Two bands were obtained: one for the plasmid vector (4200 bp) and another for the cholesterol oxidase gene (2800 bp).

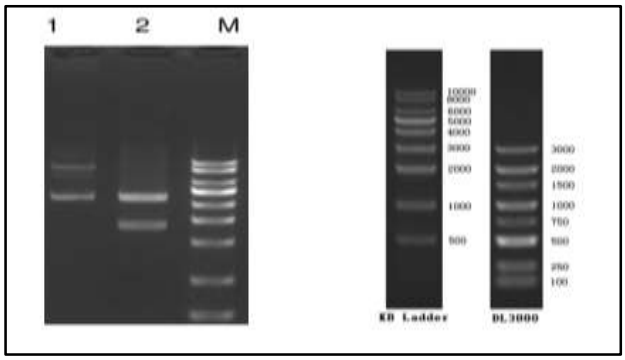

Figure 3. *Agarose gel electrophoresis (1%) of restriction pattern digestion of pET-28a (+)/Cox_william with MluI and XhoI*

Prokaryotic microbes created all of the cholesterol oxidase (pathogenic and nonpathogenic bacteria). Nonpathogenic bacteria use ChO as a metabolic tool for getting carbon sources from cholesterol breakdown, but pathogenic bacteria use it to infect host macrophages by oxidizing membrane cholesterol [18]. Many attempts have been attempted to extract ChO from original microorganisms so far. However, there are several drawbacks to this strategy, such as challenging growing circumstances and limited production of the original microorganisms [19]. ChO genes from several bacterial sources have been cloned and expressed, indicating that they are suitable for commercial enzyme production [20].

These "recombinant" forms were employed to effectively convert *E. coli*; the process seemed to produce 100% recombinant clones. (Shuldiner and his friends devised another LIC approach that utilizes denaturation and heterologous annealing of the PCR product and vector and is difficult to regulate [21]. The automodel command was then used to conduct homology modeling. The variable target function approach with conjugate gradients was then used to improve each model [22]. The current work produced a phylogenetic tree based on detected nucleic acid variations. This tree depicted the genetic relationship between Williamsia marianensis cholesterol oxidase and cholesterol oxidases from other species.

3. Conclusions

The purpose of this study was to find and express the cholesterol oxidase gene from Williamsia marianensis in E. coli, as well as to look at the sequence encoded cholesterol oxidase in silico. The findings of this investigation revealed the three-dimensional structure of Williamensia marienesi cholesterol oxidase protein sequence. Burkholderia cepacia FAD glucose dehydrogenase gamma-alpha subunit complex crystal structure).Improved enzymatic performance had been attained using a design based on structure and function relationships. Qin and his team in 2014 were investigated substrate selectivity and affinity by introducing amino acid alterations into Streptomyces cholesterol oxidase utilizing site-directed mutagenesis and structural comparisons [22].

The recombinant Cox william construct was first expressed at 4.5 U/mL in E. coli BL21 (DE3) Rosetta strains bearing the pET-28a (+)/Cox william construct. When the LB growing medium was replaced with the applied optimized method, the traceable Cox william construct activity in the cell lysate of the recombinant Rosetta strain was effectively increased. After ion exchange column separation, cholesterol oxidase was purified to homogeneity and contained DEAE Sepharose CL-6B with 501.05 U total activity and 31.15 mg protein. With a specific activity of 16.08 U/mg of protein, the enzyme was isolated [23]. In *E. coli* BL21 (DE3) Rosetta strains carrying the pET-28a (+)/Cox william construct, the recombinant Cox william construct was initially produced at 4.5 U/mL. The traceable Cox william construct activity in the cell lysate of the recombinant Rosetta strain was effectively raised

when the LB growth medium was changed with the applied optimized technique.

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Research Article

Experimental Testing of the Radiation Shielding Properties for Steel

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Radiation Shielding
Steel
NaI (Tl) detector

Abstract:

The development of nuclear technology and starting it to bed used in various fields made radiation part of our life. Thus protection against radiation become one of the most important topics in physics. The purpose of this work is to measure radiation shielding properties of steel sample. In this study we measured radiation shielding properties of some steels using a gamma spectroscopy system.

1. Introduction

Radiation can be defined as a simply energy in motion (particles or rays) emitted from radioactive atoms and travels through space and materials as well. It can cause ionization or excitation of the atoms. Moreover, radiation is invisible and cannot be detected by human beings senses [1]. Gamma spectrometric measurement technique and the efficiency of radiological devices are important for nuclear technology [2]. Gamma emission is a type of radioactive decay; it degenerates reactions that result in transmutation and leaves the resultant nucleus in an excited state (Figure 1) [3]. The biological hazard of gamma-ray radiation is considered to be an external hazard and can result in radiation exposure to the whole body. In order to be protected from this hazardous effect radiation shielding properties of used materials should be known. In this study the absorption coefficients of steel has been measured and also calculated.

2. Experimental Details

The frequent dense material used to attenuate the gamma rays is lead [4,5]. In this study the radiation shielding properties of Boron carbide (B_4C) powders have been tested experimentally, using a gamma spectroscopy system containing NaI (TI) detector [6,7,8].

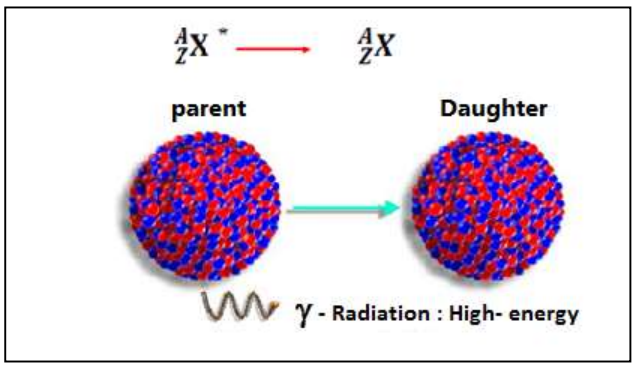

Figure 1. *The processes of gamma emission [3]*

The absorption properties of steel were measured (Figure 2). To eliminate or reduce scattering photons

and background activity, the lead plate used to cover the geometry configuration (Figure 3). The obtained spectrum is displayed in Figure 4.

In the gamma ray matter interaction either a large energy transfer or even complete absorption of the incident gamma rays may occur.

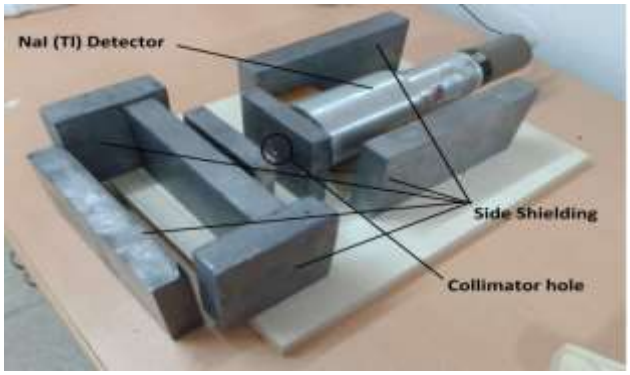

Figure 2. *The picture of the experimental setup [9]*

The linear attenuation coefficients can be obtained comparing I and I_o as shown in equation 1 [9]:

$$I = I_o e^{-\mu x} \quad (1)$$

As shown in Figure 4 that the energy calibration of system was done using ^{60}Co and ^{137}Cs sources. In figure 5, the detection efficiency is displayed as a function of energy [10].

Figure 3. *Side and up shielding plate*

3. Results and Discussions

The radiation shielding properties of steels have been measured and results were compared with the calculation. The results were displayed in Figure 6. It can be seen from this figure that the calculation and measurement are in agreement. Figure 6 also shows that the linear attenuation coefficients varied with the gamma ray energies and this may be results of the different mechanism of gamma rays with the materials.

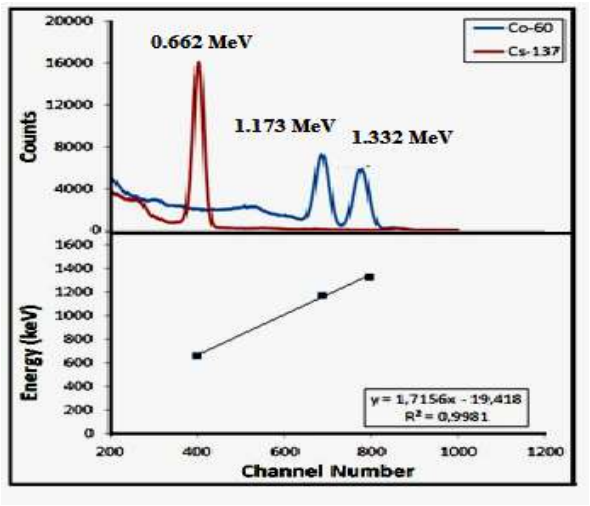

Figure 4 *Energy spectrum and related fit*

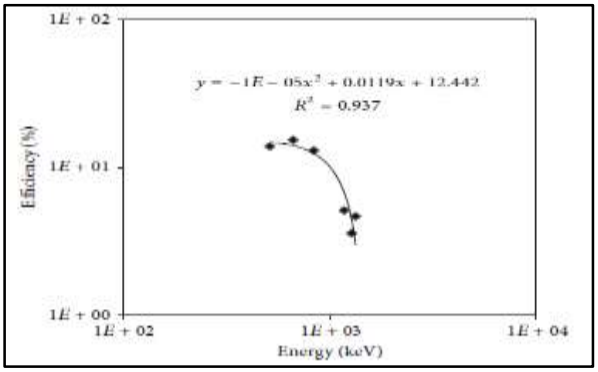

Figure 5. *NaI (Tl) detector efficiency as a function of gamma ray [9]*

4. Conclusions

The radiation shielding properties of steel sample has been calculated at photon energies of 1 keV to 100 GeV using the XCOM online calculation methods, and the experimental results were compared. It can be seen that the online calculated and the experimental measuring results are in good agreement. As well as can be concluded from this work that the linear attenuation coefficients decreased with the increasing photon energy.

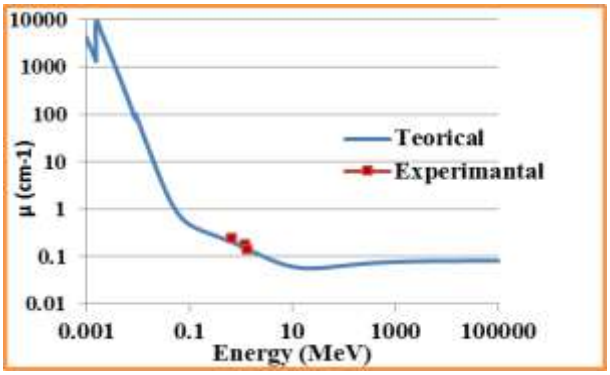

Figure 6. *The linear attenuation coefficient of composite samples as a function of photon energies*

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Research Article

The Effectiveness of Homogeneous Classifier Ensembles on Customer Churn Prediction in Banking, Insurance and Telecommunication Sectors

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Abstract:

The prediction of customer churn is a big challenging problem for companies in different sectors such as banking, telecommunication, and insurance. It is a crucial estimation for many businesses since obtaining new customers frequently costs more than holding present ones. For this reason, analysts and researchers are focus on to investigate reasons behind of customer churn analyzing behaviors of them. In this paper, an ensemble-based framework is proposed to predict the customer churn in various sectors, namely banking, insurance, and telecommunication. To demonstrate the effectiveness of proposed ensemble framework, k-NN, logistic regression, naïve Bayes, support vector machine, decision tree, random forest, multilayer perceptron algorithms are employed. Moreover, the effects of the inclusion of feature extraction process are investigated. Experiment results indicate that random forest algorithm is capable to predict churn customers with 89.93% of accuracy in banking, 95.90% of accuracy in telecommunication, and 77.53% of accuracy in insurance sectors when feature extraction procedure is carried out.

1. Introduction

In the present-day world, there is a sequence of telecom, bank, and insurance companies contending in the market to raise their customer portion. Moreover, customers have various alternatives in the shape of better quality and less costly getting service. The eventual objective of companies is to maximize their gain and subsist in a competitive market [1-2]. The churn of customers occurs when customers are not pleased with the service of any company. This concludes in service transmigration of customers who initiate replacing to other companies that operate in the same area. Because of this reason, customer satisfaction is staminal for the companies by preventing customer churn and retaining the valuable customers. [3-4].

From this point of view, companies make very serious investments to retain their customers. The companies have improved methods to determine and keep their clients since it is less costly than fascinating the new ones [3]. This is because of the expenses comprised in advertisements, workforce, and grants which can boost to nearly five to six times than holding present customers [5]. The necessity of retaining clients requires to advance a precise and high-performance approach for determining churn clients. Among the investments, there resides many data mining tools and machine learning approaches which can be employed to analyze this kind of data. The methods are evaluated to investigate the data and explore reasons behind customer churning. Moreover, the approaches can be utilized for the purpose of detecting customers that tend to churn.

Ensemble techniques utilize multiple classifiers to acquire a better success than a single learner. An ensemble classifier is a set of consolidated weak classifiers. During training stage, each classifier is trained respectively on a given training data set. An ensemble methodology is generally constructed an ensemble generation and fusion steps. In the first step, a diversified group of learners is generated from the training data set. In the second phase, the outputs of the classifiers are consolidated to acquire a final decision. The main approach in ensemble methodology is therefore to produce many classifiers and consubstantiate outputs of classifier such that the consolidation of learners boosts the

success of a base classifier [6-9]. If all the classifiers are constructed by utilizing the same technique, the ensemble system is named as homogeneous, otherwise it is entitled heterogeneous. Heterogeneous ensemble approach mainly employs more than one classifier to perform diversity [9-10]. In this work, we concentrate on the efficiency of homogenous classifier ensembles for forecasting customer churn in different sectors namely, banking, telecommunication, and insurance. For this purpose, proposed homogeneous ensemble technique, random forest, is compared with the traditional machine learning methods (k-NN, logistic regression, naïve Bayes, support vector machine, decision tree) and multilayer perceptron. Experiment results represent that the utilization of random forest method as a homogenous ensemble model outperforms conventional machine learning techniques in all sectors.

The rest of the research is designated as follows: Section 2 presents related works on the churn prediction. Section 3 presents framework and the techniques used in the research. Experiment results are given in Section 4. Section 5 concludes the paper with a conclusion and discussion.

2. Literature Background

This section presents a summary of the literature studies on churn detection. In [11], authors propose to predict customer churn in telecom sector with the help of machine learning techniques and big data platform. For this purpose, social network analysis (SNA)-based features are introduced before modeling SyriaTel telecommunication data. After that, decision tree, random forest, gradient boosted machine tree, and extreme gradient boosting techniques are assessed. Experiment results prove that the inclusion of SNA-based features boosts the prediction performance of churn customers with the increment nearly 9% in AUC. Moreover, authors emphasize extreme gradient boosting model exhibit superior performance compared to the others.

In [12], authors concentrate on the churn prediction problem and factors behind of it in telecom sector. As a first step, feature selection procedure is performed employing information gain, and correlation attribute ranking filter. Then, classification task is carried out with the aid of random forest algorithm to determine whether the customers tend to churn or not. After specifying the prediction performance, the reasons behind of churn is investigated by segmenting customers into different groups through k-means clustering. Authors conclude the study that the utilization of random forest and k-means techniques are capable to determine customers that likely to churn and factors behind of it, respectively. In [13], authors present a machine learning approach to construct a system that detect the churn customers in telecom sector. In this approach, data-preprocessing and feature analysis is performed. Then, gravitational search algorithm is carried out for the purpose of picking features up. Finally, data set is modeled with Adaboost and XGboost techniques. Authors conclude the paper that Adaboost exhibits superior performance with 81.71% of accuracy score. In [14], authors introduce a model that infers parameter estimation for the prediction of telecom clients. Principal component analysis is utilized as feature selection technique. To model the data, five different machine learning models are employed with 3 different parameter settings. These are k-nn, decision tree, random forest, stochastic gradient descent (SGD), multilayer perceptron (MLP). Based on experiment results, it is observed that third decision tree model outperforms all other models with 71% of F-measure by performing minimum sample split.

In [15], authors propose a system that predicts the customer churn using different machine learning techniques in banking sector. These methods, namely, k-nn, support vector machine, decision Tree, and random forest are blended with various feature selection techniques. Authors report that the usage of random forest method exhibits better classification accuracy compared to the others. In [16], authors focus on the churn prediction and retention of IT, banking, and telecom sectors. For this aim, classification performance of logistic regression, random forest, support vector machine, and XGBoost models are compared, comprehensively. In [17], authors propose to predict customer churn in retail banking with different machine learning models. Random forest, support vector machine, stochastic boosting, logistic regression, classification and regression trees, and multivariate adaptive regression splines are carried out on real data. Experiment results indicate that random forest, and stochastic boosting generally present better classification accuracies in different periods.

In [18], authors propose a novel technique using multi-objective rain optimization algorithm with the help of the combination of synthetic minority over-sampling (SMOTE) model with optimal weighted extreme machine learning (OWELM) method for the purpose of predicting churn of customers. The proposed technique comprises of three stages, namely pre-processing, dataset balancing, and categorization. Authors report that experiment results of proposed technique exhibit remarkable accuracy scores on three datasets. In [19], authors concentrate on metaheuristic optimization technique namely, chaotic pigeon to handle the customer churn

by predicting it with long short-term memory network model. To show the effectiveness of the proposed model, authors perform experiments on there datasets. Approximately, 95.56% accuracy score is provided on the first dataset as the best result. In [20], authors utilize the spoken contents in phone communication for the purpose of discovering possible churn of customers. A large-scale call center dataset is composed of two million calls from more than two hundred thousand clients. The experimental results indicate that the proposed model can forecast the risks of customer churn with the aid of machine learning techniques.

Our study differs from the literature studies in that both evaluating three different sectors and eight different machine learning classifiers extensively in terms of predicting customer churn.

3. Methodology

3.1. Linear Discriminant Analysis (LDA)

Linear discriminant analysis [21] is proposed by R. Fischer. It comprises discovering the projection hyperplane that diminishes the intercategory variance and maximizes the space between the reflected means of the categories. The hyperplane is utilized for categorization, reduction of dimension.

3.2. Logistic Regression (LR)

Logistic model is a statistical technique that models the probability of an event among out of two options performing by accomplishing the logarithm of the odds for the event be a linear consolidation of one or more independent predictors. In regression analysis, logistic regression [22] forecasts the variables of a logistic model or the coefficients in the linear consolidation. As in this work, there is a unique binary dependent parameter in binary logistic regression where the two values are tagged as "0" and "1".

3.3. K-Nearest Neighbor (K-NN)

K-nn is a genre of lazy learning method that is utilized for classification, and regression tasks. K-nn is a basic algorithm that is readily carried out through the nearest neighbor, distance functions. The method allocates all cases and classifies new conditions depending on similarity metrics namely, Euclidean, Manhattan, and Minkowski [23-24]. In classification and regression tasks, the input is related to the k closest training samples in the attribute space. In this study, K-nn algorithm is employed for the categorization problem enforcing Euclidean distance and setting k as 3.

3.4. Naïve Bayes (NB)

Naïve Bayes is a classifier based on Bayes' theorem that proposes independency between features [25]. The naïve Bayes technique is particularly evaluated when the size of input features is high. In the literature studies [26-32], the naïve Bayes classifier is assessed due to its superior performance, training time, and simplicity. In the experiments, Gaussian naïve Bayes model is employed.

3.5. Support Vector Machine (SVM)

The support vector machine (SVM) is a supervised machine learning technique that is one of the most popular, precise, and vigorous models for classification and regression tasks. SVM is proposed by Cortes and Vapnik [33] for the purpose of categorizing data that are linearly distinguishable. In addition to linear categorization, SVMs effectively ensure a non-linear categorization with the help of kernel trick, indirectly mapping inputs into high-dimensional attribute space. In this work, linear kernel is employed in the experiments.

3.6. Decision Tree (DT)

Decision tree [34] model constructs a classification technique that employs a graph like tree for decision making. Decision tree utilizes a tree demonstration to learn function of categorization that estimates the value of a dependent parameter, given the values of the independent features. It is a supervised learning algorithm that splits a tagged data set into smaller subsets while constructing decision tree. The procedure is sustained until the last subset has only similar objects.

3.7. Random Forest (RF)

Random forest is an ensemble learning model for regression problems and classification. The machine learning method of random decision forests is presented by Ho [35]. RF constructs multiple trees and consolidates them for the purpose of obtaining more robust and precise system outputs. To compose the forest, randomness is provided with consolidating bagging and random subspace methods. Thus, RF assesses random thresholds for each individual feature to construct different trees instead of utilizing best possible thresholds. The number of learners is set to 100 in the experiments.

3.8. Multilayer Perceptron (MLP)

The multilayer perceptron is a popular supervised learning model among other methods of artificial

neural networks that is carried out for forecasting problems in the literature. MLP composes of fundamentally three layers, namely, input layer, hidden layer, and output layer. Hidden layer may compose of one or more than of more activation specified [36]. MLP is a feed-forward neural network that maps data into a set of related outputs. The MLP has robust computing sufficiency because of facilitating the remedy of non-linear problems. In the experiments, the MLP model consists of 8 neurons and 1 dense layer. ReLU is chosen as the activation function used in the layer. In addition, the heap size is 8 and the iteration value is 500. The remaining parameters are set as default.

3.9. Model

In this work, the extensive analysis of churn prediction is proposed by utilizing machine learning algorithms. The datasets are employed to analyze churn tendency in three different sectors, namely telecom, banking, and insurance. The telecom, banking, and insurance data sets include 3333, 22067, and 6321 instances, respectively. The number of features is 14 for Insurance data set, 21 for banking and telecom data sets as seen in the Figure 1. After gathering data set, principal component analysis (PCA) is applied for the purpose of feature reduction to improve the prediction accuracy of the system. After applying PCA, 11 features for Insurance data set, 15 features for banking data set, and 17 features for telecom data set are remained. In insurance data set, the features namely, row number, surname, and HasCrCard are eliminated. In banking data set, customer_id, gender, city, dependents, branch_code, and vintage features are removed. In telecom data set, state, area code, international plan, and voice mail plan attributes are extracted. After that, data sets are modeled with six different machine learning algorithms, an ensemble algorithm, and an artificial neural network (ANN). The models are linear discriminant analysis (LDA), logistic regression (LR), k-nearest neighbor (k-NN), naïve Bayes (NB), support vector machine (SVM), decision tree (DT), random forest (RF), multilayer perceptron (MLP).

4. Experiment Results

In this section, extensive experiments are performed to predict the customer churn employing in three different sectors employing machine learning algorithms. Accuracy (AC), f-measure (FM), precision (PR), and recall (RC) are employed as evaluation metrics to demonstrate the performance of the models. The accuracy score to categorize as false when false and true when true to the total number of data presented in Equation 1. In the experiments, dataset is splitted into 80% as training set, and remaining is test set.

$$Accuracy = \frac{TP+TN}{TP+NP+TN+FN} \quad (1)$$

Precision presents the proportion of accurately estimated positive observation outcomes to sum of positive forecasts. Negatives offers the proportion of precisely forecasted negative observation scores to sum of negative predictions. In Equation 2, precision is given.

$$Precision = \frac{TP}{TP+NP} \quad (2)$$

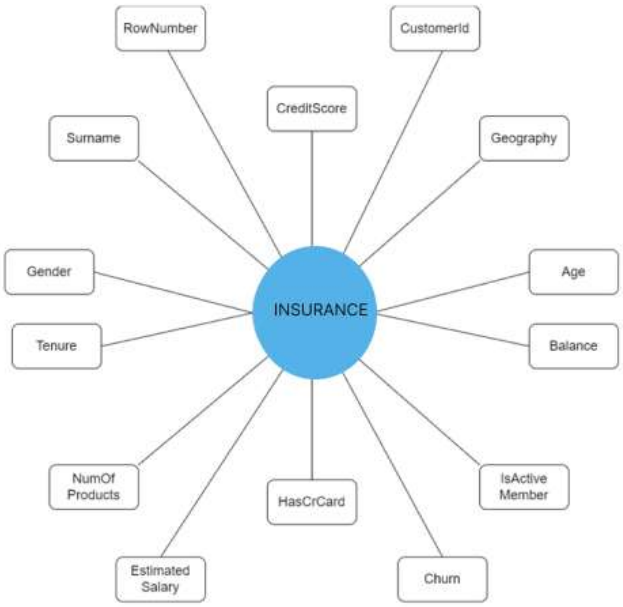

Figure 1. *The feature details of Insurance data set.*

Recall is employed for the purpose of evaluating the precision of the method. RC is calculated as the ratio of correctly estimated positive forecasts to the number of all essentially correct samples given in Equation 3.

$$Recall = \frac{TP}{TP+FN} \quad (3)$$

Both false-positive and false-negative scores are included in the F-measure calculation as in Equation 4. When the class distribution is skewed, F-measure as an evaluation metric present more realistic scores compared to the sum of accuracy criteria when assessing the performance of the method.

$$F-measure = \frac{2*Recall*Precision}{Recall+Precision} \quad (4)$$

The following abbreviations are employed in the tables: RF: Random Forest, k-NN: k-nearest neighbor, LR: Logistic Regression, LDA: Linear Discriminant Analysis, NB: Naïve Bayes, SVM: Support Vector Machine, DT: Decision Tree, MLP: Multilayer Perceptron. The best scores are shown as bold in all tables. We also present the efficiency of using feature extraction by exhibiting experiment results in the tables.

In Table 1, the accuracy results of all classification techniques are demonstrated in insurance dataset without applying feature extraction. It is obviously observed that random forest exhibits superior classification performance as a homogeneous ensemble algorithm with 72.05% of accuracy. It is followed by MLP, SVM, NB, and LR nearly 67% of accuracy. The usage of k-NN techniques does not seem meaningful because of the worst classification success with 61.60% of accuracy score. Even though MLP is the second-best technique that fits to classify churn customers, nearly 5% difference in accuracy is significant when the superior performance of RF is considered. As a result of Table 1, the utilization of ensemble model exhibits remarkable result even if feature extraction is not carried out.

Table 1. *The results of all classification techniques are demonstrated in insurance dataset without feature extraction.*

Insurance	**Evaluation Metrics**			
Models	**AC**	**FM**	**PR**	**RC**
LDA	66.98	68.34	72.21	77.45
LR	67.38	70.13	71.36	75.36
k-NN	61.60	64.57	65.13	70.30
NB	67.39	65.42	65.86	74.67
SVM	67.30	66.36	68.40	75.89
DT	65.80	67.80	67.33	72.50
RF	**72.05**	73.05	75.27	80.33
MLP	67.83	71.57	70.30	76.08

In Table 2, the performance results of all classification techniques in terms of evaluation metrics in insurance dataset are presented when feature extraction procedure is applied.

Table 2. *The results of all classification techniques are demonstrated in insurance dataset with feature extraction.*

Insurance	**Evaluation Metrics**			
Models	**AC**	**FM**	**PR**	**RC**
LDA	70.52	70.40	71.00	80.42
LR	72.80	73.35	72.81	82.60
k-NN	68.45	70.22	71.96	81.02
NB	71.94	73.90	74.57	83.55
SVM	72.07	75.48	77.85	84.46
DT	70.48	72.06	73.09	75.57
RF	**77.53**	79.10	82.55	86.92
MLP	72.14	71.90	73.10	82.13

As it is clearly seen that in Table 2, RF outperforms other techniques with 77.53% of accuracy. It is followed by LR with 72.80%, MLP with 72.14%, SVM with 72.07%, NB with 71.94%, LDA with 70.52%, DT with 70.48%, k-NN with 68.45% of accuracy scores. Furthermore, the inclusion of feature extraction process boosts the classification performance approximately 5% in RF model. The order of model performances can be summarized as: RF> LR> MLP> SVM> NB> LDA> DT> k-NN. The performance order is not like Table 1. The reason behind of this, the classification success of LR, MLP, SVM, and NB is very close to each other. The inclusion of feature extraction procedure contributes significantly to predict customer churn

Table 3. *The results of all classification techniques are demonstrated in banking dataset without feature extraction.*

Banking	**Evaluation Metrics**			
Models	**AC**	**FM**	**PR**	**RC**
LDA	81.83	83.14	81.25	81.60
LR	83.51	85.10	76.23	85.02
k-NN	84.23	87.35	81.37	88.55
NB	80.79	88.23	83.93	84.68
SVM	82.46	82.84	85.00	87.02
DT	77.68	83.10	80.59	85.94
RF	**86.38**	87.45	87.65	86.06
MLP	84.60	83.48	85.23	85.90

with minimum %4 advancement, and maximum %8 enhancement. In Table 3, the classification results of each learning model are presented in terms of different evaluation metrics for banking dataset. The superior performance of RF is clearly seen in the banking dataset with 86.38% of accuracy when feature extraction is not performed. In banking dataset, RF exhibits better classification success compared to the insurance data set with roughly 14% advancement in classification accuracy. The poorest classification performance is carried out by DT in banking dataset with 77.68% of accuracy score. Even if the success of DT is considered in insurance data set, 12% improvement is provided in banking data set. In Table 2, k-NN algorithm is surprisingly competitive with 84.23% of accuracy when the complexity of MLP algorithm with 84.60% of accuracy is considered. The success of classification models is ordered as: RF> MLP> k-NN> LR> SVM> LDA> NB> DT. In Table 4, classification performance of each technique is demonstrated in terms of different evaluation measures in banking dataset. RF outperforms others with 89.93% of accuracy. RF is capable to classify customers' churn especially in banking dataset with the help of feature extraction method. MLP is also competitive with 87.40% of accuracy score.

Table 4. *The results of all classification techniques are demonstrated in banking dataset with feature extraction.*

Banking	Evaluation Metrics			
Models	**AC**	**FM**	**PR**	**RC**
LDA	84.42	85.70	84.36	89.45
LR	85.57	87.43	86.90	90.13
k-NN	86.30	85.30	84.21	90.51
NB	81.22	83.01	82.57	87.24
SVM	85.55	86.40	85.68	88.00
DT	80.38	80.27	79.26	85.02
RF	**89.93**	90.51	89.75	93.57
MLP	87.40	88.13	87.59	90.45

Similarly, k-NN exhibits superior performance when Table 1 and Table 2 is considered in insurance data set. The inclusion of feature extraction approach does not influence the success of NB, significantly nearly with 1% improvement in accuracy result. The performance order of the models is the same as the results of Table 3. Although DT has the poorest classification success, it provides approximately 3% improvement with the inclusion of feature extraction procedure.

In Table 5, classification scores of the models are presented in telecom dataset in terms of different evaluation metrics when feature extraction process is not applied. Apart from the other data sets, NB exhibits the poorest classification performance with 84.41% of accuracy. It is followed by LDA with 84.86%, MLP with 85.22%, SVM and LR with 85.31%, k-NN with 87.41%, DT with 90.40%, and RF with 95.90% of accuracies. Differently from the Table 1, Table 2, Table 3, and Table 4, DT demonstrates the second-best classification success while in other datasets it exhibits the poor classification success. The performance sequence of the models varies as: RF> DT> k-NN> LR~SVM> MLP> LDA> NB. It can be arisen since the number samples and features of telecom dataset are proportionally less than the other datasets.

Table 5. *The results of all classification techniques are demonstrated in telecom dataset without feature extraction.*

Telecom	Evaluation Metrics			
Models	**AC**	**FM**	**PR**	**RC**
LDA	84.86	89.37	86.67	88.43
LR	85.31	84.04	82.00	88.16
k-NN	87.41	90.40	85.91	89.59
NB	84.41	86.39	86.88	85.92
SVM	85.31	85.80	84.57	85.10
DT	90.40	89.81	88.91	89.97
RF	**92.05**	91.36	90.14	89.72
MLP	85.22	86.13	85.48	85.81

In Table 6, the effect of feature extraction process is clearly observed when the improvements on each classification model are considered. RF indicates the best classification performance (95.90% of accuracy) with inclusion of feature extraction process when compared to the other datasets namely, insurance with 77.53%, and banking 89.93% of accuracy results. This means the inclusion of RF as an ensemble algorithm boosts classification success in each data set with different improvements. On the other hand, LDA exhibits the worst classification success with 85.10% of accuracy. As a result of Table 2, Table 4, and Table 6, process of feature extraction is beneficial in terms of advancing classification performance of the system to predict the customer churn for all three sectors. The best performance for each dataset is achieved by

Table 6. *The results of all classification techniques are demonstrated in telecom dataset with feature extraction.*

Telecom	Evaluation Metrics			
Models	**AC**	**FM**	**PR**	**RC**
LDA	85.10	87.22	87.95	88.36
LR	87.43	89.23	88.12	89.40
k-NN	90.15	91.55	92.00	91.23
NB	88.59	89.07	89.18	90.52
SVM	91.77	91.50	89.27	89.13
DT	93.46	90.59	91.27	90.00
RF	**95.90**	93.17	94.38	95.54
MLP	89.05	90.03	89.45	88.75

proposed RF model. The performance of the proposed model according to the training set percentages is presented in Figure 2. To show the effectiveness of the proposed model, experiment results are compared with the state-of-the-art studies. In [37], authors present transfer learning and ensemble learning based framework to categorize churn of customers. After transfer learning stage, GP-AdaBoost is employed to classification purpose. 75.40% of accuracy is obtained on orange dataset. In our experiments, after feature selection procedure, 95.90% of accuracy is achieved. In [38], authors focus on the hybrid firefly based to predict the churn of customers in telecommunication sector. Authors report that firefly-based algorithm can classify the churn customers with 86.38 of accuracy. There is a difference in terms of the number of instances when Orange telecom dataset is considered. Although dataset includes 50,000 records in [38], proposed model in our study outperforms with approximately 9% enhancement in accuracy score.

5. Conclusion and Discussion

In this work, the efficiency of homogeneous classifier ensembles on customer churn prediction in banking, insurance, and telecommunication sectors is investigated. For this purpose, different machine learning techniques are modeled to indicate the

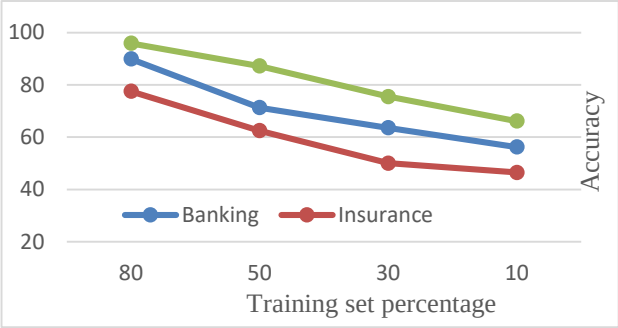

Figure 2. *The feature details of Banking data set.*

effectiveness of proposed ensemble framework. The models used in the study are k-NN, logistic regression, naïve Bayes, support vector machine, decision tree, random forest, multilayer perceptron algorithms are employed. Moreover, the impact of the inclusion of feature extraction stage are analyzed. Experiment results show random forest model can estimate churn customers with 89.93% of accuracy in banking, 95.90% of accuracy in telecommunication, and 77.53% of accuracy in insurance sectors when feature extraction procedure is performed. In future, we plan to develop deep learning methodology for predicting customers' churn by extending datasets and using different feature extraction techniques.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** 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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