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From Editor

In this issue of "International Journal of Electronics, Mechanical and Mechatronics Engineering (IJEMME)", we have especially selected the scientific areas which will cover future prospective Engineering titles such as Robotics, Mechanics, Electronics, Telecommunications, Control systems, System Engineering, Biomedical, and renewable Energy Sources.

We have selected only a few of the manuscripts to be published after a peer review process of many submitted studies. Accepted papers are as follows:

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Editor in Chief

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Explain to Interconnection Between Fe+2 Ions and Vitamin C in Food By Density Functional Theory

Merve KAYA[1]
E. Esra KASAPBAŞI[2]

Abstract
As we know vitamin C is a both reducing agent and creating acid increases the absorption of non-heme iron from the iron source in food. In this study we explain to relation between ascorbic acid with ferric iron (Fe^{+3}) by Density Functional Theory (DFT) method. Release to this effect firstly we optimized all molecules in this system than calculated to reaction mechanism energy.

Keywords: *Vitamin C, Iron metabolism, Gaussian, DFT*

Introduction
The first scientific studies on vitamin C that Holst and Frohlich is made in 1907, many foods, especially green vegetables and fruits began with the discovery of the inhibitory effects of the disease scurvy (1,2). Vitamin C, plays an important role in the water-soluble vitamins. There are two forms of structurally; D-ascorbic acid and L-ascorbic acid.D-ascorbic acid is inactive. The L isomer is biologically active form (3). Vitamin C is monosaccharide derivative which the chemical structure is $C_6H_8O_6$. In case of light red crystals, odorless and sour taste is a substance having (5). One of the most important function of Vitamin C, protecting the bodies against infection and bacterial toxin. Infections reduce the amount of vitamin C in the body. When these vitamins is taken a sufficient amount, prevented infection and vitamin C taken an amount increased, is seen that infections are reduction (6).

Dietary iron, there are heme iron (ferrous iron Fe^{+2}) and non-heme iron (ferric iron Fe^{+3}) found two forms caused by hemoglobin and myoglobin. Acid environment and reducing agents, especially non-heme are positive factors for the absorption of iron (7). Ascorbic acid is a both reducing agent and creating acid environment increases the absorption of non-heme iron from the iron source and availability. Ferric iron Fe^{+3}, ferrous iron Fe^{+2}reductions by ascorbic acid as a result of non-heme iron absorption is known to increase (8). In a study performed; the meal added to 50-100 mg ascorbic acid has been reported that the absorption of non-heme increase 2-3 times. In another study; yet given with meals 3 times a day for 9 months for women who have entered menopause 100 mg of ascorbic acid, iron storage status of women has been found to significantly affect positive (9).

Theoretically there are similar studies in the literature (10). However, vitamin C does not have a study on the impact of the reduction of ferrous iron (Fe^{+2}) to ferric iron (Fe^{+3}) (11).

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Materials and Methods

In this study we tried to explain reaction mechanism of Ascorbic Acid with Ferric Iron (Fe^{+3}). The studied molecules are named as Cvit, Cvit1, Cvit2, Cvit3, Cvit4, Cvit5, Cvit6 and Cvit7 which are depicted in Figure 1.In Table 1 for studied molecules code of molecules, molecular formulas, name of molecules and molecular weights are given.

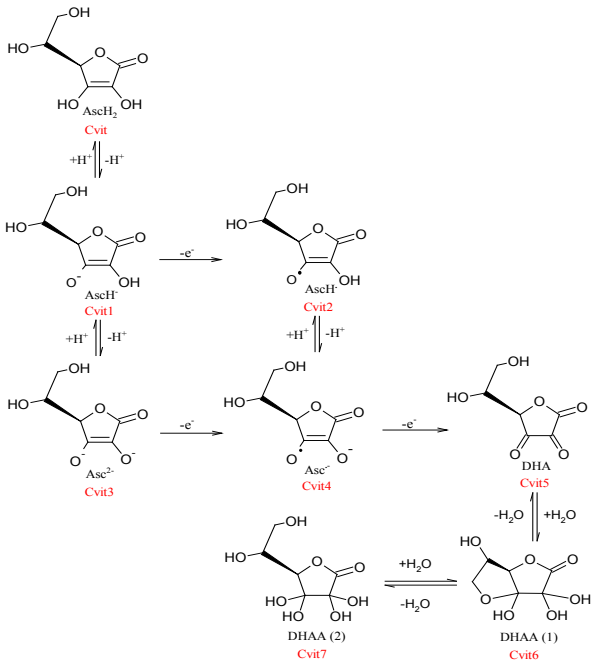

Figure1.*The Studied Molecules*

Table 1.*Code, structure formula, name and molecular weight for studying molecules*

Code	Structure formula	Name	Molecular weight (g)
Cvit	$C_6H_8O_6$	Ascorbic asit (Asc)	176
Cvit1	$C_6H_7O_6^-$	$AscH^-$	175
Cvit2	$C_6H_7O_6$	$AscH^-$	175
Cvit3	$C_6H_6O_6^{-2}$	$AscH^{2-}$	174
Cvit4	$C_6H_6O_6^-$	Asc^-	174
Cvit5	$C_6H_6O_6$	DHA	174
Cvit6	$C_6H_8O_7$	DHAA	192
Cvit7	$C_6H_{10}O_8$	DHAA	210
	Fe^{+2}	Ferroiron	55,84
	Fe^{+3}	Ferric iron	55,84
	H^+	Hydrogen ion	1
	H_2O	water	18

We can divide our study in third parts. In the first part, these molecules are optimized by the density functional theory (DFT) (12,13) method, using the B3LYP hybrid functional (14) with the 6-31g(d) (15) basis set (basis set 1) implemented a DFT study on the structural and optical properties, in the Gaussian 03W software package (16) which are illustrated in Figure 1. After optimization, reaction energies are calculated using optimized molecule energies. In the second part, enlargedbases set 6-311G (d,p) (basis set 2) are used for reaction energy. Then the results of reaction energies which are calculated with 6-311G (d,p) and 6-31G (d) are compared. In the last part, Natural Bond Orbitals (NBO) charge distribution of moleculesis calculated. In every stage of reaction mechanism we measured the charge transfers between molecules using calculated NBO charges.

Results and Discussion

Geometry optimizations of molecules are obtained using DFT methods B3LYP functional with basis sets 1 and 2 at gas phase and in water solution. Optimized molecular energies are given in Table 2.

Table 2. *Molecular Energy for Studying Molecules in kcal/mol*

Molecule	6-31G (d) Gas phase		6-311G (d,p)	
	E (a.u.)	E (kkal/mol)	E (a.u.)	E (kkal/mol)
Cvit	-684,75	-429.680,53	-684,97	-429.815,65
Cvit1	-684,23	-429.352,82	-684,41	-429.467,68
Cvit2	-684,12	-429.286,70	-684,33	-429.417,17
Cvit3	-683,50	-428.894,65	-683,72	-429.031,63
Cvit4	-683,62	-428.971,87	-683,83	-429.102,23
Cvit5	-683,52	-428.909,05	-683,72	-429.035,57
Cvit6	-759,98	-476.887,79	-760,21	-477.034,44
Cvit7	-836,41	-524.844,45	-836,68	-525.015,71
Fe^{+2}	-1261,50	-792.216,93	-1262,60	-792.280,63
Fe^{+3}	-1261,27	-791.446,50	-1261,36	-791.501,91
H_2O	-76,01	-476.96,19	-76,45	-479.70,77
H^+	0	0	-0,50	-315,10

When Table 2 observed basis set 2 energies are higher than basis set 1. This change is between -0,2 to -0,27 kcal/ mol for Cvit, Cvit1, Cvit2, Cvit3, Cvit4, Cvit5, Cvit6 and Cvit7.

The energies of reactions which are given in Figure 1 are calculated using equation 1 for basis set 1 and basis set 2. The results are given in Table 3.

$$\Delta H = \Sigma product - \Sigma reactant \quad \text{(Eq 1)}$$

Table 3. *6-31G (d) ve 6-311G (d,p) baz setleri ile hesaplanmış reaksiyon enerjileri*

ΔH	Reaction Mechanism	6-31G (d) E (kcal/mol)	6-311G (d,p) E (kcal/mol)
ΔH_1	Cvit→ Cvit1	327,71	32,87
ΔH_2	Cvit1→ Cvit2	66,12	50,50
ΔH_3	Cvit2 → Cvit4	314,83	-0,16
ΔH_4	Cvit4 → Cvit5	-62,83	66,67
ΔH_5	Cvit5 → Cvit6	-282,55	-28,10
ΔH_6	Cvit6 → Cvit7	-260,47	-10,50
ΔH_7	Cvit1 → Cvit3	458,17	120,94
ΔH_8	Cvit3 → Cvit4	-77,22	-70,60
ΔH_9	$Fe^{+3} + e^- \rightarrow Fe^{+2}$	-770,43	-778,72
ΔH_{10}	Cvit1 + Fe^{+3}→ Cvit2 + Fe^{+2}	-704,32	-728,22
ΔH_{11}	Cvit3 + Fe^{+3}→ Cvit4 + Fe^{+2}	-847,66	-849,32
ΔH_{12}	Cvit4 + Fe^{+3}→ Cvit5 + Fe^{+2}	-707,61	-711,70

$$\Delta H_1 \ \Delta H_2 \ \Delta H_3 \ \Delta H_4 \ \Delta H_5 \ \Delta H_6$$

Cvit→Cvit1→Cvit2→Cvit4→Cvit5→Cvit6→Cvit7

$$\Delta H_{Total} = \Delta H_1 \ \Delta H_2 \ \Delta H_3 \ \Delta H_4 \ \Delta H_5 \ \Delta H_6 \quad \text{(Eq 2)}$$

$$\Delta H_{Total} = 102{,}80 \text{ kkal/mol}$$

Regarding to Equation 2 total reaction mechanism energy is calculated. As can be concluded from the results total reaction mechanism is endothermic. Using Ferric Iron used as source of electron (Equation 3) total reaction mechanism is recalculated.

$$Fe^{+3} + e^- \rightarrow Fe^{+2} \quad \text{(Eq 3)}$$

As electron source when iron is used total reaction is exothermic.

$$\Delta H_{Total} = -\ 1312{,}41 \text{ kkal/mol}$$

Same calculation carried out for basis 2 as done in basis 1.

ΔH_{Total} = 111,28 kcal/mol without iron for basis set 2

ΔH_{Total} = -1445,81 kcal/mol with iron for basis set 2.

For all molecules used in this study the giving atomic numbers show in Figure 2 for references molecule.In order to calculated NBO charges `pop=(nbo,savenbos)` key word are used. Calculating NBO charges are given in Table 4.

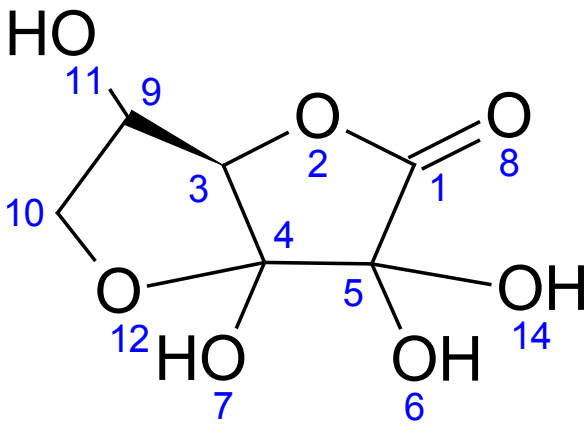

Figure2. *Referencemolecule with giving atomic numbers*

In order to better observe the change of charges during reactions a graph is plotted as in Figure 3 using values inthe Table 4.

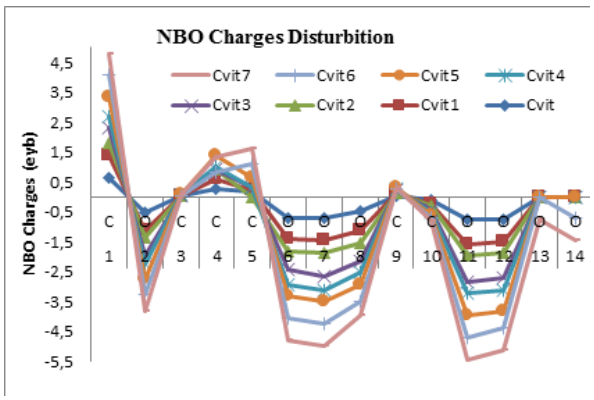

Figure 3. *NBO charge transfer graph between molecules*

When Figure 3 is investigated:

- In Cvit1 while charges of number 1 and 4 carbon atoms increase, the charge of the number 5 carbon atom decreases compared to Cvit. The reason for this behaviour can be attributed to removing of one H atom from hydroxyl group which is bounded to the number 1 C atom. When compared to Cvit, charges of all oxygens in Cvit1 are increased.
- Due to the removed electron in Cvit2 charges of the oxygens are decreased. Despite such decrease in Oxygens, the number 5 C atom in Cvit2 had different negative values.
- While in transition from Cvit2 to Cvit4, structure loses 1 hydrogen atom and the

Table 4. *NBO charge distributions of the molecules (in eyb)*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	C	O	C	C	C	O	O	O	C	C	O	O	O	O
Cvit	0.64	-0.53	0.01	0.26	0.19	-0.71	-0.69	-0.47	0.05	-0.12	-0.76	-0.74	-	-
Cvit1	0.72	-0.60	0.01	0.33	0.02	-0.72	-0.76	-0.65	0.05	-0.12	-0.81	-0.78	-	-
Cvit2	0.45	-0.24	0.001	0.31	-0.22	-0.38	-0.43	-0.42	0.03	-0.07	-0.37	-0.37	-	-
Cvit3	0.52	-0.59	0.02	0.04	0.33	-0.64	-0.80	-0.64	0.08	-0.12	-0.92	-0.84	-	-
Cvit4	0.35	-0.28	0.01	0.07	0.02	-0.50	-0.43	-0.34	0.03	-0.07	-0.37	-0.38	-	-
Cvit5	0.65	-0.51	0.003	0.36	0.30	-0.37	-0.38	-0.43	0.05	-0.12	-0.74	-0.72	-	-
Cvit6	0.77	-0.53	-0.03	-0.56	0.49	-0.74	-0.75	-0.53	-0.01	-0.08	-0.72	-0.57	-	-0.73
Cvit7	0.69	-0.53	0.03	0.53	0.47	-0.74	-0.76	-0.47	0.05	-0.13	-0.77	-0.74	-0.75	-0.72

number 4 and 1 C atom loses more charge compared to all other structure.

- It has been observed that since the structure lost an electron while forming Cvit5, It showed similar changes with Cvit2. While forming Cvit6 and Cvit7 a water joined in both structures.
- In Cvit6 number 4 C atom negatively charged however in transition to Cvit7 it changed back to earlier value

Conclusion

In this study we explain to relation between ascorbic acid with ferric iron (Fe+3) by Density Functional Theory (DFT) method.

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The Control of Brushless DC Motors

H. C. BAYRAKTAR[1]
H. H. BALIK[2]

Abstract
In this paper, about brushless DC motors and their structures, working principles, types, control logic and control methods commonly used are given general information. Nowadays, using BLDC motors are increased because of their advantages. For example, simple structure, easy control, small size and high effiency etc. Therefore, BLDC motors and their controls has become increasingly important in recently. The result of this paper, most common control techniques are also discussed.

Keywords: *Brushless DC Motor; Control*

1. Introduction

BLDC motor is a special electric machine. It becomes within class of synchronous motor. The rotor of BLDC motor is constituted permanent magnet. The structure of BLDC motor looks like synchronous machines.

BLDC motor is defined the shape of the back-EMF of the synchronous motor. Both BLDC and PMSM (Permanent Magnet Synchronous Motor) have permanent magnets on the rotor, but differ in the flux distributions and back-EMF profiles. The back-EMF is trapezoidal in BLDC motor case and sinusoidal in the PMSM motor case. For that reason, the mathematical model of BLDC motor is non-linear because of analysing of BLDC motor is difficult [1].

Nowadays, brushless DC motors have been preferred more than the other electric motors because of their advantages. Principal advantages; high efficiency, high reliability, less maintenance, silent operation, being easily cooled, long life (no brush and collector erosion) and being easily controlled. Unfortunately, BLDC motors have disadvantages that have a control system more complexity, expensive system and require position sensors to sensing rotor position. Sensorless control contains higher requirements for control algorithms and more complicated electronics. Sensorless control of BLDC motors can't achieve high speed and acceleration according to motor control with sensors [2].

These motors have been widely used in a variety of applications in automobile industry (hybrid vehicles), space and computer technology, medical electronic, military areas, industrial automation, robotic applications and household products [2].

2. Structures

BLDC motor is composed of a permanent magnetic rotor and three winding stator coils. Besides, it's used to operate inverter and driver circuit and controller [4]. Fig.1 illustrates BLDC motor's structure.

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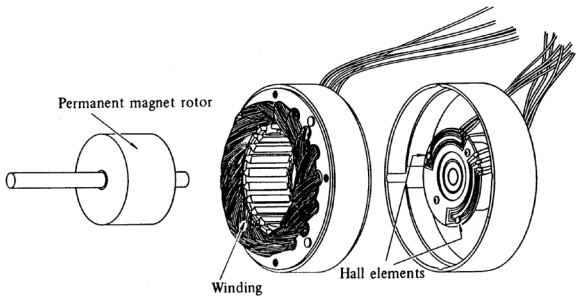

Fig.1. *Disassembled view of a brushless dc motor [5].*

The construction of brushless dc motor very is very similar to the ac motor. The structure of a typical three-phase brushless dc motor is illustrated Fig.1. Stator is a static part [7]. The number of stator slots is chosen depending on the rotor poles, number of phase and the winding shape. Stator windings can be connected with Y or Δ configurations as asynchronous motors are connected [8].

The rotor with permanent magnet are used to usually occur one or more permanent magnets in BLDC motors. Rotating part is rotor. The rotor is constructed with permanent magnets because of there is no brush and collector. For that reason no arc, no maintenance and reduced losses of friction. For the rotor is producted, optimum magnetic material is determined. Ferrite magnets are the most popular choices for low-cost motors. But ferrite magnets have low-flux density which is disadvantage [8].

Permanent magnets in rotor are mounted in different forms. Firstly, they can be mounted on the rotor surface. Secondly, they can be mounted in different ways and thirdly, the rotor can be completely occured from permanent magnets [9].

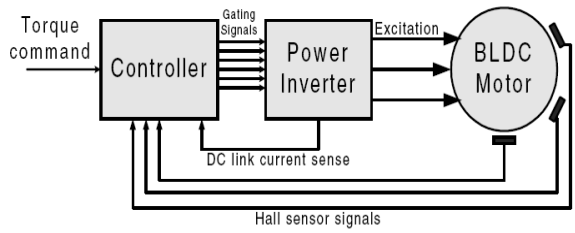

Fig.2. *BLDC motor drive schematic [6].*

Feed-back units are third structure. The stator windings should be energized in a sequence according to rotor position. Rotor position is determined with sensors. Besides, The current and phase values are measured for driver [4]. Fig.2 illustrates the structure of BLDC motor and it's driver system.

The position sensors are used for BLDC motors, for rotor speed and position is controlled. Traditionally, the sensors are used in BLDC motors which mounted on the motor shaft or stator. Hall effect and optic sensors are the most populer sensors. Besides, if the drive of BLDC motors is decided with sensorless, this form is also commonly used in recently [4]. Fig.3 illustrates BLDC motor transverse section.

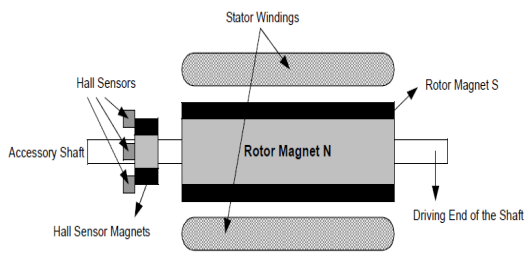

Fig.3. *BLDC motor transverse section [7].*

But sensorless control of BLDC motors can't achieve high speed and acceleration according to sensor-based control of BLDC motors [3].

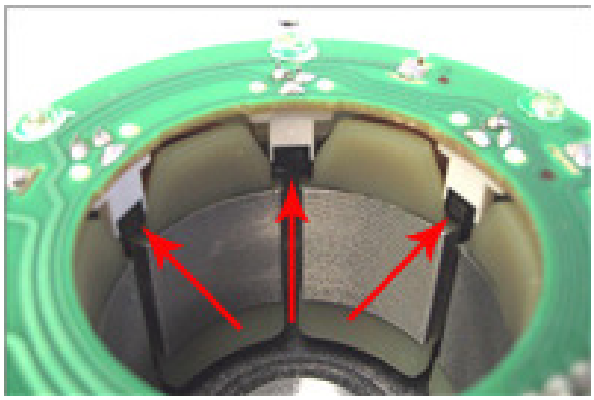

Fig.4. *The position of Hall Sensors in BLDC motor [10].*

Magnetic flux is provided by the rotor permanent magnets for Hall effect sensors. Hall voltage is a small value. It's 30 mV. Hall voltage is increased by the amplifier [11]. Hall effect sensors are mounted the intervals of 120° or 60° in BLDC motors [10]. Fig. 4 illustrates the shape of Hall sensors in BLDC motor.

Optic sensors are also position sensors which provide to measured accurately the rotor position as angular [1]. Optic sensors have two discs. This discs which are stationary and active. Their working principles; can be detected movement as linear or angular and the light is transmitted or not transmitted in two discs from a light source is sent out [12].

Zero crossing dedector is used to know the rotor position according to occur back-EMF on stator windings. This sensor is connected with motor driver. It's compared to the voltage which superimposed the stator coils and feeding voltage which have semi value. This advantages; this dedectors no movement section and no connected with movement motor section [1].

No sensor studies, Kalman Filter Theory is used as a stronger method. In this method, a mathematical model that contains position, speed and back-EMF values is used. In prediction stage, the change in the motor status at any point in time is predicted by using this method. The predicted back-EMF is compared with measured value and the difference is used for optimizing the motor operation. By using Kalman Method, position and speed of motor can be predicted not only at zero crossings but also at any given time. Therefore more accurate commutation and so higher efficiency can be obtained [13].

Inverter and driver layer is fourth unit. The voltage is obtained for controlling motor in this unit. This unit is inverter system which contains AC/DC inverter, breake resistance, filter and semiconductor switches (For example; transistor, mosfer, IGBT etc.). Controller determines in time which the semiconductor switches remain on or off. This unit occurs from semiconductors which is a switching pattern, is a interval unit [4].

This layer provides to turn of stator windings current to use the rotor position knowledge. Thus, the rotate of rotor is obtained. Controller sents on/off signals who are six semiconductor switches depends on the rotor position knowledge [1]. Fig.5 illustrates switching pattern which is used mosfets.

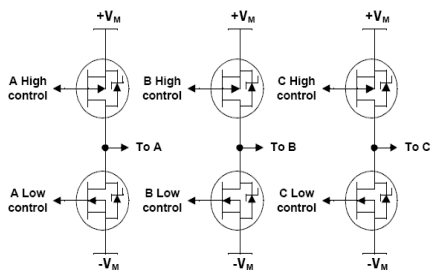

Fig.5. *BLDC motor driver which is used mosfets [14].*

BLDC motor is supplied from a three-phase inverter, and the switching actions can be simply triggered by the use of signals from position sensors that are mounted at appropriate points around the stator. This switching actions performs in proper sequence. Controller provides to switch the driver depends on position sensors knowledge. For one phase positive voltage, for one phase negative voltage is superimposed by the controller. At the same time, the third phase also is not superimposed voltage. This operation is performed systematically which is superimposed respectively for each phase differently. Hence, controller has this driver system configuration which provides obtaining torque. The driver is the most important part which determines the motor performance. Controller and switchs also determine the level of driver performance. For a driver, switches are the most important materials. For the choose of switch, It's considered to switching speed and losses. Mosfet is commonly used as a switch material. But, It's also used another semiconductor materials. For example, transistors, thyristor, IGBT etc. IGBT is a semiconductor switching material which operates rapidly than transistors but slowly than mosfets. Mosfets are the best choose for the driver system of BLDC motors have not high power [1].

PWM (Pulse Width Modulation) process is obtaining voltage at different impulse width by switching a fixed source and therefore voltage control at very wide ranges can be optained. Impulse width obtained depends on the total of duration the switch remains on and off, the duration the switch remains on. This is provided by changing the switch off duration or period [1].

Finally, controller is the fifth structure. Using referance entry and position sensor information, controller performs requiring work situations with generating control signals. Control algorithm is determined by the control signals which is generated by the controller. The status of PWM signals is also controlled according to control algorithm. Fundamentally, the speed, current and position rotation is controlled by the controller. Controller is composed of both software and hardware structures [4].

3. Types of BLDC Motor

There are three types of BLDC motors, called inrunner, outrunner and disc type [12]. Besides, There are two types, some BLDC motors have sensors and some BLDC motors have no sensors [15].

3.1. Outrunner Motors

The stator windings are located in the core of the motor. The rotor magnets surround the stator windings. This type, magnets are embedded in rotor. Stator and rotor structure seems like in brush DC motor's stucture. This motors have high inertia and are cooled difficult [16]. Fig.6 illustrates outrunner BLDC motor structure.

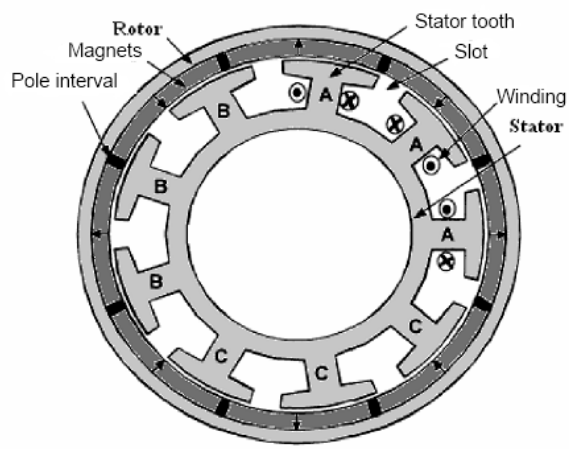

Fig.6. *Outrunner BLDC motor structure [16].*

It's also known outline BLDC motors. Outrunner motors spin slower but output more torque. Hence, they are used for helicopter and plane etc. [15].

3.2 Disc Type BLDC Motors

Disc types brushless DC motors can prefer low power and low speed applications. Fig.7 illustrates disc type BLDC motor structure.

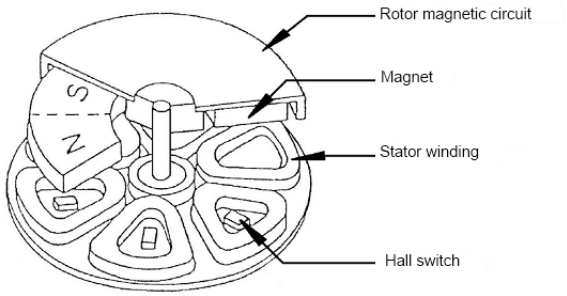

Fig.7. *Disc type BLDC motor structure [16].*

If we need low speed but high power, we should choose inrunner motor which has high number of poles. If this motor's speed is more than 1000 rpm, it's cooled very problem. For that reason, it's take measures. Thus, the cost is increased [16].

3.3 Inrunner Motors

The inrunner BLDC motor has permanent magnetes located on the inside of the stationary electromagnets. This motor seems like synchronous and asynchronous motors as construction [16]. Fig. 8 illustrates surface mounted magnets and embedded magnets BLDC motor structure.

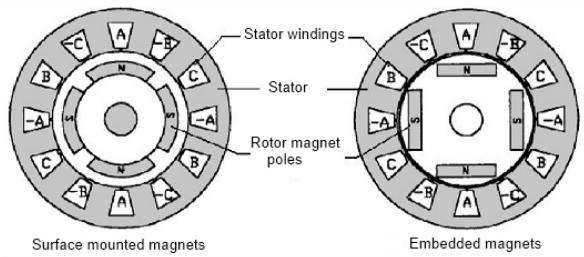

Fig.8. *Inrunner BLDC motor structure [16].*

It's also known inline BLDC motor. Inrunner motors are good when high speed are needed. They are more efficient than outrunner motors the faster they spin. Inrunner motors are low torque than outrunner motors [15].

Permanent magnets are mounted at different arrangements in a rotor. Fig. 9 illustrates different arrangements of magnets in a rotor.

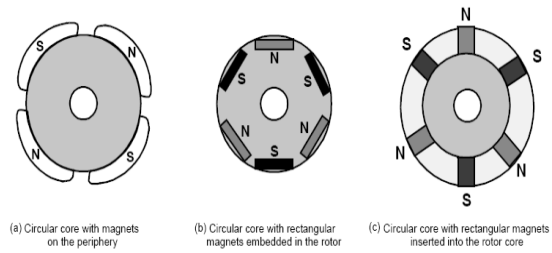

Fig.9. *Different arrangements of magnets in a rotor [7].*

Firstly, permanent magnets are mounted at rotor surface (Fig.9.a). In second configuration, rectangular permanent magnets are embedded in the rotor (Fig.9.b) and finally, rectangular permanent magnets are inserted into the rotor core (Fig.9.c) [12].

4. Pros and Cons

4.1 Pros

●The machine size of BLDC motors is smaller than DC and asynchronous machines because of no brush and collector. Hence, this motors can be used in high speed applications and can be also reduced the inertia moment [2].

●The speed control of BLDC motors is very good. The speed range which can be controlled is higher than asynchronous motors [2].
●BLDC motors required less maintenance than brushed DC motor because of absence of brushes [7].
●High efficiency is obtained by BLDC motors [7].
●Electric noise generation is lower than brushed DC motor [7].
●The life of BLDC motors is long [7].
●The operate of BLDC motor is reliable [2].
●For operate of BLDC motors, need not exciting current [2].
●The torque/volume ratio of BLDC motors is high. Hence, product of BLDC motor is used lower copper [2].
●Cooling operation is easy in BLDC motors [2].

4.2 Cons

●For the operate of BLDC motors, external power electronic and rotor position information which is desired in operation, requires. Using Hall effect sensors requires in BLDC motor operation [3].
●For the sensorless operation of BLDC motors, using additional algorithyms require. This method is more expensive than the others [3].
●Inverter errors can occur in BLDC motor's drivers [16].
●The permanent magnet BLDC motors can not reach very high speed. Because, this motors provide stable exciting [16].
●If the permanent magnets are used long time, magnetism properties are damaged because of atmospheric and thermic effects [16].

Nowadays, because of technological advanced, using BLDC motor increases and the disadvantages of BLDC motor is reduced [12].

5. Working Principle

BLDC motor has stator windings which are fed by inverter. Inverter is also fed by a current source. Inverter consists of power switches. The power switches (semiconductor switches) switch respectively depends on rotor position. The respect of power switches operation is determined by a position dedector in rotor or sensorless control algorithym. Fig. 10 illustrates BLDC motor drive system circuit diagram with position feed-back.

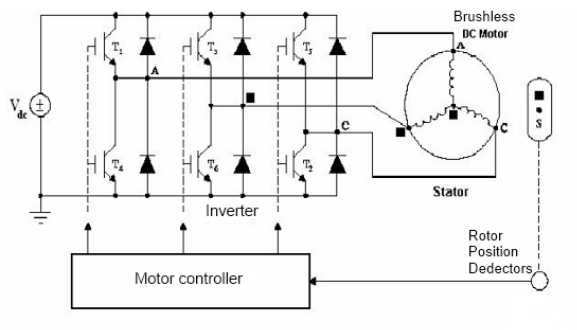

Fig.10. *BLDC motor drive system circuit diagram with position feed-back [9].*

The direction of current flow is altered in stator windings by using rotor position information. This process is performed by the power switches. This configuration is illustrated by Fig. 5. In this way, the direction of currrent flow and voltage which is superimposed in stator windings, and rotating rotor is provided controlling power switches. Hence, magnetic field poles occur in stator windings. The opposite poles attract each other and the same poles push each other. According to this principle, magnetic field poles in stator and rotor interact each other. For that reason, the torque occurs. The values of torque depends on stator and rotor magnetic field strength. The rotor position alters due to rotating rotor. The new position is dedected by the sensors, and is sent the controller. The new position in rotor

is evaluated by the controller, and the new position of power switches is determined. The sensors and switches altering position values which is rotated the rotor, are illustrated in

Table.1. *The corresponding rotor position of sensor and the position of switch values [1].*

		Hall sensors			Position of switches					
Position	Angle of position Φ	H1	H2	H3	Q1	Q2	Q3	Q4	Q5	Q6
1	0<=Φ<60	1	0	0	1	0	0	1	0	0
2	60<=Φ<120	1	1	0	1	0	0	0	1	0
3	120<=Φ<180	0	1	0	0	0	1	0	0	1
4	180<=Φ<240	0	1	1	0	1	1	0	0	0
5	240<=Φ<300	0	0	1	0	1	0	0	0	1
6	300<=Φ<360	1	0	1	0	0	0	1	1	0

According to the new position of rotor, the rotor interact the push and attract. The rotate of rotor is provide as continuously by repeated switching in rapidly [12].

6. Mathematical Model

For the design of BLDC motor controller, system processing model is determined. Hence, all parts and materials are determined in system. The system requires to comprise of all parts and materials. Besides, the system should be linear. If the system is nonlinear, the system is assumed linear by using some approaches [12].

For the mathematical model of BLDC motor, it is used the phase-variable approach in general due to simplier than the others. The current equations of the three windings in phase variables are defined as (1);

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} R & 0 & 0 \\ 0 & R & 0 \\ 0 & 0 & R \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \begin{bmatrix} L-M & 0 & 0 \\ 0 & L-M & 0 \\ 0 & 0 & L-M \end{bmatrix} \frac{d}{dt} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \begin{bmatrix} e_a \\ e_b \\ e_c \end{bmatrix}$$

In this equation, V_a, V_b, V_c are the phase voltages, the phase currents are i_a, i_b, i_c the phase back-emf voltages are e_a, e_b, e_c the phase resistance is *R,* the self inductance of each phase is *L,* the mutual inductance between any two phases is

The electromagnetic torque is defined as (2);

$$T_e = \frac{(e_a.i_a + e_b.i_b + e_c.i_c)}{w_m} \qquad (2)$$

In this equation, the mechanical speed of the rotor is w_m .

The equation of motion is defined as (3);

$$\frac{d}{dt} w_m = \frac{(T_e - T_L - B.w_m)}{J} \qquad (3)$$

In this equation, the load torque is T_L, the damping constant is B, the moment of inertia of the drive is J .

The equation (4) defines the relationship between the electrical frequency and the mechanical speed.

$$w_e = (\frac{P}{2})\, w_m \qquad (4)$$

In this equation, P is the number of poles [17].

7. The Control

In BLDC motor applications, control has become increasingly important besides motor design. BLDC motors are controlled by the fundamental power electronic circuits. However, it's necessary that many applications are implemented by the developed control algorithms. Increase in microprocessor capabilities, applicability of obtained mathematical model have made easy designing digital controllers for these models. Due to the improvements mentioned above,

technologically advanced and economical solutions are now possible for industrial needs [18].

The aim of all the BLDC motor control methods is performed the optimal control [19].

For the control of BLDC motor, in using control systems, the input values of system are determined for obtained output values which is desired. The value of error is referance value and output value difference. The input signal which will superimpose the system can be generated a value which will reduced minimum error value. In accordance with this purpose, the value of system output and the value of referance output is compared. For estimating system output, using dedector is required [20].

Parameters in brusless DC motors, such as motor current, torque, rotor position and speed are controlled using various control methods. Up to this point, many control methods are used. For controlling sensitively the speed control of DC motors, many control methods are also used up to this point. For example, artificial neural networks [21], fuzzy logic [22], wavelet teknique [16], genetic algorithm [23] etc. Besides, PID control is used alone or together with this methods up to this point [24]. The control methods of BLDC motors are two categories as classic and modern control methods.

7.1 The Classic Control Methods

Classic control methods are the parametric controls of BLDC motors which are done using the classic controller. The types of PI (proportional-integral control), PD (proportional-derivative control) and PID (proportional-integral and derivative control) controllers are a classic controller. Classic controllers are used for controlling BLDC motors due to their simplicity of structure and enough efficiency in most applications, in general. In the types of PI controllers, proportional and integral coefficients are calibrated; in the types of PD controllers, proportional and derivative coefficients are calibrated; finally the types of PID controllers, proportional, integral and derivative coefficients are calibrated. By this means, the desired working performance is obtained. However, requiring the model of the system to be controlled and determining the optimum gain values by trial and error method are among the disadvantages of this method, together with lack of performance during sinusoidal and instantaneous system changes. Therefore, classic controllers are commonly used for applications that do not require high precision [25,26].

For applications that require very high precision, modern control methods are preferred. Fuzzy logic, artificial neural network, genetic algorithm, neural fuzzy controllers are examples of modern control techniques [27].

7.2 The Modern Control Methods

A. Fuzzy Logic:

Fuzzy logic is the most convenient control method for conditions where classical logic is not enough. Especially, if mathematical model of a system is not constructed or is very difficult to construct, and it is a non-linear system, fuzzy logic control method where human perception and experiences are utilized is preferred. Fuzzy controllers use linguistic terms. This process comprises three stage in fuzzy controllers:

- In fuzzification interface, we have to fuzzify the data or create membership values for the data and put them into fuzzy sets.

●In fuzzy inference mechanism (rule evaluation), fuzzy rules are obtained. Fuzzy rule base provides fuzzy rules which infer requiring fuzzy values for calibrating system is controlled. This rules are obtained depends on knowledge and experience about system.

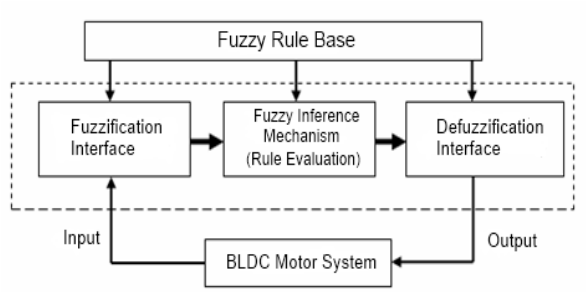

Fig.11. *The structure of fuzzy controller [16].*

●In defuzzification interface, fuzzy result values are obtained as again precision values using defuzzification method, and finally, system is calibrated this results [28].

B. Genetic Algorithm:

This method is used first time by John Holland in 1975. Genetic algorithm is a evolution algorithm which provides the optimization of functions are performed with modelling operation of biological process. The every member (individual) of population is represent as chromosomes. For the fitness of population, minimization and maximization is done according to determined rules. First process which will be determined requiring in genetic algorithm. An aim function related system and this function depends on boundary conditions is obtained with first process. The mathematical model related first process is obtained. Then, this mathematical model and boundary conditions are adapted the algorithm. The increasing of number of parameters provide better optimization in determining aim function [29]. Fig. 12 illustrates operation sequence in genetic algorithm.

The selection, crossover and mutation are the main operations of genetic algorithm.

The first community is created arbitrary, in general. In the process, strings with high fitness receive multiple copies in the next generation while strings with low fitness receive fewer copies or even none at all. The selection mechanisms provide to receive determining strings for the next generation.

Crossover is the most important genetic operator. This process is responsable combined and mixed of building blocks as again. Thus, this process is important for obtaining new solution. With this process, certain part of a solution replaces another solution. In this way, new seeds is obtained.

Mutation is a operatör which provides genetic alternation. Random alternations is transferred genes during a generation is copied the next generation. Rarely, mutation causes disappearing good individuals.

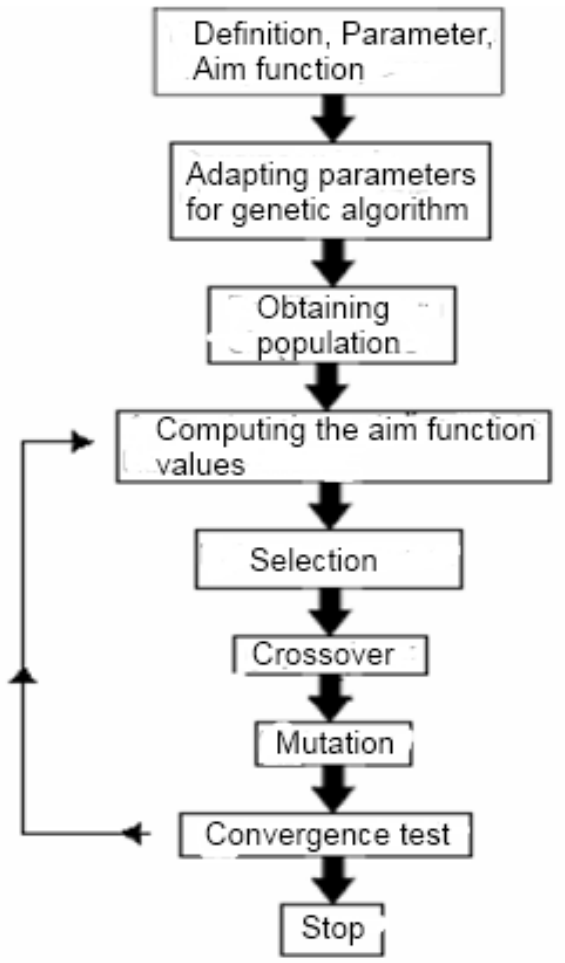

Fig.12. *The operation sequence in genetic algorithm [29].*

A configuration in genetic algorithm selects elite individuals. This configuration because of, the best individuals are transferred the next generation [30].

C. Artificial Neural Networks

Artificial neural networks are done, if mathematical model of a system is not constructed or is very difficult to construct, if the solution of uncertain, having incomplete data and noisy systems is desired [31].

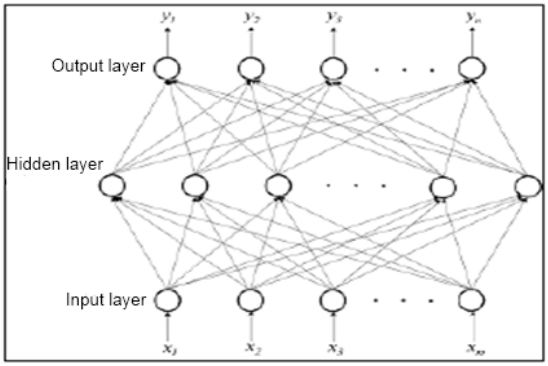

Fig.12. *The multilayer perceptron model [32].*

There are many artificial neural netwoks in literature. But, multilayer perceptron model is used commonly [33]. Fig. 13 illustrates multilayer perceptron structure.

The multilayer layer perceptron consists of three or more layers (an input and an output layer with on or more hidden layers). There are neurons in layers. If output value of each neuron present in interlayer is computed. The result of operation is obtained. For this purpose, firstly, this neuron depends on inputs with the same inputs which related weights are multiplied. The results of multiply are added. Obtaining total value can be computed as a total function of output [32].

Obtaining function is threshold, sigmoid or hyperbolic tangent function. Output values of neurons present in another layers are computed similarly. The value of error is output of network and desiring of output differance. Until error value is determining error value, the weights of network is altered and again is spreaded backward. This process is performed according to determined training algorithm. A great number of training algorithms are used in artificial neural network [32].

D. Neural-Fuzzy Controller

Neural-fuzzy network or fuzzy-neural network is combined artificial neural network and fuzzy logic network. Neural-fuzzy network is obtained combining advantages of this methods. Neural-fuzzy network and fuzzy-neural network have different means, in general. The functions of fuzzy-neural network, which the functions of artificial neural network are operated by the functions of fuzzy logic are performed this principle. The functions of neural-fuzzy network, which the functions of fuzzy logic are operated by the functions of artificial neural network are performed this principle. Nowadays, neural-fuzzy controller which has neural-fuzzy network structures is used. Neural-fuzzy controller can be used in all areas which are used artificial neural network and fuzzy logic. Besides, this controller is also used to control non-linear system, especially. Thus, neural-fuzzy controller is used determining parameter alternation, estimating moment and flux, and controlling speed and position [34].

E. Wavelet Technique

With Wavelet Theory is analysed nonstationary signals in time and frequency domain. Because of this property, this theory is used in image processing commonly. In using this theory in BLDC motors, Fourier Transformation is used for performing the transform of parameters in frequency domain. Commutation times of BLDC motors are determined by using low and high pass filter processes, using Daubechies Filter processes etc. In other words, the rotor position is determined by this processes [16].

8. The Conclusions

In this paper general information about BLDC motors and their control icluding basic structure and driving, types, pros and cons, mathematical model, working principle, control logic and control methods commonly used are discussed.

BLDC motors are DC motors which have long life and very effiency, because of there is no brush and collector. The precise speed control can be obtained in BLDC motors. The high torque is obtained with small size. Hence, nowadays BLDC motor which is preferred is a motor type.

Nowadays, parameters in BLDC motors, such as motor current, torque, rotor position and speed are controlled using various control methods. The various controllers are used for controlling BLDC motors. Controller has two types in general, classic and modern controllers. Classic controllers are used for controlling BLDC motors due to their simplicity of structure and high efficiency in most applications. At the same time, classic controllers (i.e. PI, PD and PID types) are commonly used for applications that do not require high precision. Classic controllers admit as linear the relation of between phase currents and rotor speed, in controlling motor. Hence, the current and speed control is considered separately.

For applications that require very high precision, modern control methods are preferred. Fuzzy logic, artificial neural network, genetic algorithm, neural-fuzzy controllers are examples of modern control methods. Especially if mathematical model of a system is not constructed or very difficult to construct, and it is a non-linear system, the use of modern controllers are preferred.

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Wireless sensor technology usage areas in livestock farming over the world and in Turkey

Pınar KIRCI[1]

Abstract

In our century the greatest and most important innovations occur at telecommunication industry. Lately, telecommunication is a vital incident for people, they need to communicate basicly by transmitting files or chatting at every place like farms, homes, warehouses, stores, hospitals, schools and cafes. To provide these needs of people, the easiest and cheapest technology is wireless network technology. With the help of the wireless technology, people can share data whenever they want and wherever they are, even they are mobile. The technology allows us to connect workstations, laptops, mobile phones, handheld PCs and even bar code scanners. Besides, agriculture and farming is the backbone of a country, thus the farmers should follow the recent developments about technology to provide the needs of ever increasing human population with decreasing lands for agriculture and farming. Today, the basic aim is to lower the costs and provide healthy products as seed, farm animals, vegetables and fruits. In the paper, latest improvements in agriculture and farming is examined briefly, in the way of technological developments which are a few years old and new implementations over the world and in Turkey. The investigations are basicly focused on wireless sensor network usage since the sensor technology is very suitable for health and environment monitoring of both people and animals. In America and Europe, sensor technology is used for more than ten years intensively but in Turkey only big livestock farms use such a delicate and advantageous technology for only a few years, in spite of the computer and network using number of people permanently increases in Turkey. In the paper, it is mentioned that the construction of sensor systems in the farms is very easy and useful for the farmers' budget and also for the economy of a country.

Keywords: *Wireless sensor technology; livestock farming; monitoring; farming in Turkey*

1. Introduction

Wireless sensor networks (WSNs) cover wide areas over the world depending on the technology, equipments and basic needs with consuming less power and cost than other presented communication technologies. Because of their crucial specialities, they are utilized at many different areas; at environment monitoring to collect data about the wildlife of animals, air conditions, pollution rates in air, water and soil and at disaster monitoring to collect, evaluate data and to take precautions such as at volcanic eruptions, earthquakes, flood disasters and hurricanes. Furthermore, it is used for health monitoring for patients and old people at hospitals and also at their homes with remote monitoring. Besides, another developing and growing technology and market is product monitoring at animal farms. It is very considerable in our century because

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of the ever growing healthy food demand of increasing human population. To provide the needs of people, many production methods become old fashioned and inadequate. For this reason, to increase the productivity, new technological methods; especially WSNs are used for big farms. A WSN based production monitoring systems at animal farms are composed of basic parts: a network structure which is composed of farm indoor and outdoor sensors, access devices like gateway and public communication networks and the management part of the farm with veterinary part (1).

Communication, computer and information technologies are ever growing and developing technologies with the recent advances produced by researchers. These technologies are combined and reached to millions of people with many devices basicly laptops, mobile phones and applications together with internet. Wireless networks enable people to reach network resources at every location in their home/office or in a primary networking environment. With the help of the increasing computer and mobile phone usage, many applications are based on these devices like e-agriculture, e-livestock and e-education. Here, the technology usage rates depend on gender, age and education level of people and many more factors. Mobile device usage rates at livestock management is examined in Turkey (2) according to many different factors like personal income, farm type and number of employee. Besides, the internet technology and computer usage over the world is examined in (3). We examined the technological developments used in livestock management over the world with the latest improvements. Then we presented the researches about the technological usage rates in Turkey because the aim of this study was to compare the technology utilization of Turkey in livestock management with other countries.

2. Materials and methods

2.1. Remote monitoring of hens

For the last twenty years, the hens are layed at cages but this system is out of date. Today, egg producers decided to raise the hens at non-cage environments. Because the in-cage environments cause stagnancy and stress over hens and eventually weak, unhealthy and diseased hens are produced. Consequently, these facts effect the egg production rates, quality of the eggs and other products gained from hens. Meanwhile, to monitor the hens at non-cage environments is very difficult. Also, researchers mostly focused on egg production rates, water, nutrition, medicine consumption rates of the hens and also the indoor environment temperature, moisture and oxygen rates. Contemporarily, many different factors and parameters are considered including every aspects in a daily routine of a hen. In (4) wearable sensors are attached to the hens and they are used to monitor the activities of the hens. With the offline machine learning methodology based system, six activities are trained to be able to monitor the hens, these are; raise, drink, dust-bathe, stand, walk or run, sit or sleep. Besides, there are many important illnesses that influence the health of the hens and the productivity rates. Thus, these illnesses should be monitored with sensors. One of the well known of these illnesses is avian influenza (HPAI) infection at birds and mammals. Infected chickens with HPAI viruses are examined widely but initial diagnosis is more important, because if there is an infected hen at the cage, the virus spreads very quickly from hen to hen at every 10 minutes, thus it is very important to be able to catch the first infected hens before infecting other hens in the cage.

Here, a temperature sensor and an accelerometer including wireless sensor is mounted to the hen, to be able to monitor the movements, body temperature and also to detect the unusual states of hens caused by the infection of virus. As soon as the sensors catch fever at the body of a hen or weakness at the movements of the hen, it informs the manager by sending a report that includes health informations (5). Today, most of the studies are concentrated on the wearable sensors to be able to catch the changes immediately.

2.2. Remote monitoring of cattles

For cattles mostly static sensors are used in the farms,. The animals are monitored easily, if they are in the monitoring area of the static sensors that are mounted at definite places in the farms. But, if the animals are out of the monitoring area of the sensors, then the animals' activities can not be monitored. This fact is the basic disadvantage of the static sensors, since animals may become ill or injured out of the sensors' monitoring area.

Also leg or neck collars are used at big animals, mostly at cattles to collect data like body temperature, breath rates, heart rates, movement speed and periods. But these collars should be cheap for farmers and they should be light for animals. And also, they should not make animals uncomfortable or irritate their skin, because if the animals feel themselves uncomfortable, they try to get rid of the collars so extra cost and damage emerge or collars may cause extra stress for animals which effect the products gained from them. In the paper (6,7), mobile animals are monitored with the mounted antennas on the animals' necks for collecting real time data at every second and at every place. Basic animal monitoring system structure is composed of mobile sensors mounted on animals, static indoor sensors inside the farm, the static outdoor sensors outside the farm at the area around the farm houses and main sensor at the monitoring station for managers and veterineries. In (8), low cost animal health monitoring is given for examining the health of animals, providing treatment for them and providing initial diagnose for the illnesses to prevent the spreading of viruses (9). To be able to detect such a valuable data; a pulse oximeter, a GPS (Global Positioning System),an electrode belt, a body temperature sensor, a respiration transducer and also an environment temperature transducer including sensors are used (10).

2.3. Remote monitoring of other animals

In paper (11) the seperation anxiety at dogs is examined. This is an important disorder type and a kind of dog behavior problem which is difficult to treat, for this reason it should be realized as early as possible and this detection will be easier with sensors either mounted on the dog or positioned around the dog's environment to follow its anormal movements. Because, by monitoring the movements of a dog, many problems can be catched easily and rapidly. With the sensor technology, air and water changes, fish behaivours and reactions of fishes to innovations around them are monitored easily for instance with eco aquafarm system. Here, it is very simple to notice the effects of a disease in the farm with the environment monitoring system, state analysing simulation system and eventually with the disease diagnosing system which constructs the main eco aquafarm system. The fishes are so delicate animals, they are effected by the changes around them easily such as the temperature, oxygen rates and the salinity of their water influences their improvement, health and reproduction. Therefore, these parameters of an aquaculture farm should be

followed during the day to be able to protect the farm. In (12), these parameters are monitored and data is collected by sensors, then the collected data is sent to a server over a mobile terminal. If the system finds out a problem at the collected data, it informs related people. Besides, the system examines the collected data to follow the aquaculture environment changes, especially for providing early treatment for affected fishes before spreading of the viruses to the whole aquaculture farm. Also, at ZebraNet (13), the animals around a zebra is monitored by a sensor on the zebra. This is another type of monitoring technique. Here, the sensor mounted animal is not monitored but other animals and environment around it is monitored.

2.4. Remote monitoring of people

Contemporarily, to support and improve the ill and old people's life standards, sensor technology is the most attention attracting technology. The sensors are used for detecting emergency situations, monitoring daily activities and drug interactions on people. The occurance of abrupt and damaging changes at the body state of a person is named as emergency situations and they should be immediately detected and cured as soon as possible. Because these situations may cause big, affective and long term injuries at the body of a person. With the sensor technology, this type of care needing people can be monitored during the day and if an abnormal situation is detected at heartbeat, respiration, body temperature and blood pressure rates, then the hospital, nurse or the family can be informed instantly. By monitoring daily activities, social interactions, movement, sleeping, toilet and shower usage rates of people at indoor or outdoor, better security and health conditions can be provided for patients. Furthermore, monitoring is the best and cheapest way to prevent malnutrition, loss of consciousness and also for providing hygiene of old and healing people after a medical procedure. Besides, drugs may cause side effects; sleeping, nutrition, behaviour and mental disorders as a result of drug interactions for this reason, they should be followed by telemedicine and e-health systems (14).

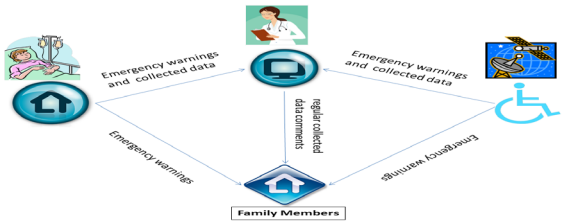

Figure 1: *Basic architecture of the health monitoring system*

Old people, neuromuscular disordered patients and paralysed patients need rather costly, special care and wheelchairs to be able to move. In (15) vital health conditions of people are monitored while they are mobile with their wheelchairs by the mounted sensor system which is working together with the GPS to provide outdoor localization and RFID to provide indoor localization as presented in figure 1. With the sensor system, remote healthcare assistance is provided for patients using wheelchairs together with monitoring their health status and current locations (16).

3. Results

The ever increasing population of people causes to enlarge the living areas of people over the habitat of natural animals, plants, forests and agricultural areas thus the consumption of natural resources will augment over the world. Therefore, the production amounts need to be increased at very limited areas with limited costs. Today, instead of utilizing human power, utilizing technological devices like computers, mobile phones, sensors and

wireless components, minimize cost, time loss and error factors. At current state, the increase of food demand and need for healthy products is a vital and big problem for human race. The gained protein from animals are more valuable for people than vegetal products, such as beef, chicken meat, fish, egg and milk.

In livestock management, providing well being of animals and increasing the productivity are the basic factors for farming. The positions of the farms, the enviromental conditions inside and outside the farms should be ensured with the structural design and technical equipments. In livestock management, to acquire highest efficiency, good maintenance, influential nutrition and convenient environment conditions should be provided to make a profit in production. To ensure the convenient environment conditions, farm area and the construction of farm structure should provide suitable and comfortable living space for animals. Afterwards, environment conditions and situations of animals need to be monitored to be able to ensure the health of animals together with the productivity and earn the best income.

Together with the adequate equipments, the design of the farm is the most important factor at livestock management. To provide the heat and humidity balance, air movements, gas and dust rate in the air are crucial factors effecting the indoor environment parameters in the farm. Besides, convenient ventilation and illumination systems should be designed according to the specifications of the farm because determining the light quality, the basic hours for light usage and air quality are very important since these are very vital variables. Furthermore, feeding and watering of the animals should be performed quickly, on time and with best quality fodder. Cleaning of the animals, farms and environment of the farms need to be considered. Additionally, here the basic aim is providing all of these factors with lowest cost and least labor usage but for big farms that are composed of many barns, ensuring the coordination is a big problem. Therefore, big farms and corporations try to use less labor but more technology; computers, wireless equipments and sensors for monitoring, sensing, evaluating and managing.

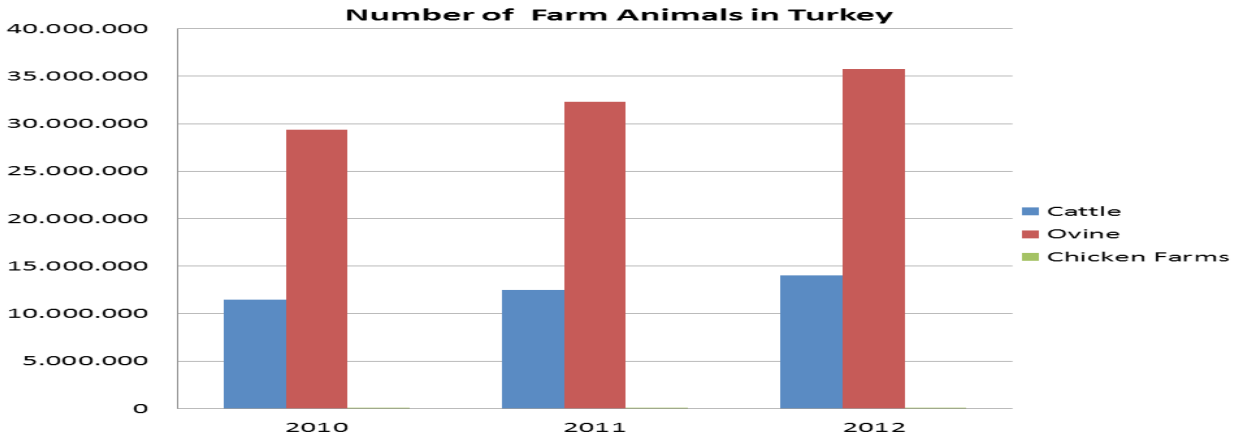

Figure 2: *The number of farm animals and chicken farms in Turkey between 2010-2012 (17)*

Eventually, it is easier and cheaper to control and manage the waterers, mangers, heaters and ventilation in the farms with the help of the sensor technology. In Turkey, especially at the chicken farms, sensors are mostly used for a few basic systems. For instance, to provide ventilation in the farm, delicate sensors are used to detect heat and humidity. Today, to provide the increasing demands of people in Turkey, animal nurturing in small farms turn into big production farms as given in figure 2 and figure 3. But, nurturing animals in big farms is very difficult and expensive thus the organization period as we mentioned above is very important.

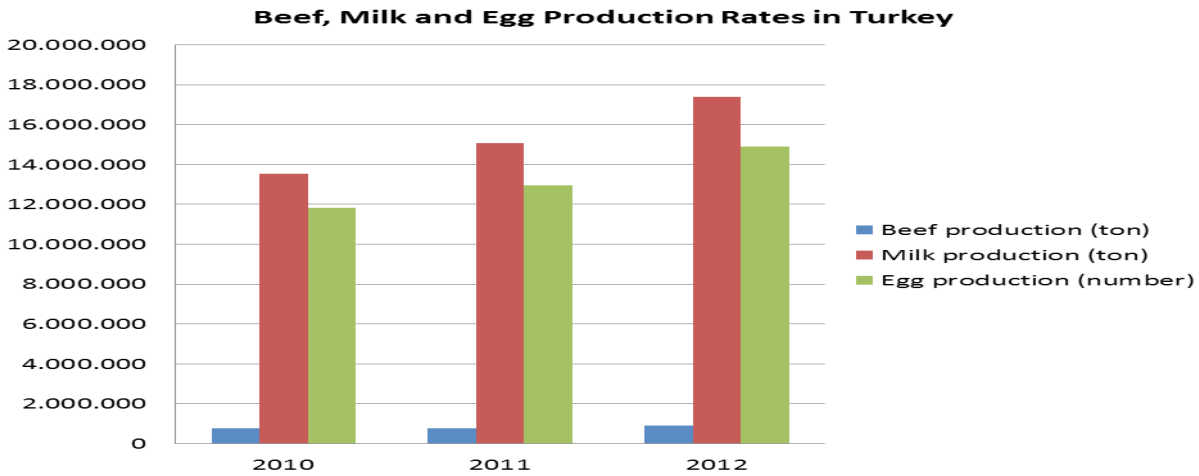

Figure 3: *Beef, milk and egg production rates in Turkey between 2010-2012 (17)*

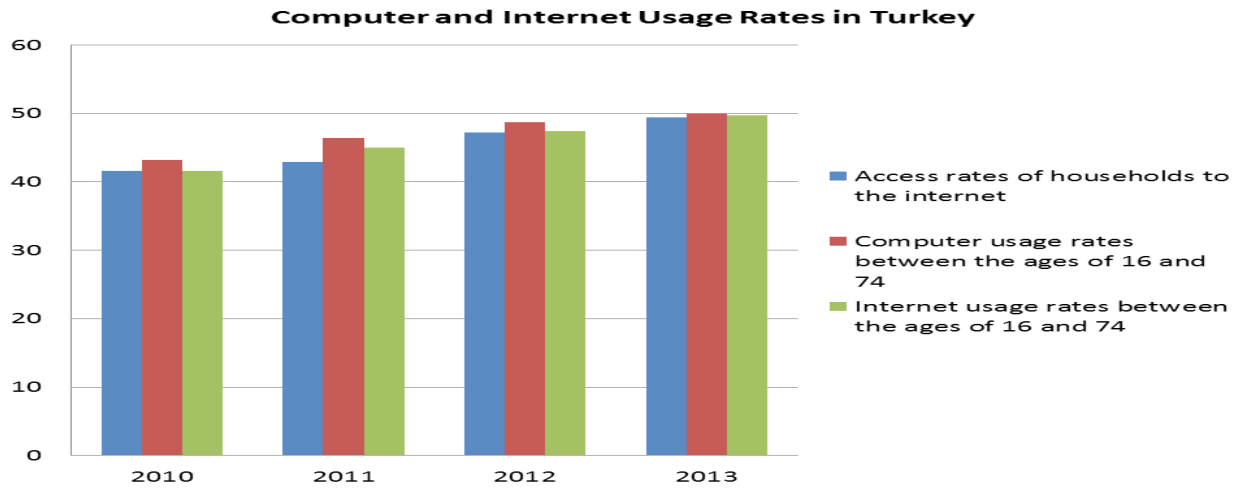

Figure 4: *Computer and internet usage rates in Turkey between 2010-2013 (20)*

The utilized technology at the farms is as important as the utilized equipments at the farms because labor and the production loss is the most costly part at production farms. Instead of utilizing labor, using technological devices decrease the cost, production loss and time loss. In Turkey, almost every home own a computer together with internet as given in figure 4, so it is getting easier to benefit from technological developments. Farmers monitor the farm, the animals, farm conditions and other necessary factors about the farm during 24 hours a day from their houses or outside by their computers and mobile phones with mounting some sensors in the farm according to the usage topics. Furthermore, owing to the sensor systems, the waterers, mangers, heaters and ventilation in the farms can be monitored, controlled and renewed if the rates diminishes to the specific values. Else, by monitoring animals, it will be easier and quicker to catch ill and dead animals in the big and crowded farms thus they can be send away from the farm immediately. Additionally, indoor and outdoor farm informations can be collected and can be stored, thus production cost is decreased, better and healthy products can be gained easily (18-21).

4. Conclusion

Contemporarily, livestock management is becoming a huge and still growing industry. With dense livestock farming, developing automation systems and technology, livestock management in smaller areas together with overcoming more work with less labor produce high production rates and makes the livestock management more profitable. But, badly designed dense livestock farming, restricts basic needs of animals like wandering, sunbathing and disintering around in the nature which disrupt animals' adaptation to their environment and other animals around them. Higher heat and humidity than needed amounts, bad lighting, ineffective feeding, uneducated farmers about animal behaviours and needs, using wrong equipments, sheltering more animals than appropriate numbers at a definite living area and not removing the dead and diseased animals from the farms as soon as possible influence animals badly, makes them stressful and uncomfortable. For this reason, when it is talked about the farms that possess the optimum conditions for animals, it means the farms that provide adequate environment for animals to be able to grow with best conditions they need, especially

without stress and with best care. Good planned and constructed farms present many benefits like acquiring most product with the least input; with decreasing the death rates, fodder consumption and energy usage; by improving the product quality and decreasing the labor need. Consequently, to increase the productivity; the construction of the buildings, the needed technology and devices, the place of the farm and the labor should meet the needs of the considered farming type (22). The construction stage of such a sensor sytem is a little bit tiresome and costly. Accordingly, in Turkey only big farms choose sensor technology instead of utilizing from old fashined methods. But, after constructing the system, the gained profit during a very short time is remarkable. Thus, in addition to big farms, middle sized farms should also utilize the WSN technology in Turkey.

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Total Phenolic Content and Radical Scavenging Activity of Carthamus Tinctorius L.

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Sibel KAHRAMAN[2]

Abstract

Extract from leaves of Carthamus tinctorius L. was prepared by using soxhlet extraction method. Total phenolic, flavonoid content and also antioxidant activity of leaves from Carthamus tinctorius L. were determined. To determine the antioxidant capacity, 1,1-diphenyl-2-picryl-hydrazyl free radical (DPPH•) scavenging, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid) ($ABTS^{\cdot+}$) radical scavenging tests were used. Reducing power of the extract was also tested. Total phenolic and flavonoid content of the extract were determined as 77.38 ± 6.62 mg GAE/g, 25.49 ± 0.26 mg CE/g dry weight of extract respectively. DPPH radical scavenging activity was determined as 89%. ABTS radical scavenging activity was found as 58% at 1 mg/mL concentration. Reducing power was found as 0.885.

Keywords: *safflower, antioxidant activity, phenolic, Carthamus tinctorius L.*

Introduction

Free radicals and other reactive oxygen species are responsible from many diseases. To prevent these risk it is advised increased consumption of natural antioxidants abundant in foods[1]. Phenolic compounds which is found in plants exhibit antioxidant activity.

Carthamus tinctorius L. commonly known as Safflower or false Saffron, a member of Compositeae family, has been used traditional medicine in Turkey. It is also used for purgative, analgesic, antipyretic, antidote to poisoning for a long time all over the world. A dye is obtained from the flower petals of *Carthamus tinctorius* L. and used for different purposes like coloring rice or bread or dyeing cloth [2]. Safflower seeds contain 13-46% oil and oil content of the seeds very similar to olive oil. It is known with high linoleic acid content. It contains linoleic acid (63-72 %), oleic acid (16-25 %) and linolenic acid(1-6%)[3]. This prevents blood cholestrol [4]. More than 200 compounds have been isolated from *C. tinctorius*. These compounds are mostly consist of flavonoids, phenylethanoid glycosides, coumarins, fatty acids, steroids and polysaccharides [5]. Some researchers reported the antioxidant activity of seeds and flowers of Carthamus tinctorius L. but antioxidant activity of leaves weren't investigated yet. Therefore the aim of this study to determine phenolic and flavonoid contents of leaves of *Carthamus tinctorius* L. and also radical scavenging activities,

2. MATERIAL and METHOD

2.1. Chemicals

2,2'-azino-bis (3-ethyl benzothiazoline -6-sulfonic acid) diammonium salt (ABTS), 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox), (+) catechin hydrate, 2,2-diphenyl-1-picryl-hydrazyl(DPPH), a-tocopherol, ascorbic acid and pyrocatechol were obtained from Sigma Chemical Co. (St. Louis, MO, USA). Trichloroacetic acid (TCA), ferric chloride were obtained from

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Merck. All other reagents used in this study were of analytical grade.

2.2. Plant materials

Carthamus tinctorus L. leaves were collected in July from Tekirdag area. Leaves were washed with distilled water and dried at room temperature.

2.3. Preparation of extract

Carthamus tinctorius L. extract were prepared by soxhlet extraction method with ethanol for 4 hours. The extract was then filtered and evaporated to dryness.

2.4. Total Phenolic Content

Total phenolic content of the extract was analyzed according to the method of Slinkard and Singleton[6] with slight modifications. The plant extract was tested in 1-4 mg concentrations. Total phenolic content of plant extract was calculated with the standard curve of gallic acid and expressed as µg gallic acid equivalent. The extract was analyzed in triplicate. Results are expressed as mean value.

2.4. Total Flavonoid Content

Total flavonoid content of the extract was determined according to the method of Zhishen[7]. Standart curve was prepared with catechin. Extract in different concentrations were analyzed in triplicate and flavonoid content expressed as µg(+)-catechin equivalent.

2.5. DPPH radical scavenging activity

To determine the antioxidant activity of extracts DPPH radical scavenging activity was used[8]. DPPH radical solution was prepared freshly at 20 mg/L concentration in methanol. 1.5 mL of DPPH solution and 0.75 mL of extracts at different concentrations were added into test tubes. After 30 minutes incubation in the dark, absorbances were recorded at 517 nm with spectrophotometer. Results were calculated as percentage inhbition with the following formula:

DPPH radical scavenging activity (%) = $(A_0 - A_1 / A_0) \times 100$

whereA_0 is the absorbance of DPPH• in methanol solution without an antioxidant, and A_1 is the absorbance of DPPH• in the presence of an antioxidant.

2.6. ABTS Radical Scavenging Activity

The 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical scavenging assay was done according to the method of Re et al. [9]. To prepare an ABTS radical solution equal volume of ABTS(7 mM) and ammonium persulphate solutions (2.45 mM) were mixed and then incubated in the dark at 25 ^{0}C for 12–16 h and then diluted with ethanol until the absorbance at 734 nm was 0.70 ± 0.003. Different quantities of each sample were mixed with 3 mL of ABTS radical solution and the change in absorbance was recorded at 734 nm for 6 minutes. Ascorbic acid was used as standart. The ABTS radical scavenging capacity of the sample was calculated by the following formula:

ABTS radical scavenging activity: $((A_{blank} - A_{sample})/A_{blank}) \times 100$

A_{blank} : Absorbance of the ABTS radical solution without an antioxidant

A_{sample} : Absorbance of the ABTS radical solution in the presence of an antioxidant

2.7. Determination of Reducing Power

Extract was tested for determination of reducing power by the method of Oyaizu[10]. Various concentrations of the extract from

safflower leaves (2.5 mL) were mixed with 2.5 mL of sodium phosphate buffer(200 mM, pH:6.6) and 2.5 mL of 1% potassium ferricyanide. The mixtures were incubated at 50 ^{0}C for 20 min. Then 2.5 mL of 10% trichloroacetic acid was added into test tubes and centrifuged. After centrifugation 2.5 mL of supernatant solution was mixed with 2.5 mL of distilled water and 0.5 mL of 1% $FeCl_3$. Absorbances of the mixtures were measured at 700 nm spectrophotometrically. α- Tocopherol used as standart.

3. RESULTS and DISCUSSION

3.1. Total Phenolic and Flavonoid Content

Leaves of Safflower were extracted by using soxhlet extraction method. Ethanol used as solvent. Total phenolic content of the extract was determined as 77.38 ± 6.62 mg GAE/g dry weight of extract. It is reported in the literature that total phenolic content seeds of *Carthamus tinctorius* L. as 126 ± 2.4 mg GAE/mg [11]. Kruawan et al.[12] reported that water extract from flower of Carthamus tinctorius L. as 139.98±18.02 mg GAE/g. Our results show that extract from the leaves contains less phenolic content from seeds and flower of safflower. Total flavonoid content of the leaves were found as 25.49 ± 0.26 mg CE/g dry weight basis. The total flavonoid content seed of *Carthamus tinctorius* L. was found 62.2 ± 1.9 mg QE/g [11]. The total flavonoid content of CTE contain less flavonoid than seeds. 8 flavonoids were isolated from leaves of *Carthamus tinctorius* L.

3.2. DPPH Radical Scavenging Activity

The method based on the discolourization of deep violet colour of α,α-diphenyl-β-picrylhydrazyl radical. Therefore antioxidants act as hydrogen donor, in the presence of an antioxidant DPPH radical reduced and absorbance decreases. % DPPH radical scavenging activity of *Carthamus tinctorius* L. extract was determined as 53%, 75%, 81%, 89% respectively at 1,2,3,4 mg/mL concentration. Inhibition percentage of the extract increased with increasing concentration. The results indicates that soxhlet extract of the leaves has significant antioxidant capacity. Trolox was used as standart. As can be seen in Fig 1. antioxidant activity of CTE is very close to trolox. % DPPH radical scavenging activity of CTE is higher than seeds of safflower (36.2 ± 0.5 % for 1 mg/mL)[11] but lower than flowers of safflower (96.65%) [12].

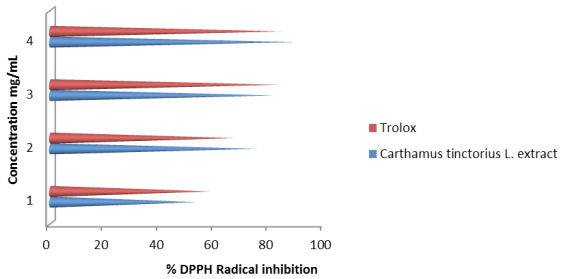

Fig 1. *% DPPH Radical Scavenging Activity of Carthamus tinctorius L. extract*

3.3. ABTS Radical Scavenging Activity

ABTS radical was prepared by mixing ABTS solution and potassium persulfate solution in 1:1 portion. Blue green ABTS radical was decolorized in the presence of H donor. Antioxidant compounds decolorize the ABTS radical because of their hydrogen donating capability. ABTS radical scavenging activity of CTE was tested for different volumes. Ascorbic acid used as reference. ABTS radical scavenging activity extract from seeds of *Carthamus tinctorius* L. 15.3 ± 4.4 % at 1 mg/mL concentration[11]. Fig 2. shows ABTS radical scavenging activity of CTE.

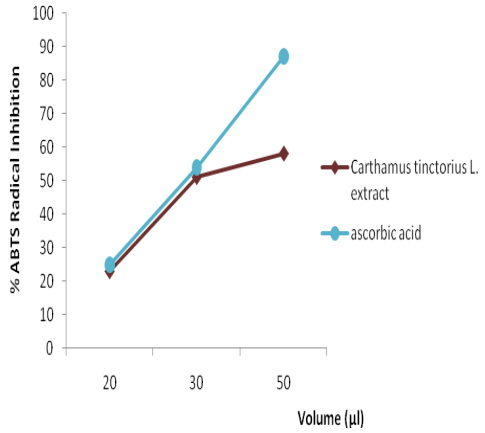

Fig 2. *% ABTS Radical scavenging activity*

3.4. Reducing Power

Reducing power activity is related with the antioxidant activity. In the presence of an antioxidant the yellow colors of mixture turn into blue gren color[13]. As can be seen in Fig 3. CTE showed lower activity than α-tocopherol standart. Reducing power was found as 0.598, 0.688, 0.796, 0.885 respectively at 0.5, 1, 1.5, 2 mg/mL concentrations. Reducing power of plant extract are increased with the increasing concentration. These findings are very similar to the phenolic content results. It can be said that reducing power activity was originated from the phenolic content of the extracts.

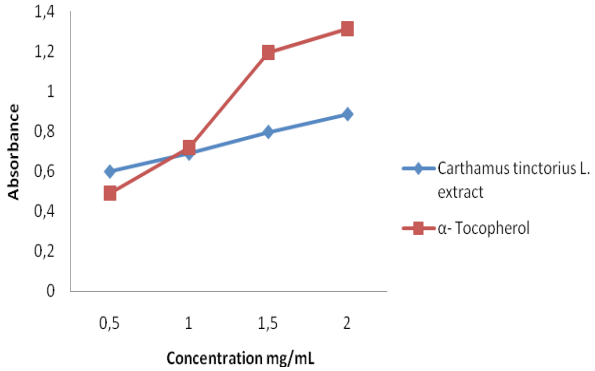

Fig 3. *Reducing power of Carthamus tinctorius L. extract*

Conclusion

According to our result leaves of *Carthamus tinctorius* L contain important amount phenolic compound. These results lower than other parts of the plant like seed and flower. Also plant extract has significant antioxidant activity.

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